



Small fossil wolverine *Gulo* from Middle Pleistocene of Poland

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Abstract. Fossil wolverine remains were excavated in Deszczowa Cave (southern Poland). The oldest specimens were found in layers I and III, related to Saalian Glaciation (OIS 6). These are: a skull fragment with upper carnassial; another skull fragment with upper incisor; and a loose upper canine. The measurements of the upper carnassial (buccal length = 19.5 mm, width = 11.8 mm) indicate a small sized *Gulo*. It may be concluded that a small form of wolverine, typical for warm periods according to Bergmann's rule and known from late Middle Pleistocene sites of Europe and North America, was also present in Poland before the Last Glaciation. It cannot be excluded that specimens from Deszczowa Cave represent the *G. schlosseri* species or an intermediate form between *G. schlosseri* and *G. gulo*.

Key words: *Gulo gulo*, *Gulo schlosseri*, Bergmann's rule, Deszczowa Cave, southern Poland.

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I. INTRODUCTION

Genus *Gulo* (wolverines) consists of several species, at least: *G. gulo* (LINNAEUS, 1758) from late Middle Pleistocene to Holocene, *G. schlosseri* KORMOS, 1914 from Early and early Middle Pleistocene and *G. minor* SOTNIKOVA, 1982 from Pliocene. However some authors prefer to distinguish additional species-level taxa, like: *G. gidleyi* HALL, 1936 from Middle Pleistocene, of North America (GIDLEY & GAZIN 1938), *G. spelaeus* GOLDFUSS, 1818 from Middle and Late Pleistocene of Eurasia (ŞTIUCĂ 1993), and recent *G. luscus* (LINNAEUS, 1758) or *G. hylaeus* ELLIOT, 1905 from North America (ELLIOT 1905; HALL & KELSON 1959; ŞTIUCĂ 1993). In opposition of this there exists a thesis that all wolverines from Middle Pleistocene, Late Pleistocene, Holocene and the recent should be regarded as a single species, *G. gulo* (BRYANT 1986). Irrespective of the taxonomic nomenclature, it is beside any doubt that there occurred distinguishable size forms of wolverines in the past (KURTÉN 1973; BRYANT 1986; ŞTIUCĂ 1993; DÖPPES 2001).

Some wolverine remains were found in Deszczowa Cave (Kraków-Częstochowa Upland, southern Poland, GPS coordinates: 50°35'15"N 19°32'34"E), during the archaeo-

logical explorations conducted in years 1992-1994 (CYREK et al. 2000). Deszczowa Cave is a small fissure-like cavern located on the east slope of the limestone hill Popielowa Góra, about 15 m above the valley bottom, with eastern entrance exposure. The sediments consist mainly of fine and medium grained sands (Fig. 1), a typical feature of cave sediments from that part of the Kraków-Częstochowa Upland. The sediments were initially attributed to Last Glaciation (Weichselian, often called 'Vistulian' in Poland) and Holocene (CYREK et al. 2000). Later, NADACHOWSKI et al. (2009) presented a new age interpretation, based on the fossil fauna, mainly of rodents. NADACHOWSKI et al. connected the lower part of the profile (layers I-IV) with Penultimate (Saalian) Glaciation (OIS 6). KRAJCARZ and MADEYSKA (2010) presented a slightly modified version of stratigraphy, based on the analysis of weathering parameters. They identified the Eemian layer (OIS 5e, layer IV) and layers from Penultimate Glaciation (I-III, Fig. 1).

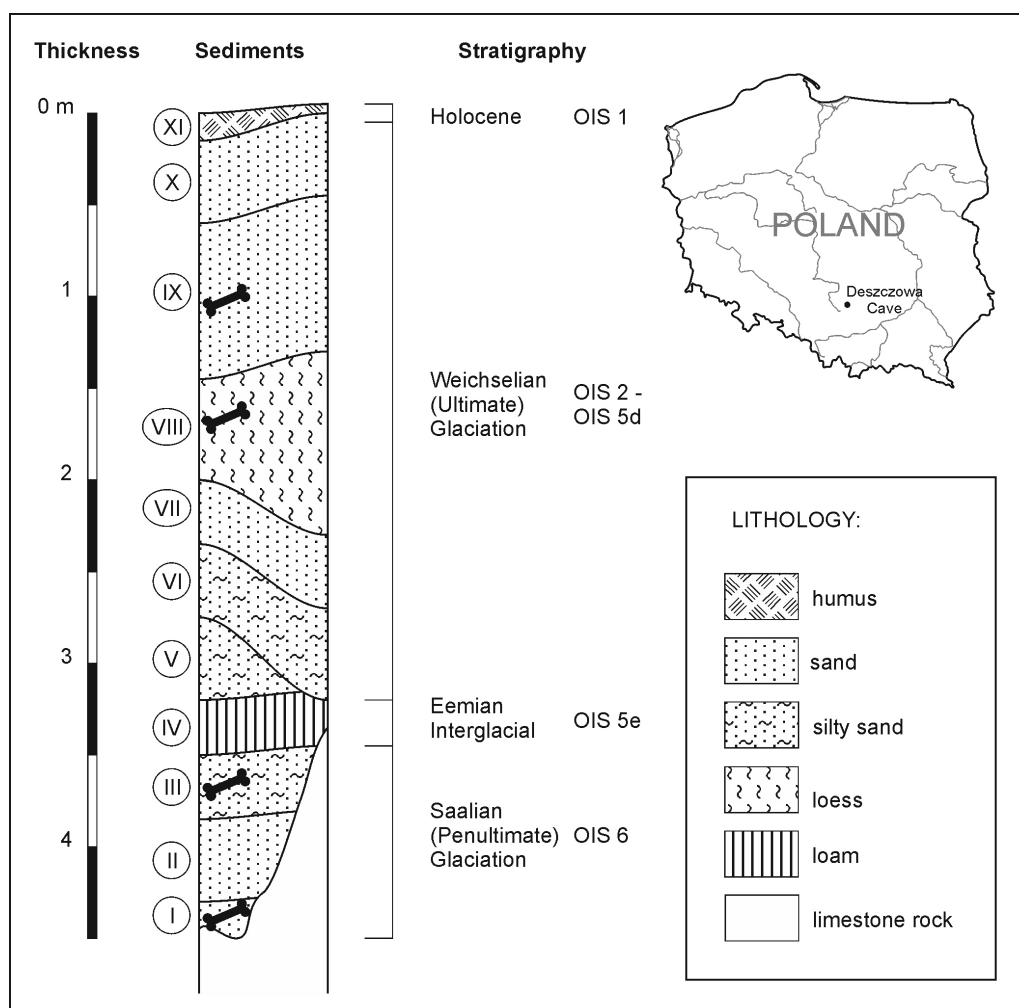


Fig. 1. Localization of Deszczowa Cave and profile of sediments; layers with wolverine findings are marked with black bones. Roman numerals in circles are the numbers of layers according to CYREK et al. (2000); stratigraphy after KRAJCARZ and MADEYSKA (2010).

II. MATERIAL AND METHODS

The wolverine remains were found in Deszczowa Cave in four layers: I, III, VIII and IX. Remains include 14 bones (three of them with teeth) and one loose tooth. Only three specimens come from the lower layers (I and III) and are the subject of this paper. They are: a bone fragment with upper carnassial; another bone fragment with upper incisor; and a loose upper canine. The material is stored at the Institute of Systematics and Evolution of Animals, Polish Academy of Sciences, Kraków, Poland (ISEA PAS). Collection numbers of the remains are: ISEA MF/4050, ISEA MF/4051, and ISEA MF/4052.

The measurements were conducted only on teeth. The methods follow VON DEN DRIESCH (1976) and WÓJCIK (1974), the measurement definitions are shown in table I. Each measurement was taken with accuracy of 0.1 mm. Measurements were repeated three times, then the mean value was calculated and presented as a result (rounded to the nearest 0.1).

III. RESULTS

Only one specimen was found in layer I. It is a left upper canine (*C sin.*, Fig. 2: A1, A2), inventory number ISEA MF/4050. The preservation state is bad, the tooth is cracked and the proximal part of root is missing. The crown is worn, with a transverse rubbed plate, and approximately $\frac{1}{4}$ of its primary height is lost, which indicates a senile animal. Measurements are shown in Table I.

Two wolverine specimens were excavated from layer III. They both consist of skull fragments with teeth. One specimen is a fragment of premaxilla with third right incisor (*I3 dext.*), inventory number ISEA MF/4051 (Fig. 2: B1, B2). The whole tooth is preserved and its preservation state is good.

The second specimen is a maxilla fragment with left carnassial (*P4 sin.*) and a small fragment of P3 root and proximal part of a crown, inventory number ISEA MF/4052 (Fig. 2: C1, C2, C3). Carnassial is whole and well preserved, however the enamel is slightly cracked. P3 is fragmentary and not suitable for measuring. The measurements of incisor and carnassial are shown in Table I.

Although P3 is poorly preserved, it may be seen that there is no diastema between P3 and P4. This feature makes the fossil specimen similar to the modern and Late Pleistocene *G. gulo* (BONIFAY 1971; see also: PALES & GARCIA 1981: plate 24; PULLIAINEN 1993: fig. 154; DÖPPES 2001: fig. 3; MARCISZAK & KOVALCHUK 2011: fig. 2) and to the Middle Pleistocene *G. gidleyi* from North America (see GIDLEY & GAZIN 1938: figs. 19, 20), but different from *G. schlosseri* from L'Escaie (BONIFAY 1971). Carnassial is massive. Paracone is high and massive, with cingulum on its mesiobuccal side. Metacone is low and wide, without cingulum on its buccal side, like the specimen from L'Escaie. Cingulum is present on lingual side of metacone, where it forms a crest. Parastyle is small but distinctly stands out. The niche between parastyle and protocone has wide arcuate shape and in occlusal view the mesial margin of protocone forms an obtuse angle with the lingual margin of parastyle. Similar features may be observed in *G. schlosseri* (BONIFAY 1971: plate 26), but not in the Late Pleistocene to recent *G. gulo* (see for example PULLIAINEN 1993: fig. 154 or DÖPPES 2001: fig. 3).

Table I

Wolverine from Deszczowa Cave (layers I-III) – definitions and results of teeth measurements

Symbol	Name	Definition	Measurement (mm)
<i>upper carnassial</i>			
Hpa	paracone height	the smallest distance between the most elevated point of the paracone and the crown base, measured on the labial side	9.3
Hpr	protocone height	the smallest distance between the most elevated point of the protocone and the crown base, measured on the lingual side	3.6
Lb	buccal length	the maximal length; the biggest distance between the most mesial and the most distal points of the crown	19.5
Ll	lingual length	the biggest distance between the edge of protocone and the edge of metastyle	18.4
Lm	medial length	the smallest distance between the most distal point of the crown and the edge between protocone and parastyle	17.4
Wi	width	the smallest distance between the line connecting the most labial points of the crown edge and the most lingual point of the edge	11.8
Wpa	paracone width	the smallest distance between the labial and lingual edges of paracone	6.8
<i>canine</i>			
H	height	the smallest distance between the most elevated point of a crown and the rear edge of a crown, measured on the distal side	14.2 (worn!)
L	length	the distance between the most mesial and the most distal points of the crown edge	9.9
W	width	the smallest diameter of the crown/root boundary	7.8
<i>incisor</i>			
H	height	the same as H of canine	10.9
L	length	the same as L of canine	7.1
W	width	the same as W of canine	6.2

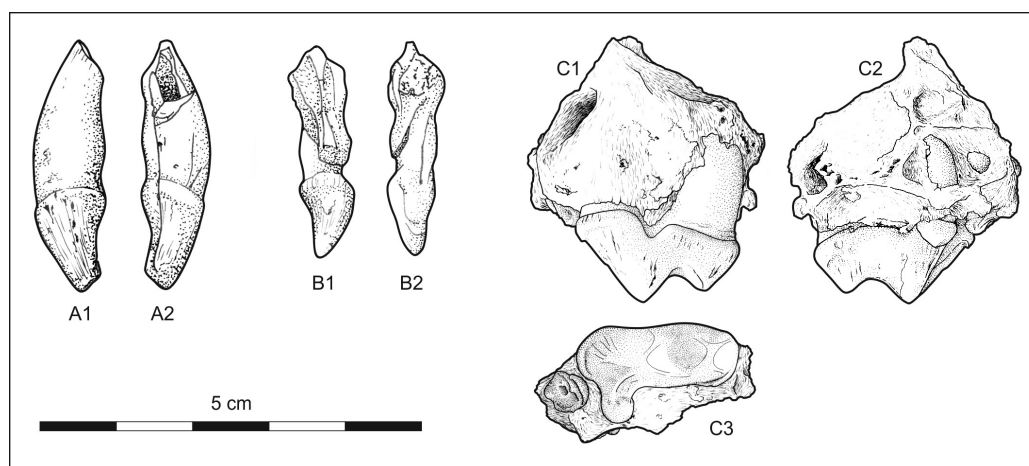


Fig. 2. Wolverine (*Gulo*) remains from Deszczowa Cave: C *sin.* – buccal (A1) and lingual view (A2), layer I; I3 *dext.* – buccal (B1) and lingual view (B2), layer III; maxilla fragment with P4 *sin.* and fragment of P3 *sin.* – buccal (C1), lingual (C2) and occlusal (C3) view, layer III.

IV. DISCUSSION

Apart from the remains from the lower layers of Deszczowa Cave there are several findings of wolverines from Poland. Most of them are dated to the Weichselian Glaciation (OIS 5d-2). They were found at a number of sites: Deszczowa Cave, layers VIII and IX (CYREK et al. 2000; a photo of one specimen shown by WOJTAL 2007; OIS 2 according to NADACHOWSKI et al. 2009 and KRAJCARZ & MADEYSKA 2010); Nietoperzowa Cave, layer 4 (WOJTAL 2007; OIS 3 according to KRAJCARZ & MADEYSKA 2010); Mamutowa Cave, layer V (NADACHOWSKI 1976; photo shown by WOJTAL 2007; probably OIS 3); Ciemna Cave, layer C8 (KRUKOWSKI 1939; probably OIS 5). Some of the remains were found without stratigraphic data or their stratigraphy is unclear or unpublished, however it is possible that they also derive from the Weichselian Glaciation (Cave in Czarkowa, Mamutowa Cave, Borsuka Cave; see KOWALSKI 1959; WOJTAL et al. 2011) or the Holocene (Solna Jama Cave, BIEROŃSKI et al. 2007; photo shown by STEFANIAK et al. 2009). During editorial process of this paper a single remain was also found in Middle Pleistocene sediments from Biśnik Cave (MARCISZAK et al. 2011), however detailed data on this specimen were not available for the author. Only the remains from Żabia Cave date from the Early Pleistocene (WOLSAN 1989; MARCISZAK 2007; NADACHOWSKI et al. 2011). These specimens were described as *Gulo schlosseri*; the others are believed to belong to *Gulo gulo*.

The size of the wolverine *G. gulo* stays in accordance with the Bergmann's rule, confirmed for modern males (MEIRI et al. 2004) and marked in a form of different-sized subspecies located in different latitudinal ranges (for example: *G. g. gulo*, *G. g. albus*, *G. g. jacutensis*, *G. g. katschemakensis* etc., see NOWAK 1991; ARISTOV & BARYSHNIKOV 2001). The effects of Bergmann's rule are also visible in a time dimension. The wolverines from the cold climate of the Last Glacial Maximum are large; the younger Late Glacial and

Early Holocene wolverines, that lived during the climatic warming, are typically smaller; and the modern wolverines, after the several thousand years of adaptation to warm climate, are the smallest ones (KURTÉN & RAUSCH 1959; PULLIAINEN 1993; MARCISZAK & KOVALCHUK 2011). Analogically, the well dated wolverine remains from Ingarano (SARDELLA 2001), Scocul Scorotei, Baia de Fier and Duruitoarea Veche (ȘTIUCĂ 1993), from Tornewton Cave (KURTÉN 1973) and many sites from Germany (DÖPPES 2001, 2005) show the increase of size during the beginning of the Ultimate Glaciation, reaching the biggest size in the middle of the Glacial Maximum and the decrease of size during the final phases of the Glaciation. In conclusion two size forms of wolverines may be distinguished: (1) the large form connected with glaciation periods and (2) the small one that occurs during interglacial warmings. The size of wolverine remains may be treated, although with some care, as an indicator of palaeoclimate.

The measurements of P4 clearly indicate the small form of wolverine from layer III of Deszczowa Cave (see diagram on Fig. 3). That wolverine was smaller than both the Weichselian form and even the Early Holocene form. According to Bergmann's rule the specimen should be connected with a warm climatic period. Its size fits to the variability of Holocene / modern wolverines, however it falls within the lower part of their range. The dimensions are also very close to the size of Middle Pleistocene wolverines, including *G. schlosseri*. Taking the stratigraphical position of the finding into consideration it becomes more possible that the specimen from Deszczowa Cave is a small form of late Middle Pleistocene *G. gulo* from one of the late Saalian (OIS 6) interstadials. Small wolverines from that period are known from Eurasia and North America (HALL 1936; KURTÉN & RAUSCH 1959; KURTÉN 1973; BRYANT 1986; ȘTIUCĂ 1993).

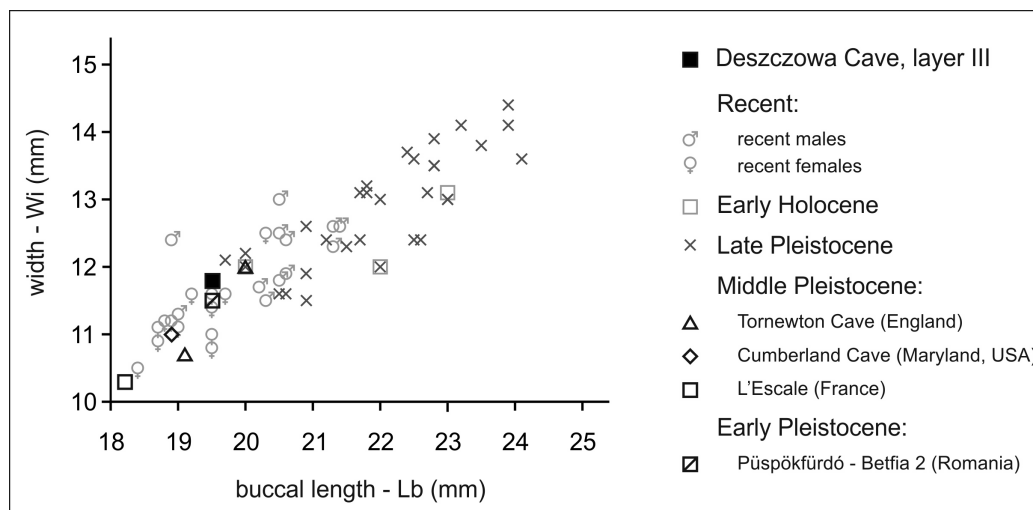


Fig. 3. Diagram of width / buccal length ratio of wolverine upper carnassial. Data after: recent – DEGERBØL (1935), PULLIAINEN (1993); Early Holocene – HILZHEIMER (1936; age corrected by KURTÉN & RAUSCH 1959); Late Pleistocene – KOPY (1951), MARTIN (1968), ALTUNA (1972), XU & WEI (1987), ȘTIUCĂ (1993), DÖPPES (2001), MARCISZAK & KOVALCHUK (2011); Tornewton Cave – KURTÉN (1973); Cumberland Cave – GIDLEY & GAZIN (1938); L'Escale – BONIFAY (1971); Püspökfürdő – MOTTL (1940).

However, it cannot be excluded that the discussed specimen represents the *G. schlosseri* species. Two species – *G. gulo* and *G. schlosseri* – are morphologically distinguishable on the basis of either lower carnassial or P3 shape (BRYANT 1986). The differences in canine and upper carnassial morphology, described by BONIFAY (1971), are non-metric. However, according to these differences the upper carnassial from Deszczowa Cave displays features intermediate between *G. schlosseri* and *G. gulo*. The preserved remains are insufficient to verify their taxonomic position.

It should be noted that in the same layers I-III other Middle Pleistocene taxa were discovered. They are: *Vulpes praeglacialis* (KORMOS, 1932), *Panthera spelaea fossilis* REICHENAU, 1906, *Microtus oeconomus malei* HINTON 1907, and *Dicrostonyx simplicior* GLOGER 1841 (CYREK et al. 2000; BARYCKA 2008; NADACHOWSKI et al. 2009). Presence of early Middle Pleistocene lion and fox remains in late Saalian sediments is not an expected situation and it may be explained as a result of redeposition from older sediments (CYREK et al. 2000; KRAJCARZ & MADEYSKA 2010). Such interpretation makes the presence of *G. schlosseri* remains in Deszczowa Cave possible.

V. CONCLUSIONS

In Poland before the Last Glaciation (Weichselian Glaciation, OIS 5d-2) occurred the small form of a wolverine, similar to other wolverines from the late Middle Pleistocene, like the findings from Tornewton in England or Old Crow and Cumberland Cave in North America. Such a form from Poland is known to date only from one site, the Deszczowa Cave. Later, during Weichselian Glaciation, the small form became replaced by a larger one, well adapted to the severe climate of the last glaciation.

The systematic position of wolverine remains from lower layers of Deszczowa Cave is not clear. Their connection with the *G. schlosseri* species may not be excluded. It is possible that the wolverine from Deszczowa Cave represents an intermediate form within the long line of evolution from *G. schlosseri* to *G. gulo*. Further DNA analysis is necessary to resolve the systematic position of the find.

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