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ISOTOPE ANALYSIS OF ANIMAL TEETH FROM THE MAGDALENIAN SITE OF BAD KÖSEN-LENGEFELD

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Fig. 1 Overview from south of the site in Bad Kösen-Lengefeld. Photo taken from the tower of "Burg Saaleck". Clearly visible is the excavation tent in white (Uthmeier 2021a, 15, Abb. 2).

Introduction

The site of Bad Kösen-Lengefeld (see Fig. 1) is dated to the Magdalenian period, a process spreading from roughly 20.000 to 14.000 calBP (Maier 2021, 209). It can be interpreted not only as a hunting station for Hunter-Gatherers, but also as a repeatedly used base camp (Uthmeier 2021 b, 182). It is located in eastern Germany, on a river terrace close to the river Saale. The position of the site between the narrowing valley and potential crossing of ungulate herds offered convenient conditions for the late upper palaeolithic hunters (Uthmeier 2021 a, 13).

As part of an internship at the Max Planck Institute for Geoanthropology in Jena, we examined the teeth of animals from the field site to gain a broader understanding of the environment and climatic conditions as well as changes in diet and mobility. We want to understand the relationship between the different species and their hunters and the rhythm of occupation at the site. In this poster we present the applied method on the samples and want to share our experience while choosing the right teeth. To this day, we are waiting for the results of the measurements, so our questions remain unanswered so far.

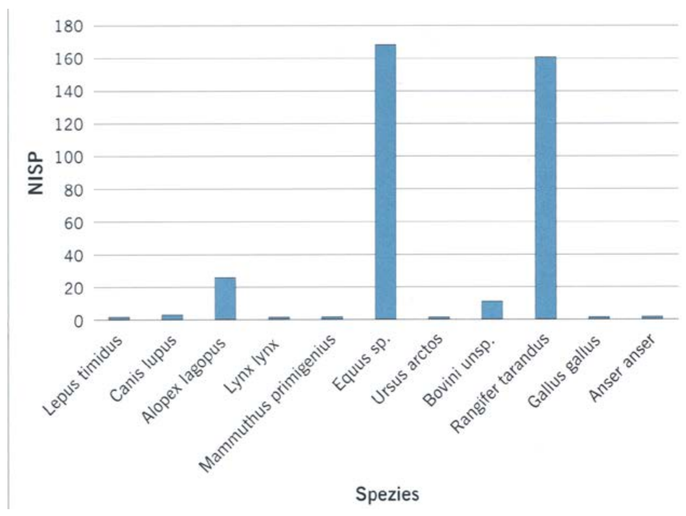

Fig. 2 Species found during the excavation in 2011 in NISP (Puskar 2021, 77, Abb. 3).

Bad Kösen – faunal assemblage

The convenient conditions for palaeolithic hunters on the site are also reflected in the faunal assemblage. Numerous animals have been killed, probably close to the site. The most important hunted game is wild horse (*Equus sp.*) and reindeer (*Rangifer tarandus*), which is a similar situation with most upper palaeolithic sites in middle Europe (Puskar 2021, 73). Next to these ungulates, a great number of foxes, polar foxes (*Vulpes lagopes*) and red foxes (*Vulpes vulpes*), were excavated as well. Other species' remains, such as cattle, bear, wisent, wolf and smaller mammals, have been present in fewer numbers. Tool marks discovered on the bones of horse and reindeer suggest the exploitation (Meindl 2021) and artifact making (Puskar 2021) on-site.

Concluding, the most important prey for palaeolithic Hunter-Gatherers of Bad Kösen-Lengefeld have been wild horses, which have been excavated at the site during the campaigns of 2011 to 2019 in great numbers, closely followed by reindeer. Also the polar fox has presumably been systematically hunted. The other animal remains were probably part of a more random hunt (Puskar 2021). The species found at the campaign in 2011 are visible in Fig. 2.

Isotope analysis

Different variations and abundance of heavy and light isotopes in all ecosystems of earth makes it possible to recreate the climatic conditions of the past and let us track species interactions as well as their diets and migrations (Ben-David/Flaherty 2012). The oxygen

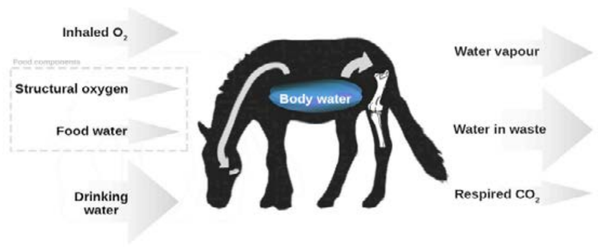

Fig. 3 How the isotopic composition of body water is influenced by the isotopic composition of consumed sources of oxygen (Pederzani/Britton 2019, 81, Fig. 3).

isotope composition in mammalian skeletal tissues for example, is heavily influenced by body water which is influenced by the oxygen isotopic composition of food sources (Pederzani/Britton 2019). The most important driver of skeletal tissue $\Delta^{18}O$ is precipitation, which varies in oxygen isotopic composition due to several predictable effects such as altitude, latitude, temperature, continentality, precipitation amount, humidity and seasonality (Pederzani/Britton 2019). All these effects need to be considered while analysing the measurement results.

Bioapatite gives an isotopic signature of oxygen influxes during the period of tissue formation, dental enamel forms during the first years of life and does not undergo remodelling (Pederzani & Britton 2019). We chose tooth enamel for our studies, because of its resistance to diagenesis and measurement precision. An example on how isotopes effect the body is shown in Fig. 3.

Sample selection

For the sample selection we chose reindeer and wild horse teeth, to cover a great range of different individuals and to get a picture on the diet of the hunted animals and the environmental conditions in which they lived. For local results also fox teeth were included in the isotope analysis (see Fig. 4).

We deciphered the minimum number of individuals (MNI) by selecting the teeth which were mostly present in the assemblage, from one side of the mammals' mandibular on adult individuals. We wanted to take samples from at least five individuals for the horse and reindeer teeth. Unfortunately it was not possible to find as much preferred bones, so we also included teeth from younger individuals as well as an incisor in one case. With this solution we were able to take samples from six horse-, four reindeer- and three fox individuals. As the bones were mostly in a bad condition regarding the preservation, we chose a few more teeth from the same individual if possible. Additionally we took bulk samples from every tooth, in case we did not get enough sampling material from the sequential sampling for the analysis. Especially the fox teeth were too small. All in all, 16 teeth were sampled and we took 91 samples in total.

Fig. 4 EExamples of excavated and to be sampled teeth of horse (A; BK/L 15-888), reindeer (B; BK/L 18-181) and fox (C; BK/L 14-41) from the site.

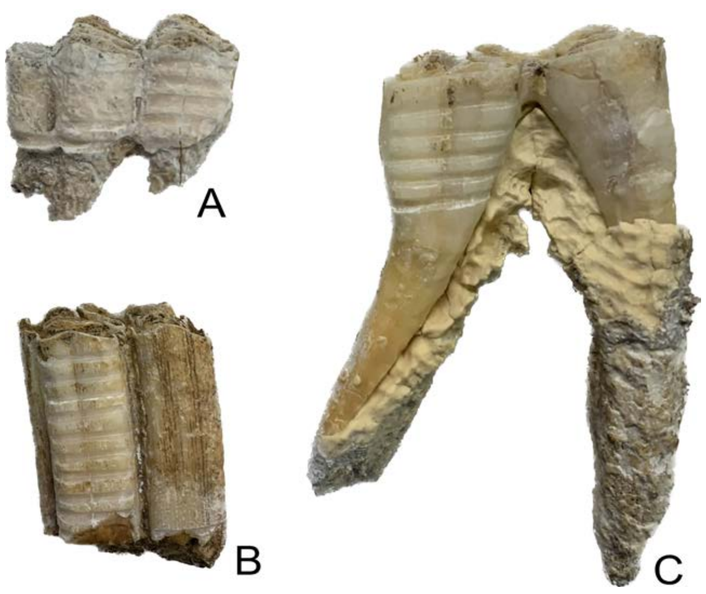

Fig. 5 Sampled teeth from a reindeer M3 (A; BK/L 11-220) and horse P4 (B; BK/L 13-562). Clearly visible is the sequential sampling in 2 mm intervals from top to bottom. A horse P3 (C; BK/L 15-888) shows the heavily presence of calculus, which was removed with the sand blaster.

Fig. 6 Picture of Janos Puschmann (back) and Viktoria Fries (front) during the pre-treatment of the samples.

Method

The method used for the treatment of the samples was assigned to us by the staff of the laboratory and was conducted under close surveillance.

For the isotope analysis the enamel of the teeth is necessary, which is separated by drilling. At first the tooth was cleaned from dirt or calculus.

For sequential sampling the tooth was drilled in horizontal lines from top to bottom, meaning from the older part of the tooth to the more recent built enamel, in approx. 2 mm intervals, until the root of the tooth was reached (see Fig. 5). With small teeth, or teeth in bad preservation, we decreased the intervals, so that we got as much sample material as possible. Additionally we took a bulk sample on every tooth, to get a broader picture for the analysis.

For the pre-treatment (see Fig. 6) the test tubes with the powdered enamel were filled with 1 mL of 0.1 M acetic acid and used shortly with the vortex to mix the contents well, and placed in the centrifuge for 2 min. The waste acid was removed with a pipette and the content of each micro-centrifuge tube was rinsed with MilliQ water three times in total. As much of the remaining solution as possible was removed and the tubes have been stored in the freezer for 24 hours. At last the samples were freeze-dried for four hours.

The final step for the treatment of the samples is the weighing process: 3.0 - 3.5 mg of the freeze-dried solution was taken from the micro-centrifuge tubes and placed in glass tubes for the coming isotope analysis in the mass spectrometry. We are currently waiting for the results.

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