"KISKEVÉLY KNIVES" INDICATE THE MENU OF ALPINE CAVE BEARS

COMPARATIVE STUDIES ON WEDGE SHAPED DEFECTS OF CANINES AND INCISORS

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Abstract

"Kiskevély knives" are canines of cave bears with typical lesions which are possibly grinding marks. These modified teeth were originally interpreted as artefacts. Later it was recognized that these marks on canines, but also on incisors, ("wedge shaped defects") were most likely caused by pulling out grass while feeding. This study shows the relation between the frequency of grinding marks and the altitudes of cave bear sites. The analysis of 15 cave bear faunas from Alpine sites of different altitude brought surprising results.

Samenvatting

"Kiskevély messen" zijn hoektanden van grottenberen met typische krassen die waarschijnlijk maalsporen zijn. Deze afwijkende tanden werden aanvankelijk gezien als artefacten. Later is herkend dat deze sporen op hoektanden, maar ook op snijtanden, ("wigvormige defecten") zeer waarschijnlijk zijn veroorzaakt door het uittrekken van gras tijdens het eten. Deze studie toont het verband tussen frequentie van maalsporen en hoogte boven zeeniveau van de sites. De analyse van vijftien grottenbeerfauna's van Alpine sites van verschillende hoogtes bracht verrassende resultaten.

INTRODUCTION

What are "Kiskevély knives"?

Theodor Kormos (1916) discovered cave bear canines in a small cave at Kiskevély near Budapest, which showed grinding marks and polished surfaces on crown and root. These grinding marks run from the top to the basis of the crown and can reach as far down as the root. He named these canines "Kiskevélyer Klingen" (Kiskevély knives) and assumed that palaeolithic humans formed them to use as tools.

What are "wedge shaped defects" ?

Horizontal notches on the bases of the crowns of incisors and canines have long been known in human dental medicine (Breuer, 1933). In humans these defects are produced by improper horizontal scrubbing with a toothbrush. They develop in the dentin on the base of the crown, but can also damage the enamel above. These notches are named wedge shaped defects or interproximal grooves.

Richard Breuer (1933) assumed that the tool thesis of Kormos was wrong. He proposed the idea that the "Kiskevély knives" and wedge shaped defects on the incisors and canines are the result of the food supply of cave bears. In his opinion, these defects were probably caused by grazing (pulling grass through the teeth gapes). The prehistorian Rudolf Feustel (1969) reaffirmed the opinion that the wedge shaped defects and the "Kiskevély knives" are naturally arisen.

Our new study

The motivation to conduct the new study originated from the presumption that there is a relation between the frequency of grinding marks and the altitude of cave bear sites (Gockert & Rabeder, 2015).

This study should clarify how the nutrition of the cave bears, which probably depends on the altitude of the cave, affects the grade of the abrasion on incisors and canines. Unlike today it is most likely that the nutrition consisted of soft herbs in higher altitudes, which left no traces on the teeth of the bears, while grass was dominant in lower altitudes. Grass contains little crystals, so called phytoliths, which are harder than the dental enamel of the bears. It is possible that the grass nutrition caused this dental abrasion, while the herb nutrition did not.

Terminology

We use the hypernom grinding marks for "Kiskevély knives" and wedge shaped defects of canines and incisors.

METHOD

1. The number of present adult teeth (with closed roots) was taken.
2. The number of canines and incisors with grinding marks was taken; only grinding marks with loss of substance of dentin and/or enamel were evaluated, teeth with polished surfaces without loss of substance were not used for the analysis.
3. Calculation of the percentage of teeth with grinding marks divided into canines and incisors. Canines and incisors present in too small numbers (n <20) were

excluded from the analysis: Drachenloch, Mixnitz (too little incisors), Lieglloch (too little canines, s. tab.1-2).

4. Comparison of the relations between frequency of grinding marks and altitude of sites in diagrams and trend lines.

5. Comparison to trend lines of other ecological factors.

For this analysis canines and incisors from Alpine cave bear faunas are present in sufficient quantity.

MATERIAL

Table 2 shows the number of usable teeth per site and the percentage of teeth with grinding marks. The materials used here are stored in the collections of Institute of Palaeontology of University Vienna, Natural History Museum Vienna, Oberösterreichisches Landesmuseum Linz (Austria) and Naturmuseum St. Gallen (Switzerland).

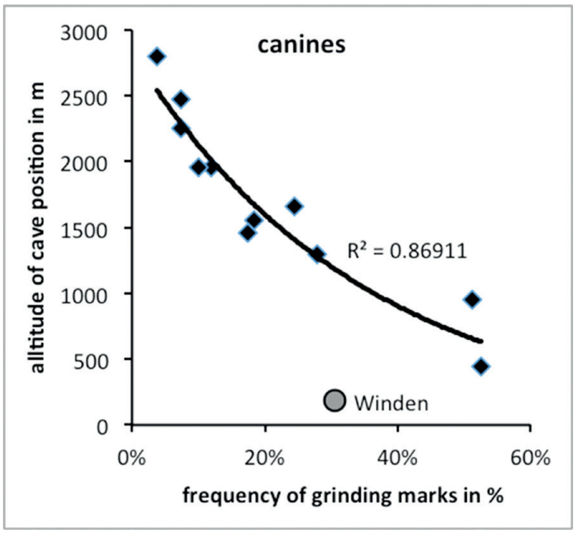

Figure 1: Scatter diagram and trend line of frequency of "Kiskevély knives" of Alpine cave bear faunas. Note the exceptional position of the canines of Winden cave

Figuur 1: Spreidingsdiagram en trendlijn van frequentie van "Kiskevély knives" van Alpine grottenbeerfaunas. Opvallend is de positie van de hoektanden uit de Windengrot

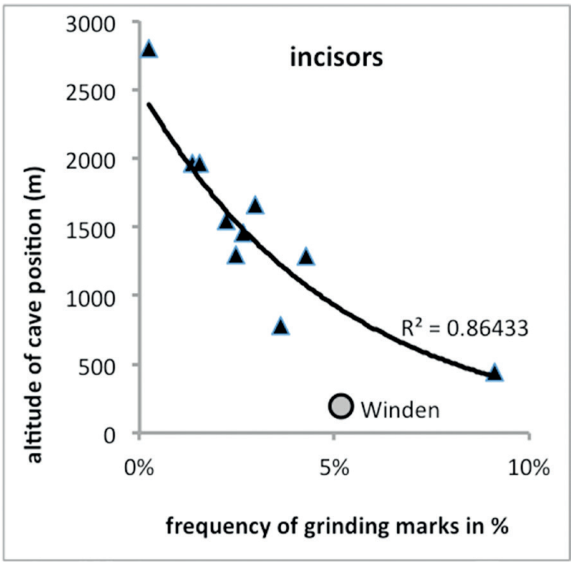

Figure 2: Scatter diagram and trend line of frequency of wedge shaped defects of Alpine cave bear faunas. Note the exceptional position of the canines of Winden cave

Figuur 2: Spreidingsdiagram en trendlijn van frequentie van wigvormige defecten van Alpine grottenbeerfaunas. Opvallend is de positie van de hoektanden uit de Windengrot

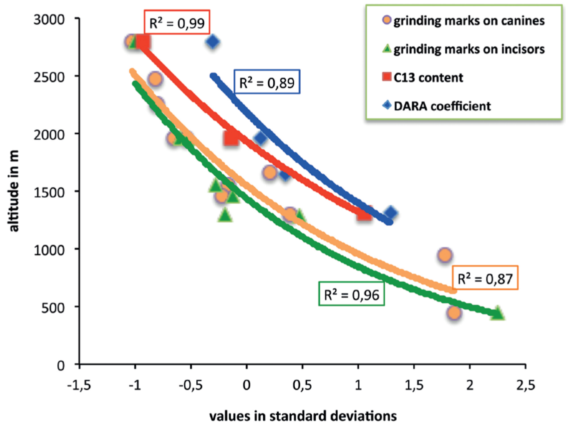

Figure 3: Comparison of trend lines of four ecological indices of Alpine cave bear faunas: frequency (%) of grinding marks on canines; frequency (%) of grinding marks on incisors; C13 δC13/C12 contents (0/00) of bone collagen; DARA coefficient of dental abrasion rate analysis. All volumes are standardized by standard deviation and centralized

Figuur 3: Vergelijking van trendlijnen van vier ecologische indicatoren van Alpine grottenbeerfaunas: frequentie (%) van maalsporen op hoektanden; frequentie (%) van maalsporen op snijtanden, C13 δC13/C12 gehalte (0/00) van botcollageen; DARA coëfficient van tandslijtagegraad (abrasie) analyse. Alle gegevens zijn gestandariseerd naar standaardafwijking en gecentraliseerd

RESULTS

The values in table 2 reveal that the frequency of teeth with grinding marks are very different. The relation between the frequency of grinding marks and the altitude of the caves is shown in figure 1 for the canines and figure 2 for the incisors.

The following statements can be made:

- The frequency of "Kiskevély knives" and wedge shaped defects are correlated to the altitude of cave bear sites;
- The frequency patterns of incisors and canines are similar.
- These correlations are not dependent on the taxonomic position of cave bears;
- The trend "the higher the cave the better the food supply" will be confirmed by the DARA-method and C13-method: bears from caves in higher altitudes had more energetic and soft plant food available than bears from lower sites;
- The correlations are highly significant: coefficient of determination $R^2 > 0,85$;
- The teeth from Winden cave show a notable exception: in both categories the percentage of grinding marks are far below expectations. Compared to alpine faunas the values of Winden cave correspond to faunas which would be found in altitudes of around 1000m above sea level.

COMPARISON WITH OTHER ANALYSES

DARA (Dental abrasion rate analysis)

The wear stages of molars are correlated with the ontogenetic ages (Holland & Rabeder, 2012). The intensity of attrition is determined by the width of the abrasion area at the m1- hypoconid (first lower molar), and the ontogenetic age by counting the cementum increments (annuli) of the root. The values show

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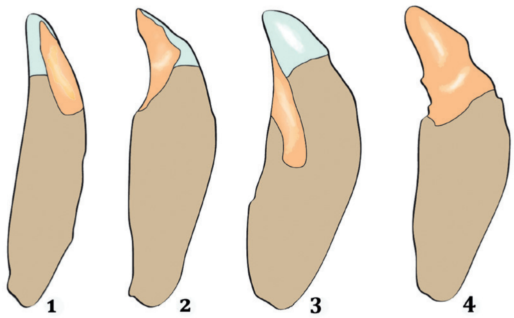

Figure 4: Schematic drawing of "Kiskevély knives" (cave bear canines with grinding marks): 1) C sup. with mesial grinding mark; 2) C inf. with distal grinding mark; 3)C inf. with distolingual grinding mark; 4) C inf. with annular grinding mark
Figuur 4: Schematische tekening van „Kiskevély knives" (hoektanden van grottenberen met maalsporen): 1) C sup. met mesiaal maalspoor; 2) C inf. met distaal maalspoor; 3) C inf. met distolinguaal maalspoor; 4) C inf. met annulair maalspoor

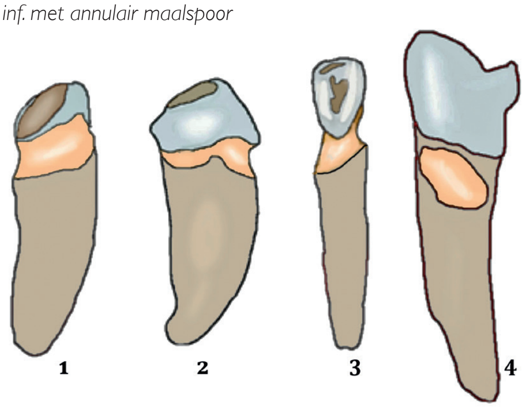

Figure 5: Schematic drawing of edge shaped defects on cave bear incisors. 1) & 2) second incisors of upper jaw with lingual and distal grinding marks; 3) first incisor of lower jaw with annular grinding mark; 4) third incisor of lower jaw with labial grinding mark
Figuur 5: Schematische tekening van wigvormige defecten op snijtanden van grottenberen. 1) & 2) tweede snijtand uit bovenkaak met linguale en distale maalsporen; 3) eerste snijtand uit onderkaak met annulair maalspoor; 4) derde snijtand uit onderkaak met labiaal maalspoor

a linear correlation: the area of attrition on the m1 inf talonid increases evenly with age. Major differences emerge when comparing the grades of attrition of cave bear faunas from various altitudes. The so-called DAR coefficient (C_{DAR}) shows the degree of abrasion, which is equivalent to the inclination of the trend line of a fauna. The higher the value of the C_{DAR}, the lower the altitude of the site. Four alpine cave bear faunas (from Conturines, Ramesch, Ochsenhalt and Gamssuzen cave) were analyzed with this method and these analyses show a negative correlation between the grade of abrasion and the altitude: the higher the sites are, the lighter the abrasion on the occlusal surface of the molars. The diet of the bears from the lower caves was tougher (silicate-rich grasses with phytoliths) than the herb-based diet in high-altitude sites (Holland & Rabeder, 2013).

C13 content

The carbon ratio C13/C12 in fossil bones can be used to draw conclusions on the composition of the diet. The more "stressed-out" plants are, the higher the C13 values. Today the C13 content of herbivore animals and the vegetation of the Alps increases with the altitude (Männel *et al.*, 2007), because the plants above the tree line are more exposed to heat, frost damage and aridity than the plants in the forest.

During the era of the cave bears (65,000 to 29,000 BP) the trend of C13 values was reversed (Bocherens *et al.*, 2011; Horacek *et al.*, 2012; Kajcarz *et al.*, 2015): the higher the altitude of the cave, the lower the C13 content. This phenomenon can be explained by a larger percentage of grass in the diet of cave bears at lower altitudes.

CONCLUSIONS AND HYPOTHESES

The accordance in the trends of C13 content, grinding marks and DAR-coefficient (figure 3) allows for the following conclusions:

1. From the close correlation of grinding marks on the teeth and altitude of the sites it is concluded that the defects depend on the food supply;

2. The vegetable diet consists of more energetic plants (more herbs) with fewer phytoliths at sites in higher altitudes. The diet of bears at lower altitudes contains more phytoliths which caused these defects on the teeth;

3. During the era of the cave bears (65,000 to 29,000 BP) the conditions in the higher mountains (1200 to 1800m) were significantly better than in areas below 1000m: energy-rich herbs and leaves of deciduous trees offered optimal nutrition, while at lower altitudes the cave bear had to switch to a grass-rich diet because of the progressive desertification due to reduction in rainfall. Loess deposits in the Alpine lowlands show the increasing desertification from 50,000 BP onward (Nigst *et al.*, 2014; Döppes & Rabeder, 1997).

4. A design of a climate model for the Alps in the Middle Wurmian shows that summer temperatures must have been much higher than present, otherwise the cave bear would not have had sufficient food available in the areas of the caves in altitudes over 2000m. The second half of the Middle Wurmian (from 50,000 BP) was characterized by gradual desertification, indicated by large loess profiles in the northern Alpine lowlands. The profile of Willendorf (Nigst *et al.*, 2014) is particularly well dated. Here the accumulation of loess starts at about 50,000 BP supported by a molluscan fauna, which, beside thermophile species, is characterized by elements of an open landscape. Within the profile these molluscs are an indicator for the progressive desertification. Only later a decline in temperature took place (Döppes & Rabeder, 1997). The reduction in rainfall probably had an impact on the Alpine areas below 1000m, where grasses dominated the open landscape. The regions between 1200 and 1800m benefitted from higher precipitation and the cave bears were able to find enough energy-rich herbs and leaves on the wooded slopes.

5. The bear cave of Winden is very special. This small cave, that was very rich in findings, is geologically located within the Alps but the low altitude of only 190m and the hilly terrain obviously offered advantageous nutritional conditions to the cave bears comparable with those of the Alpine caves above 1300m.

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cave name	taxon of Ursus	mountains	county, region, Kanton	state	altitude (m)	references
Arzberghöhle	U. ingressus	Hochschwab	Steiermark	A	735	1
Brettsteinhöhle	U. s. eremus+U. ladinicus	Totes Gebirge	Steiermark	A	1660	2,4,5
Brieglersberghöhle	U. ladinicus	Totes Gebirge	Steiermark	A	1960	2,3
Conturines	U. ladinicus	Dolomites	South Tyrol	I	2800	12,13
Drachenloch	U. spel. eremus	Glarner Alpen	St. Gallen	CH	2475	11
Gamssulzenhöhle	U. ingressus	Totes Gebirge	Upper Austria	A	1300	2,6
Hartelsgrabenhöhle	U. ingressus	Gesäuse	Steiermark	A	1230	2,7
Liegloch	U. ingressus	Totes Gebirge	Steiermark	A	1290	2,8
Merkensteinhöhle	U. ingressus	Wienerwald	Lower Austria	A	441	2
Mixnitz, Drachenhöhle	U. ingressus	Grazer Berg-land	Steiermark	A	949	2,9
Ochsenhalthöhle	U. spel. eremus	Totes Gebirge	Steiermark	A	1650	10
Ramesch-Knochen-höhle	U. spel. eremus	Totes Gebirge	Upper Austria	A	1960	2
Schreiberwandhöhle	U. spel. eremus	Dachstein	Oberöster-reich	A	2250	2
Wildkirchli	U. s. eremus + U. ingressus	Säntis	Appenzell	CH	1477	11
Windener Bärenhöhle	U. ingressus	Leithagebirge	Burgenland	A	190	2

Table 1: List of cave bear sites
Tabel 1: Lijst met vindplaatsen van grottenberen
References: 1 Fassl & Rabeder, 2015; 2 Döppes & Rabeder, 1997; 3 Rabeder et al., 2005; 4 Rabeder et al., 2001; 5 Alscher et al., 2015; 6 Rabeder, 1997; 7 Rabeder, 2005; 8 Rabeder & Pacher, 2007; 9 Frischauf et al., 2014; 10 Frischauf, 2010; 11 Pacher et al., 2014; 12 Rabeder et al., 2006; 13 Horacek et al., 2012

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