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Landscape opening and herding strategies: Carbon isotope analyses of herbivore bone collagen from the Neolithic and Bronze Age lakeshore site of Zurich-Mozartstrasse, Switzerland

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ABSTRACT

Carbon isotope analysis ($\delta^{13}C$) was performed on collagen extracted from 54 domestic cattle (*Bos taurus*) and 20 red deer (*Cervus elaphus*) bones from the Neolithic (3913–2586 BC) and Bronze Age (1950–950 cal. BC) layers of the lakeshore site Zurich-Mozartstrasse located in the lower Lake Zurich basin, Switzerland. We observed shifts in the $\delta^{13}C$ of both domestic cattle and red deer over two millennia. Mean $\delta^{13}C$ values of red deer changed from −24.1 ± 0.7‰ to −22.5 ± 0.3‰, while mean $\delta^{13}C$ values of domestic cattle showed minor changes from −22.7 ± 1.3‰ to −22.1 ± 0.3‰. Our data suggest that in the early 4th millennium BC the landscape was densely forested with red deer feeding in closed habitats and cattle grazing in more open landscapes. Forest was also a food resource for some young cattle as indicated by the lower $\delta^{13}C$ values of non-adult relative to adult animals. This points to a greater diversity of herding strategies and feeding techniques compared to the later periods. The landscape was still rather forested towards the mid-3rd millennium BC, with no obvious changes in the habitat use of the large herbivores. However, the carbon isotopes suggest a clearly reduced forest cover in the 2nd millennium BC with red deer using similar open feeding grounds as domestic cattle. Our study demonstrates that the stable carbon isotope composition of archeological bone material from large herbivores can provide integrative constraints on paleoenvironmental and vegetation changes, prehistoric animal management and land-use.

1. Introduction

Lakeshore settlements are amongst the best investigated archeological sites worldwide. Due to burial in waterlogged, and essentially anoxic, lake sediments, the preservation of (organic) finds and features is exceptional and a broad range of scientific approaches have been applied to study this legacy of our past (Menotti, 2004, 2012; Menotti and O'Sullivan, 2013). Dendrochronological investigation on almost pristine timber allows precise tree-ring dating of residential structures and the reconstruction of settlement histories (e.g. Hafner, 1993; Leuzinger, 2000; Schlichtherle et al., 2011). Within this framework, rich faunal remains provide detailed insights into subsistence strategies, and represent valuable proxies to be used for paleoenvironmental reconstructions (e.g. Hüster-Plogmann and Schibler, 1997; Deschler-Erb and Marti-Grädel, 2004; Chiquet, 2012).

While there is extensive knowledge about the actual settlement sites, little is known about the immediate surroundings of the lake dwellings in terms of subsistence activities beyond settlement frontiers. Some important conclusions have however been drawn using bio-archeological data. For example, it was shown that hunted animals, gathered plants and wood resources were of great importance in these settlements, and evidence from off-site pollen analyses suggests that the settlements' surroundings were used for agricultural activities (e.g. Schibler et al., 1997; Schibler and

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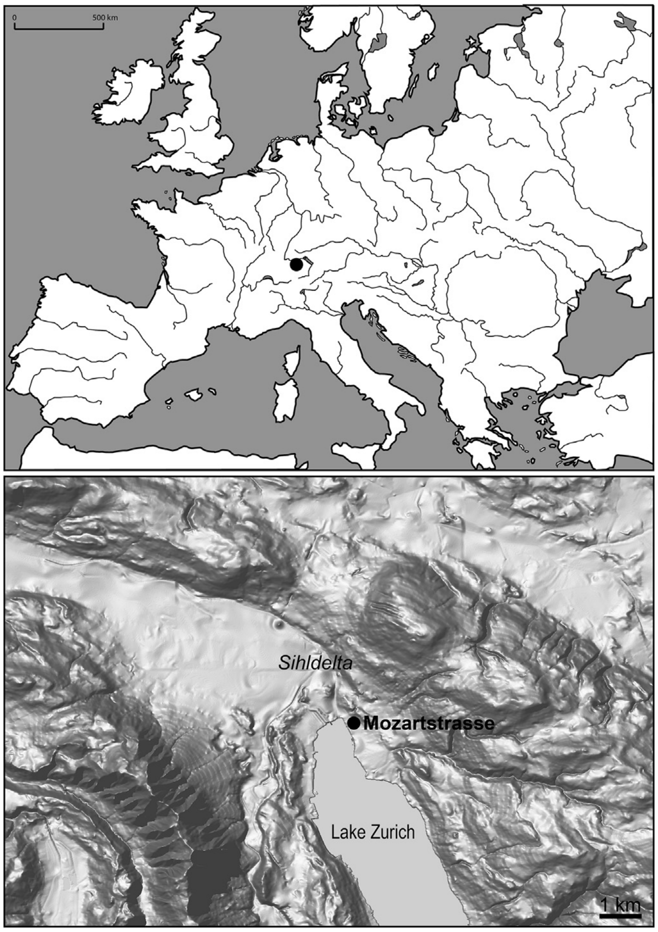

Fig. 1. Location of Zurich-Mozartstrasse at the northern end of Lake Zurich in Switzerland.

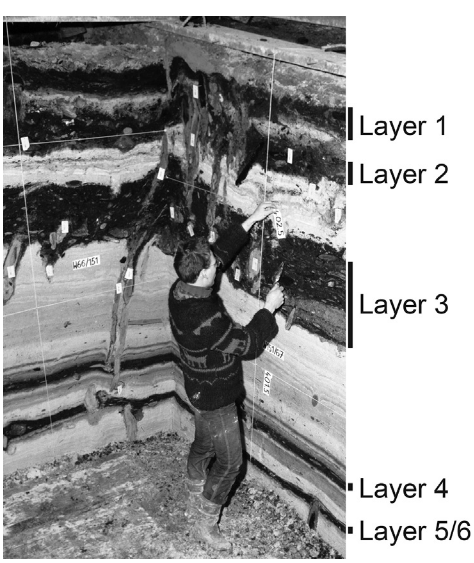

Fig. 2. Stratigraphic sequence of Zurich-Mozartstrasse with vertical wooden post remains visible in the profile. The numbered dark layers represent the settlement occupations while the white layers (lake marl) indicate phases of abandonment during lake transgressions. Each archeological layer differs in thickness within the excavated area. Photograph: Gross et al., 1987, supplemented.

Jacomet, 1999; Jacomet et al., 2004; Billamboz, 2012; Clarke, 2013). Nevertheless, these insights are rather sporadic, and the hinterland of lake dwellings remains a blind spot in many respects, despite its undoubted relevance to subsistence behavior and as potential source of information in the context of regional mobility patterns (e.g. Bleicher, 2009; Ebersbach, 2013).

The analysis of stable isotope ratios in archeological mammal bones is a promising tool for complementing archeological research of the settlements' hinterland. Carbon isotope analyses have widely been used to distinguish between a diet predominated by plants exhibiting either C_3 or C_4 photosynthetic pathways, and to evaluate the contribution of terrestrial versus marine resources in human diet (e.g. Richards et al., 2006; Fischer et al., 2007; Oelze et al., 2011; Cerling et al., 2013). As $\delta^{13}C$ values for bone collagen extracted from large herbivores are assumed to directly reflect the herbivores' diet, they can also be used as a proxy for vegetation conditions, e.g. the water availability and associated stomatal control, the dominance of specific plant types, or the degree of habitat closure, i.e. canopy (Drucker et al., 2003; Noe-Nygaard et al., 2005; Drucker et al., 2008, 2011; Bonafini et al., 2013; Gąsiorowski et al., 2014; Stevens et al.,

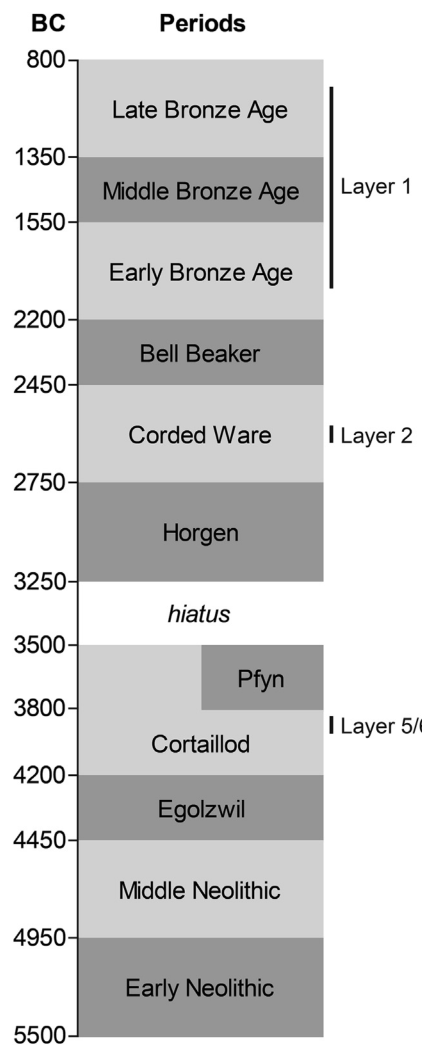

Fig. 3. Chronological scheme for the Neolithic and Bronze Age in Central Switzerland. Simplified after Rychner (1998), Hafner and Suter (2005), Stöckli (2009) and Denaire et al. (2011). Very little is known about the beginning and the end of the Early and the Middle Neolithic. The given numbers are approximations. Additionally, the temporal placement of the sampled archeological layers is shown.

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