

Cave bear cubs (*Ursus spelaeus eremus*) from the Potentialschacht at the Hochschwab massif (Styria, Austria)

Nadja Kavcik-Graumann¹, Federica Alberti², Doris Döppes³, Ronny Friedrich⁴, Susanne Lindauer⁴, Lukas Plan⁵, Julia Stockhammer¹, Gerhard Withalm¹ & Gernot Rabeder¹

¹ University of Vienna, Department of Palaeontology, Geozentrum/UZAll, Althanstraße 14, 1090 Vienna, Austria

² University of Potsdam, Institute for Biochemistry and Biology, Karl-Liebknecht-Straße 24-25, 14476 Potsdam, Germany

³ Reiss-Engelhorn-Museen, Zeughaus, C5, 68159 Mannheim, Germany

⁴ Curt-Engelhorn-Centre Archaeometry, C4/8, 68159 Mannheim, Germany

⁵ Natural History Museum, Burgring 7, 1010 Vienna, Austria

✉ nadja.kavcik@univie.ac.at



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office@museumgolling.at
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Hochschwab | cave bear cubs | morphology of the teeth | DNA analysis | ¹⁴C data
Hochschwab | juvenile Höhlenbären | Morphologie der Zähne | DNA Analysen | ¹⁴C Datierung

Abstract: On the Hochschwab karst massif in the east of the Northern Calcareous Alps (NCA), the remains of four cave bear cubs were found in the subvertical cave Potentialschacht that opens at 2,070 m a.s.l. There is severe pathology on two individually related mandibular fragments that indicate that the cubs could have fallen into the cave through narrow gaps. There are no remains of adult bears, however. According to the morphology of the teeth, DNA analysis and ¹⁴C data, these juvenile bones and teeth belong to *Ursus spelaeus eremus*, which lived here at least from 46,000 to 39,000 years before present. This proves that all large plateaus of the NCA were inhabited by cave bears of *Ursus spelaeus* group during the so-called »Cave Bear Era« of the middle Late Pleistocene. It will be discussed, which palaeoclimatological conclusions can be drawn from it.

Kurzfassung: Im Hochschwab-Karstmassiv im Osten der Nördlichen Kalkalpen (NKA) wurden die Überreste von vier Höhlenbärenjungern im subvertikalen Potentialschacht gefunden, der sich auf 2.070 m ü. M. öffnet. An zwei individuell zusammenhängenden Unterkieferfragmenten finden sich schwere Pathologien, die darauf hinweisen, dass die Jungtiere durch enge Spalten in die Höhle gefallen sein könnten. Es gibt jedoch keine Überreste von erwachsenen Bären. Anhand der Morphologie der Zähne, der DNA-Analyse und der ¹⁴C-Daten gehören diese juvenilen Knochen und Zähne zu *Ursus spelaeus eremus*, der hier mindestens 46.000 bis 39.000 Jahre vor heute lebte. Dies beweist, dass alle großen Plateaus der NKA während der so genannten »Höhlenbären-Ära« des mittleren Spätpleistozäns von Höhlenbären der *Ursus spelaeus*-Gruppe bewohnt waren. Es wird erörtert, welche paläoklimatologischen Schlussfolgerungen daraus gezogen werden können.

Introduction

The Potentialschacht (Austrian cave register no. 1744/475) is a shaft cave in the East of the Hochschwab massif, about 750 m NW of the Hochschwab peak (2,277 m), community Sankt Ilgen (Styria). The shaft entrance (Fig. 1) in 2,070 m.a.s.l. opens at the transition of the karst plateau to the steep abysses into the Salza valley to the North (Fig. 2a). The cave, which is 2,329 m long and 107 m deep, was formed under phreatic conditions. It is heavily deformed and accessible only via a sequence of shafts and narrow canyons (PLAN & BARON, 2021). This present-day entrance had to be widened to allow passage into the cave and it is almost impossible that the bears entered the cave through this entrance. They probably entered the cave through openings that are blocked today.

The cave was explored by members of the Speleological Society of Vienna and Lower Austria from 2005 to 2019. At a depth of about 60 m below the entrance, the remains of juvenile bears were found between large boulders in the so-called »Bärenhalle« (Bear Hall). Further finds of young bears were discovered at two other sites. The fossils were found at secondary sites in a mixture of clay and debris (Fig. 2b).

Material

The collected bones and teeth originate from very young bear cubs. Only in one individual the bones of the skull are partially fused, from another individual the sutures are still open. Only the diaphyses of the long bones are preserved, because no fusion

with the epiphyses had taken place. Minimum number of individuals (MNI = 4): Based on the number of three left mandible halves and six ulna fragments, at least three individuals are proven. A left isolated m1 inf that does not match any of the mentioned mandibles increases the number to four.



Fig. 1: Entrance to the cave »Potentialschacht« at the northern edge of the Hochschwab plateau at 2,070 meters above sea level (Photo: L. Plan). | Abb. 1: Eingang in den Potentialschacht auf dem nördlichen Hochschwab-Plateau auf einer Seehöhe von 2.070 m (Foto: L. Plan).

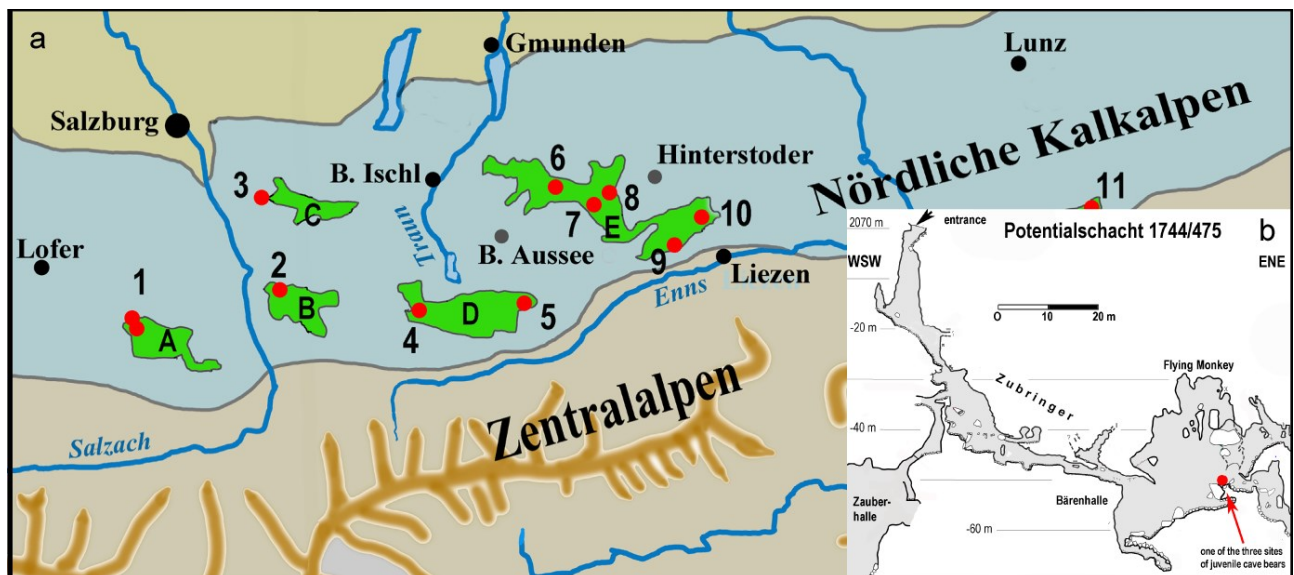


Fig. 2: a: Schematic map sketch of the Northern Calcareous Alps (eastern part) with the large karst plateaus and their bear caves, from left to right: A: Steinernes Meer, 1: Hennenkopf cave (2,070 m) and Schneiber cave (2,300 m), B: Tennengebirge, 2: Bärenfalle (2,100 m), C: Osterhorngruppe, 3: Schlenkendurchgangshöhle, D: Dachsteingebirge, 4: Schreiberwand cave (2,250 m), 4: Schottloch (1,980 m), E: Totes Gebirge, 6: Salzofen (2,005 m), 7: Brettstein-Bärenhöhle (1,660 m), 8: Brieglersberg cave (1,960 m), 9: Ochsenhalt cave (1,650 m), 10: Ramesch-Knochenhöhle (1,960 m), F: Hochschwab plateau, 11: Potentialschacht (2,070 m). b: Vereinfachter Längsschnitt des Potentialschachts, vom Eingang zur Fundstelle in der »Bärenhalle«. Nach einem Höhlenplan des Landesvereins für Höhlenkunde in Wien und Niederösterreich. Zeichnung: L. Plan, P. Oberender, B. Funk.

Ontogenetic age

All three bear cubs, from which bones and teeth were found, were approximately the same age at their death. This can be concluded – in comparison to extant brown bear – from the stages of tooth change. In all eight preserved jaws (five lower and three upper halves) only one tooth (m1 inf or M1 sup) of the permanent dentition is already in the correct position in the jaw and has already formed roots. The other molars (m2 inf, M2 sup and m3 inf) are still tooth germs and partly hidden deep in the jaw. The incisors and premolars of the permanent dentition are only recognizable as their tips look out. On the isolated teeth, the roots are developed only in germs. Compared to present-day brown bears, the ontogenetic age of all four individuals can be estimated at 5 to 8 months (Guskov, 2015). All other bones and teeth also correspond to this age. There is no trace of older bears.

Dimensions of bear remains

The mean values of the standardized length and width values are 7–9 % below the standards of *Ursus ingressus* from the Gamssulzen cave (RABEDER, 1999) and correspond to the type of a high alpine cave bear, which was also called »high alpine small form«, sensu Ehrenberg. There is a positive correlation between the dimensions of the cave bear teeth and the height of the sites for *Ursus ingressus*, and a negative correlation for the subspecies of *Ursus spelaeus* (RABEDER et al., 2008). In comparison with other alpine and extra-alpine cave bear faunas, the Potentialschacht (PS) lies in the common cluster of *Ursus s. eremus* and *U. s. ladinicus*. Despite the small number of specimens, the bear remains from the Potentialschacht correspond in size to cave bears from other cave bear faunas that originate from a similar elevation (Fig. 3), e.g., Bärenfalle (KRUTTER et al., 2020), Hennenkopf cave (STOCKHAMMER, 2020) and Salzofen cave (KÖNIG, 2019).

Geological age

Those, who thought that the four little bears got into the cave by a single accident and could not get out again, were surprised by the absolute dating of three bones (Tab. 1). According to the available data, at least three »accidents« occurred at different times. All dates lie within the time span of the »Alpine Cave Bear Era«, which lasted from about 65,000 to 25,000 years before present (DÖPPES et al., 2018; NAGEL et al., 2018).

Taxonomy

The size of the teeth shows us that the juvenile jaws are from a relatively small-bodied cave bear, typical for high alpine sites. Therefore, an assignment to the species *Ursus ingressus* is not likely. The DNA analysis of a bone (sample PS1) confirms this assignment. The bear remains from the Potentialschacht are from *Ursus spelaeus eremus*.

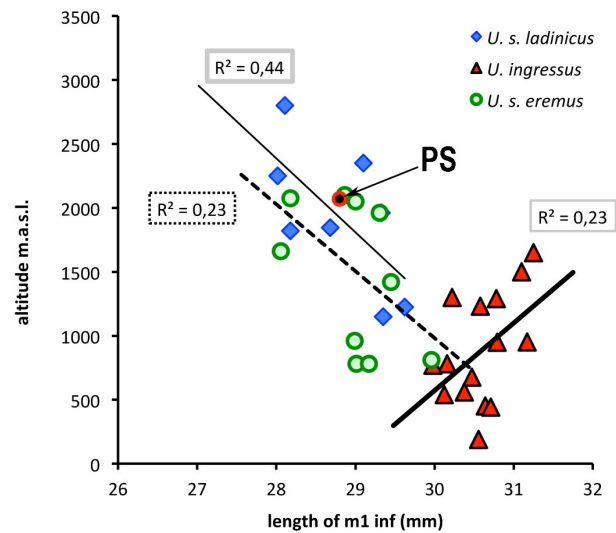


Fig. 3: Comparison of average length of m1 inf of cave bear faunas versus elevation of sites. The value from the Potentialschacht (PS) is in the cluster *U. s. eremus* and *U. s. ladinicus*. | Abb. 3: Vergleich der durchschnittlichen Länge der m1 inf von Höhlenbärenfaunas gegen die Seehöhe der Höhleneingänge. Der Wert des Potentialschachts (PS) liegt im Cluster von *U. s. eremus* und *U. s. ladinicus*.

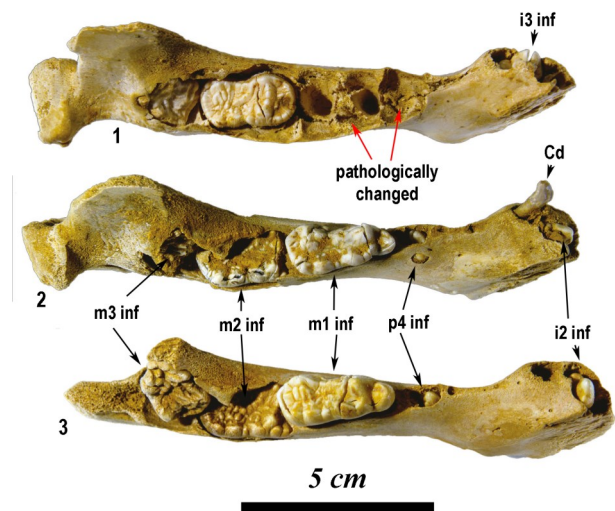


Fig. 4: Three left mandibles (oblique view from medio-occlusal) of juvenile cave bears (*Ursus spelaeus eremus*) from the Potentialschacht. 1 (PSmd-1): mandible with traces of massive inflammation in the area of the first two molars, which probably led to tooth loss. 2 and 3 (PSmd-2 and 5): on both mandibles the m1 is in situ; p4, m2 and m3 were already created but not yet in function (Photos: G. Withalm). | Abb. 4: Drei linke Unterkieferhälften von juvenilen Höhlenbären (*Ursus spelaeus eremus*) aus dem Potentialschacht. 1 (PSmd-1): Unterkiefer mit Spuren einer massiven Entzündung im Bereich der ersten beiden Backenzähne, die wahrscheinlich zum Zahnverlust führte. 2 und 3 (PSmd-2 und 5): Bei beiden Unterkiefern ist der erste Backenzahn (m1) schon am endgültigen Platz, während die übrigen Backenzähne (p4, m2 und m3) bereits angelegt sind, aber noch nicht in Funktion waren.

LabNr.	sample name	element	¹⁴ C age aBP	δ ¹³ C	cal 1-sigma calBP	cal 2-sigma calBP	C:N	C %	collagen %	molecular estimate age aBP (median)	95% HPD interval (aBP)
MAMS-48555	PS2	humerus juvenile	33,800 ± 160	-27.1	39,260–38,684	39,399–38,170	3.3	36.8	7.5	–	–
MAMS-40178	PS1	bone	38,280 ± 230	-30.4	40,630–40,281	40,812–40,108	2.9	36.7	9.4	60,524	49,337–72,164
MAMS-48556	PS6	costa fragment	43,470 ± 470	-27.5	46,221–45,320	46,865–44,945	3.2	44.2	10.1	–	–

Tab. 1: Radiocarbon dates and molecular age of cave bear (*Ursus s. eremus*) bone samples from the Potentialschacht. Radiocarbon calibration was performed using the IntCal20 dataset and OxCal software. | Tab. 1: Radiokarbonaten und Molekularalter von Höhlenbärenresten (*Ursus s. eremus*) aus dem Potentialschacht.

Pathology

Two mandibular halves show pathological changes and were therefore subjected to a detailed examination (Fig. 4). The two mandible fragments belong to one individual, which is evident from the same stage of development of the dentition and the dimensions, as well as from the fact that the two match well at the symphysis. The most interesting piece here is the broken right mandible branch, which presumably suffered a pathological fracture. On both sides of the fracture zones of intensive bone remodelling are recognizable, on one hand by the structural changes of the bone, on the other hand by the increased vascularization. The left mandible also shows pathological changes: the ramus horizontalis is spread linguo-buccally and the p4 inf and the m1 inf are missing. There are no convincing reasons to assume that the reason for this fracture is to be found in a violent inflammation of the p4. Another possible explanation would be trauma, such as can occur in an accident. It can therefore be assumed that the fracture of the right mandible and the pathological changes on the left mandible resulted from a fall.

Discussion

With the new findings in the Hochschwab area, there are now indications from all large karst plateaus of the Northern Calcareous Alps (Fig. 2a) that these plateaus were inhabited by cave bears during the so-called »Cave Bear Era«. Today, these karst plateaus are treeless and partly free of vegetation. The cave bears were highly specialized herbivores, which could master life in high alpine regions only by spending the vegetation-free time of the winter in caves. Their food did not consist of plants of the alpine vegetation but of leaves and herbs of the mixed deciduous forest of the montane vegetation zone. This is shown by the morphology of the teeth, the shape of the jaws, and the values of the ¹³C content of the fossil bones (KRUTTER et al., 2020). The time span in which the plateaus were inhabited by cave bears ranges from »well before 60,000 years ago to about 25,000 years before today« (DÖPPES et al., 2018). From almost all cave bear faunas of the karst plateaus there are DNA analyses that tell us that these cave bears originate exclusively from one of the subspecies of *Ursus spelaeus* (*U. s. eremus* or *U. s. ladinicus*). Alpine caves with remains of *Ursus ingressus* are not found on or at the edge of plateaus, but in slopes below the plateau formations (Gamsulzen cave, Liegloch, Arzberg cave, Torrener

Bärenhöhle; DÖPPES & RABEDER, 1997; FASSL & RABEDER, 2015; RABEDER & PACHER, 2007; DÖPPES et al., 2020) or in the foothills of the Northern Alps (Herdengel cave, Merkenstein cave, Nixloch etc.; DÖPPES & RABEDER, 1997; RABEDER et al., 2018).

References

- DÖPPES, D. & RABEDER, G. (1997): Pliozäne und pleistozäne Faunen Österreichs. Ein Katalog der wichtigsten Fossilfundstellen und ihrer Faunen. – Mitt. Komm. Quartärforsch. Österr. Akad. Wiss. 10: 1-411.
- DÖPPES, D., RABEDER, G., FRISCHAUF, C., KAVCIK-GRAUMANN, N., KROMER, B., LINDAUER, S., FRIEDRICH, R. & ROSENDAHL, W. (2018): Extinction pattern of Alpine cave bears - new data and climatological interpretation. – Historical Biology 31,4: 422-428.
- DÖPPES, D., ALBERTI, F., BARLOW, A., KRUTTER, S., FRIEDRICH, R., HOFREITER, M., LINDAUER, S., KAVCIK-GRAUMANN, N., ROSENDAHL, W. & RABEDER, G. (2020): The Late Pleistocene cave bear fauna of the Torrener Bärenhöhle in the Northern Alps (Salzburg, Austria). – Historical Biology 33,11: 3065-3074.
- FASSL, S. & RABEDER, G. (2015): Die Höhlenbären der Arzberghöhle (1741/4) bei Wildalpen. Neue Daten und Forschungsergebnisse von *Ursus ingressus*. – Mitt. d. Vereines f. Höhlenkunde in Obersteier 32-34: 248-254.
- GUSKOV, V. Y. (2015): Skull-Based Method of Age Determination for the Brown Bear *Ursus arctos* Linnaeus, 1758. – Achievem. Life Sci. 8: 137-141.
- KÖNIG, F. (2019): Die Höhlenbärenreste der Grabung Ehrenberg 1950 – 1964 aus der Salzofenhöhle im Toten Gebirge (Stmk). Teil 2: Backenzähne. – Diplomarbeit Universität Wien.
- KRUTTER, S., FRISCHAUF, C., RABEDER, G., BRANDNER, D., DÖPPES, D., FRIEDRICH, R., LINDAUER, S., ROSENDAHL, W. & STRASSER, W. (2020): Die jungpleistozäne Höhlenfauna der Bärenfalle im Tennengebirge (Salzburg, Österreich). Ergebnisse aus der Forschungskampagne 2015-2017. – Mitteilungen aus dem Haus der Natur 26: 30-50.
- NAGEL, N., LINDENBAUER, J., KAVCIK-GRAUMANN, N. & RABEDER, G. (2018): Subtropical steppe inhabitants in the Late Pleistocene cave faunas of Eastern Middle Europe. – Slovenský Kras, Acta Carsologica Slovaca 65,1: 99-110.
- PLAN, L. & BARON, I. (2021): Der Potentialschacht im Hochschwab (1744/475). – Höhlenkundliche Mitteilungen Wien 77, 7-8: 137-147.

- RABEDER, G. (1999): Die Evolution des Höhlenbärengebisses. — Mitteilungen der Kommission für Erdwissenschaften der Österreichischen Akademie der Wissenschaften 11: 1-102.
- RABEDER, G., DEBELJAK, I., HOFREITER, M. & WITHALM, G. (2008): Morphological response of cave bears (*Ursus spelaeus* group) to high-alpine habitats. — Die Höhle 59, 1-4: 59-70.
- RABEDER, G., DÖPPES, D., LINDAUER, S., FRIEDRICH, R., KROMER, B., ROSENDAHL, W. & PACHER, M. (2018): Die systematische und chronologische Stellung der Bären aus der Merkensteinerhöhle. — Wiss. Mitt. Niederösterr. Landesmuseum 28: 9-52.
- RABEDER, G. & PACHER, M. (2007): Neue paläontologische Forschungsergebnisse aus dem Lieglloch. — Mitt. d. Vereines f. Höhlenkunde in Obersteier, 25-26: 158-165.
- STOCKHAMMER, J. (2020): Die fossilen Bären der Hennenkopfhöhle im Steinernen Meer (Land Salzburg). — Diplomarbeit Universität Wien.