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Reduced intensity of bone fat exploitation correlates with increased potential access to dairy fats in early Neolithic Europe

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ABSTRACT

Important nutritional resources can be acquired by breaking bone shafts to access marrow, whereas heavy comminution and boiling of cancellous bone is required to extract bone grease. Since labour and fuel costs of these processes differ considerably, the relative intensities of these activities provide a possible proxy for nutritional stress or elevated fat requirements in the context of an overall subsistence strategy. We investigated faunal material from eleven early Neolithic sites in central Europe for bone fracture and fragmentation patterns to ascertain the intensity of bone marrow and grease exploitation. These data indicate that bone grease processing was practised rarely if at all during the early Neolithic, likely made unnecessary by ample access to crop carbohydrates. Bone marrow was exploited at all sites, but with varying intensity that exhibited a significant negative correlation with the proportion of milk-producing domestic ruminants. This observation is consistent with the hypothesis that fats obtained from dairy products reduced requirements for intensive marrow exploitation.

1. Introduction

The exploitation of the fat reserves within animal bones by early farmers in central Europe is poorly understood. Intensive utilisation is traditionally associated with hunter-gatherer societies in harsh environments (e.g. Binford, 1978; Speth, 1989; Leechman, 1951), rather than farming societies living in relatively warm and wet temperate climates (Rück, 2009). Nevertheless, bone fats could have been a crucial resource for early Neolithic farmers, especially at times of nutritional stress.

1.1. Sites studied

Eleven sites were studied, attributed to three early Neolithic linear pottery cultures. In Hungary, three Alföld (ALP; 5600-4700 calBC, Domboróczki, 2009) and one Transdanubian (TLP; 5600/5500–5000/4900 calBC, Oross and Bánffy, 2009) sites were analysed, in addition to seven sites from the central European Linearbandkeramik culture (LBK 5500-5000 calBC, Bickle and Whittle, 2013). The TLP culture is closely associated with the wider LBK phenomenon (Whittle et al., 2013: 49), but the ALP on the Great Hungarian Plain is often distinguished by its different settlement and material culture style, Neolithisation process and connections with the Vinča cultural complex to the south (Bánffy, 2004, 2008; Oross and Bánffy, 2009). Both Hungarian variations also followed earlier farming societies in their locales, unlike the LBK, which was the first farming society of central Europe (Bickle and Whittle, 2013; Whittle et al., 2013; Raczky and Anders, 2012: 273; Kalicz and Makkay, 1977: 38–56; Whittle, 2007).

The subsistence of these cultures was based largely on domesticated crops and animals, and supplemented with wild flora and fauna (Whittle, 2007; Glass, 1991; Lüning, 2000; Kreuz et al., 2005; Jacomet, 2007; Kohler–Schneider and Caneppele, 2008; Bogaard et al., 2011). Animal carcasses would have provided meat and fat, and domestic ruminants may have been partially managed for milk production (Bogucki, 1984, 1988; Salque et al., 2012, 2013; Gillis et al., 2017). Fat reserves within animal bones were utilised, although the exploitation of this resource is poorly characterised in these cultures despite its potentially crucial contribution to diet (Marciniak, 2005, 2011; Boulestin et al., 2009; Johnson et al., 2016; Johnson, 2017).

1.2. Importance of fat

Fats are a particularly important dietary component. By weight they provide more than double the calories of carbohydrate and protein and can be a source of essential fatty acids and lipid-soluble vitamins such as A, D, E and K (Outram, 2001, 2004; Mead et al., 1986; Erasmus, 1986). In periods of nutritional stress, particularly when access to carbohydrates is limited, fat consumption can commute the adverse and potentially fatal effects of a protein-rich diet (Speth and Spielmann, 1983: 13; Speth, 1989; Outram, 2004). However, great effort is

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typically required to extract all fats from a carcass, particularly those within bones. Bone fat resources increase in importance as nutritionally stressed animals utilise their subcutaneous fat reserves leaving only lean meat high in protein, while bone fat may remain (Cheatum, 1949; Brooks, 1977; Peterson et al., 1982; Davis et al., 1987; Outram, 2004; Speth and Spielmann, 1983: 12; Speth, 1990). Intensive extraction of bone fats may therefore indicate that other dietary sources are not meeting requirements, and that the society may be experiencing subsistence stress (Outram, 2004).

The most rudimentary form of bone fat processing is extracting marrow fat, where marrow-bearing bones are fractured using percussive force and the marrow extracted (Binford, 1978). Marrow is used extensively by both hunter-gatherer and mixed farming societies (see for example Binford, 1978; Abe, 2005; Gifford-Gonzalez, 1993; Speth, 1989: 185; Lee, 1979). Before or after marrow extraction, bones may also be boiled in stews to liquefy soluble nutrients and enrich the resultant broth (Binford, 1978; Gifford-Gonzalez, 1993; Richards, 1951). Epiphyses and other cancellous elements may be split in this case to increase the surface area and thus the rate of nutrient extraction (Church and Lyman, 2003; Janzen et al., 2014), but also to 'pot-size' them for the vessels they are to be boiled in (Oliver, 1993; Gifford-Gonzalez, 1993). Bone grease processing, the most intensive form of bone fat extraction, involves heavy comminution and boiling of cancellous axial and articular bone, resulting in liquefied bone grease that floats to the surface and can be scooped off (Leechman, 1951; Binford, 1978; Outram, 2002: 51; 2005: 33; Abe, 2005: 116). Use of grease is particularly prevalent in ethnographic accounts of hunter-gatherers living in highly seasonal or harsh climates (e.g. Leechman, 1951; Saint-Germain, 1997; Binford, 1978; Abe, 2005; Speth, 1990), and was practised in farming communities at times of subsistence stress (e.g. Outram, 2003). Grease extraction requires a great deal of time, energy and fuel (Church and Lyman, 2003; Janzen et al., 2014), whereas bone marrow extraction and bone-enriched stews require comparatively little effort. However, bone grease has several advantages over bone marrow and bone-fat enriched stews; particularly that grease is a more storable fat source (Leechman, 1951) that is less likely to spoil as a result of rendering.

The demand for bone fat would potentially be reduced by access to cattle and caprine milk, an excellent alternative source of dietary fat. Cattle milk has a fat content of between 3.5% and 5.5%, goats approximately 3.5% and sheep approximately 5% (Ryan, 2005; Outram and Mulville, 2005). Whilst our data do not permit us to directly estimate the amount of milk exploitation at each site, we assume a monotonic relationship between the proportion of milk bearing animals and the amount of milk exploitation. Therefore, we hypothesise that the intensity of bone fat extraction, particularly marrow fat, would negatively correlate with the proportion of milk producing animals.

2. Methodology

2.1. Archaeological signatures of bone fat exploitation

The processes involved in bone marrow and grease exploitation have different archaeological signatures, which revolve around the identification of human-induced fracture and fragmentation of bones. Dynamic loading on the diaphysis of fresh (peri-mortem) long bones causes a helical fracture with a smooth fracture surface texture and acute or obtuse angles of that surface to the cortical surface, and may cause percussion marks or impact and rebound scars around the point of loading (Morlan, 1984; Johnson, 1985; Outram, 1998, 2001, 2002; Blumenschine and Selvaggio, 1988). These "fresh" fractures can be a signature of bone fat extraction. Over time bone loses moisture and has a greater tendency to fracture in straight lines or steps, following drying-induced micro-cracks along the bone's structure (Johnson, 1985: 160). These "dry" fracture surfaces tend to be perpendicular to the cortical surface and the texture of the fracture is more granular than fresh bone (Johnson, 1985: 177; Outram, 2001, 2002). All these features are often present in their full extent in mineralised bones that have lost their energy-absorbing and elastic capabilities through extensive moisture loss, protein degradation and altered microstructure (Johnson, 1985: 178; Outram, 2001: 403). Dry and mineralised breaks are more likely to be caused by deposition practices, taphonomic processes, and later context disturbance. These three bone fracture types – fresh, dry and mineralised – occur in a sequence, as bones fractured when fresh can also be later fractured when dry and/or mineralised, but not vice versa (Johnson et al., 2016).

Bone marrow processing can be inferred from high levels of fresh fracture on marrow-bearing bones – i.e. the humerus, femur, radius, tibia, mandible and metapodia (Outram, 1998, 2002, 2004). Where exploitation of marrow is intensive, unbroken marrow-bearing bones are rare, diaphysis fragments are common, and high-yield marrow-bearing bones may be preferentially targeted (Outram, 2004: 75). Some further minor fragmentation of articular ends may be associated with pot-sizing and boiling in stews (Gifford-Gonzalez, 1993). In addition to freshly-fractured long bones, high levels of fragmentation of cancellous bone is the primary signature of intensive bone grease rendering. The greatest amount of bone, in terms of mass, should be found in the smallest size classes; fragmented cancellous bone should be common and whole grease-bearing bones and long bones with complete epiphyses should be rare (Outram, 2001, 2005). On sites where bone grease processing was an established practice it is possible that archaeological features related to this activity will be discovered (for example Karr et al., 2015). If the assemblage fragmentation is indeed a result of human agency and not inadvertent modification such as bioturbation, trampling or compaction, it is likely that bones rarely targeted for marrow or grease, such as ribs, will be preserved in a less fragmented state. If non-deliberate taphonomic factors were the principal cause of fragmentation then such elements would be equally affected (see Outram, 2001: 409).

2.2. Bone fat recording methodologies

The methodology employed to study the different types of bone fat processing involved characterising fracture types, fragmentation levels, and the type of bones fragmented. Observed fracture types (fresh, dry and/or mineralised) visible on marrow-bearing bone were recorded based on characteristics described above. Canid bones showed different carcass processing traditions from 'food' animals and were removed from the analysis in this paper. Where more than one fracture affected a single specimen, these fractures were listed in order of the first fracture that must have occurred based on moisture loss (Parmenter, 2015), and then grouped by subsequent sequences of fracture (Johnson et al., 2016). These different fracture sequences, rather than the number of overall fractures, are presented using a fracture history profile (Johnson et al., 2016). On sites with large amounts of subsequent taphonomic fracture, presenting fracture types as a proportion of the total number of fractures can underrepresent those fractures caused by marrow processing. By grouping specimens by the fracture sequence that affected the bone, the intensity of marrow processing is accurately presented, whilst still giving an indication of taphonomic fracture (Johnson et al., 2016, Fig. 3). Fragmentation was analysed by weighing all bones – both identifiable and indeterminate - and assigning them a specimen type, such as cancellous, diaphysis, rib, and a size class based on maximum dimensions (Outram, 1999; Gron, 2015). Mass (g) was used as a measure of fragmentation as a whole bone broken into many pieces still represents the same mass. Mass therefore shows the distribution of bone in all size classes, whereas small bone fragments are overrepresented by frequency. The analysis also involved a basic identification of the bone to species, element and zones represented (Dobney and Rielly, 1988) where possible. Bones with evidence of tool use were removed from analysis. Extensive analysis of butchery, heat exposure, animal gnawing and taphonomic agents was also undertaken