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Large mammals from historical collections of open-air sites of Silesia (southern Poland) with special reference to carnivores and rhinoceros

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ABSTRACT

The information presented here is based on 174 sites; it is a result of a detailed historical collection revision of materials from Silesia and also the first comprehensive paper after the early German and Polish compilations. Though our work includes both quantitative and qualitative updates, it is neither exhaustive nor complete. It is very likely that many finds have not yet been reported to scientific institutions or museums, or else remain in private collections. The localities concerned are dominated by remains found under or within alluvial deposits of the last glaciation or in the context of loess sediments. Most of the documented remains are from the Late Pleistocene. Cold-adapted members of steppe-tundra faunal assemblages, such as *Mammuthus primigenius*, *Equus ferus*, *Coelodonta antiquitatis*, *Rangifer tarandus*, *Ovibos moschatus*, and *Bison priscus* dominate. Most artiodactyls were found in alluvial sediments, in bogs or swamps, while carnivores are represented only by isolated remains. The location of faunal assemblages and isolated finds shows the importance of river valleys as migrations routes. Silesia stretches along the Odra River, which runs in a roughly south-north direction, and connects the Sudety Mts and the Głubczyce Plateau with the wide, open lowlands of Eastern Germany and Western Poland.

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Introduction

Fossil mammals have attracted attention of earth workers and miners since the early eighteenth century. The earliest information about the palaeontological finds in Silesia comes from the archaeological sites in Masłów and its environs. The excavations in the region continued for over 150 years; they served L. A. Hermann to create the first archaeological monograph in Silesia (Hermann and Brachvogel 1711). Some of the archaeological sites yielded also numerous animal remains which, in the resulting descriptions and drawings, were interpreted as mammoth and referred to as the 'giants from Masłów' (Hermann 1711, 182, figures 7 and 9). These spectacular discoveries caused understandable surprise and curiosity, which was reflected in collecting and exhibiting such fossils in castle and church cabinets of curiosities. The finds from Masłów added to the collections of the Oleśnica castle, which were also described by another author of significant works on modern and fossil fauna of Silesia as 'Silesia Subterranea' (Volkmann 1720). In addition to the material from Masłów, the author described the discovery of large bones in the cemetery at the parish church in Trzebnica and mentioned the finding of mammoth bones at the Cathedral of St. Peter and Paul in Legnica.

Over the next 130 years there were almost no studies on the fossil fauna of Silesia; the first compilations and renewed interest started only in the first half of the nineteenth century Welzel (1842) described a mammoth molar and two humerus fragments of the same individual, as well as a piece of a large deer antler from Otmuchów. Göppert (1830) mentioned some mammoth and cave lion remains from Witków. The first compilation of all the mammal finds was Hensel's (1852) paper where the author presented the history of Silesian theriofauna from the earliest discoveries to the present. He described, among other remains, a large lion carnassial from Witkowo, several cave bear bones from Kąty Wrocławskie, numerous bones of mammoth and horse, and some sites with remains of deer and bovids (Hensel 1852).

The second half of the nineteenth century was a period of intense industrialisation of Silesia and thus significant intensification of earthworks related to the railway and road infrastructure, development of towns and villages, as well as a broad-based action of drainage and regulation of watercourses. Many remains, mainly of large cold-adapted ungulates of open grasslands, were found in the course of these works; the most numerous were the woolly mammoth, woolly rhinoceros and horse (Gürich 1885). Many of them were incomplete: fragments of skulls, mandibles, long bones, pelvis or ribs were further damaged during the extraction, like the woolly rhinoceros from Skarszyn (Römer 1881b) or Żmigród (Römer 1873). Numerous finds from that period come from river sediments and clays, which are remnants of glacial deposits and are usually dated as the second half of the last glaciation (Römer 1874, 1875, 1879, 1881a, 1881b;

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Table 1. List of rediscovered and revised fossil material from Silesian open sites.

No	Site	Coll. no	Preservation state	Age
Carnivora				
Panthera spelaea spelaea				
10	Brzeziny	BRZ/M/Pss/1	Left humerus lack proximal end	ad
106	Pyskowice	PYS/M/Pss/1	Left humerus lack proximal end	ad
106	Pyskowice	PYS/M/Pss/2	Proximal end of right femur	ad
106	Pyskowice	PYS/M/Pss/1	Thoracic VI	ad
106	Pyskowice	MUZ PIG 1742.II.1	Right body mandible with p3-m1	ad
122	Sosnowiec-Milowice	MIL/M/Pss/1	Body of left mandible with c1-m1	ad
144	Węgry	WEG/M/Pss/1	Ramus of right mandible with p4-m1	ad
Canis lupus				
153	Wrocław Hallera street 1	WRO/H/M/Cl/1	Trigonid of left m1	ad
Mustela nivalis				
102	Pietraszyn 11	PT11/Mnv/1	Left P4	ad
Ursus arctos priscus				
97	Pawłowiczki	PAW/M/Ua/1	Left maxilla fr. with M1-M2 alveoli	ad
119	Skarszyn	SKA/M/Ua/1	Shaft fr. and distal end of left femur	ad
165	Ziębice	ZIE/M/Ua/1	Left mandible body fr.	ad
Ursus ex. gr. *spelaeus*				
73	Lubliniec	LUB/M/Uspx/1	Left c1	ad
Proboscidea				
Mammuthus primigenius				
10	Brzeziny	BRZ/M/1	M1, 2 M2, 2 M3, m3, 3 molars, mandible fr., 2 x atlas, cervical, right scapula, scapula fr., 4 ribs fr., 6 radius fr., right pelvis fr., 2 x pelvis fr., 2 tibiae fr.	ad
13	Chorzów	CHO/M/1	Atlas	juv
13	Chorzów	CHO/M/2	Pelvis	ad
27	Dzierżysław		48 teeth fr., M3, proximal end of right femur, 6 ribs fr.	ad
52	Kąty Opolskie	KOP/M/1	Upper molar	juv
60	Kopanie-Kruszyna canal	KKB/M/1	Radius fr.	ad
109	Racibórz-Ostróg	RAC/M/1	Tibia	ad
152	Wójcice B		Tusks and molars fr.	ad
153	Wrocław Hallera street 1		Tusk fr., 6 molars fr.	ad
154	Wrocław-Oporów		Zygomatic bone, 2 tusks fr., left M1, right M2, 2 molars fr., left scapula, left humerus, left and right femur, right tibia	ad
161	Zastruże 4		Tusk fr., 5 x thoracic, sacrum, 2 x caudal, right scapula, right capitatum, complete pelvis, right tibia, right talus, right calcaneus, right cuboid, left ectocuneiform	ad
Perissodactyla				
Coleodonta antiquus				
4	Bobrów	BOB/M/1	Damaged pelvis	ad
10	Brzeziny	BRZ/M/2	Shaft with damaged distal end of left humerus	ad
10	Brzeziny	BRZ/M/3	Shaft of right radius	ad
10	Brzeziny	BRZ/M/4	Left humerus shaft fr.	ad
13	Chorzów	CHO/M/3	Body of right mandible with strongly worn m3	ad
13	Chorzów	CHO/M/4	Shafts fr. of two right humeri	ad
13	Chorzów	CHO/M/5	Left pelvis fr.	ad
45	Imbramowice	IMB/M/1	Left mandible fr.	ad
47	Jelenia Góra	JEL/M/2	Pelvis	ad
97	Pawłowiczki	PAW/M/1	Nasal bones fr.	ad
97	Pawłowiczki	PAW/M/2	Right pelvis fr.	ad
97	Pawłowiczki	PAW/M/3	Tibia shaft fr.	ad
97	Pawłowiczki	PAW/M/4–5	Two bones fr.	ad
98	Perzów	PER/M/	fr. of right pelvis	ad
109	Racibórz-Ostróg	RAC/M/2	Unidentified fr.	ad
118	Siemonia	SIE/M/1	Long bones fr.	ad
119	Skarszyn	SKA/M/1	Left, worn M1	ad
119	Skarszyn	SKA/M/2	Right M2	ad
119	Skarszyn	SKA/M/3	Left M2	ad
119	Skarszyn	SKA/M/4	Right M2	ad
119	Skarszyn	SKA/M/5	Right m2	
119	Skarszyn	SKA/M/6	Right m1	
119	Skarszyn	SKA/M/7	Left m1	
119	Skarszyn	SKA/M/8	Right zygomatic arch	ad
119	Skarszyn	SKA/M/9	Frontal bone fr.	ad
119	Skarszyn	SKA/M/10	Occipital bone fr.	ad.
119	Skarszyn	SKA/M/11	Anterior half of left, damaged mandible	ad
119	Skarszyn	SKA/M/12	Mandible fr. with roots fr.	ad
119	Skarszyn	SKA/M/13	Axis	ad
119	Skarszyn	SKA/M/14	Cervical	ad
119	Skarszyn	SKA/M/15	Damaged, pathological cervical VI	ad
119	Skarszyn	SKA/M/16	Damaged cervical VII	ad
119	Skarszyn	SKA/M/17	Damaged cervical	ad
119	Skarszyn	SKA/M/18	Thoracic corpus with bite marks	ad
119	Skarszyn	SKA/M/19	Slightly damaged thoracic	ad
119	Skarszyn	SKA/M/20	Slightly damaged thoracic	ad
119	Skarszyn	SKA/M/21	Slightly damaged thoracic	ad

(*Continued*)

Table 1. (*Continued*).

No	Site	Coll. no	Preservation state	Age
119	Skarszyn	SKA/M/22	5 ribs fr.	ad
119	Skarszyn	SKA/M/23	Damaged right scapula	ad
119	Skarszyn	SKA/M/24	Scapula fr.	ad
119	Skarszyn	SKA/M/25	Scapula fr.	ad
119	Skarszyn	SKA/M/26	Shaft with part of distal end of left humerus	ad
119	Skarszyn	SKA/M/27	Right humerus shaft fr.	ad
119	Skarszyn	SKA/M/28	Left ulna with damaged proximal end	ad
119	Skarszyn	SKA/M/29	Right pelvis fr.	ad
119	Skarszyn	SKA/M/30	Left mtcp II	ad
119	Skarszyn	SKA/M/31	Right mtcp II	ad
119	Skarszyn	SKA/M/32	Left mtcp IV	ad
119	Skarszyn	SKA/M/33–36	4 undetermined bones fr.	ad
134	Święcko	ŚWI/M/1	Shaft fr. of left humerus	ad
134	Święcko	ŚWI/M/2	Pelvis small fr.	ad
129	Syrynia	SYR/M/1	Upper molar	ad
137	Trzebnica	TRZ/M/1	Nasal bones fr.	ad
137	Trzebnica	TRZ/M/2	Frontal and occipital bone fr.	ad
137	Trzebnica	TRZ/M/3	Right humerus shaft fr.	ad
153	Wrocław Hallera street 1		Worn right M2, strongly worn lower molar	ad
154	Wrocław-Oporów		2 molars fr., shaft of right humerus	ad
162	Zgorzelec	ZGO/M/1	Rib fr.	ad
165	Ziębice	ZIE/M/1	Right mtcp III	ad
165	Ziębice	ZIE/M/2	Right mtcp IV	ad
174	Żmigród	ZMI/M//1	Rib fr.	ad
Stephanorhinus kirchbergensis				
153	Wrocław Hallera street 1		Left M1 or M2	ad
153	Wrocław Hallera street 1	B 129	Right M2	ad
Equus ferus				
4	Bobrów	BOB/M/2	Left P2	ad
10	Brzeziny	BRZ/M/5	Cervical, left mtts III	ad
23	Czerwoniak	CZE/M/1	Right, hind ph II	ad
27	Dzierżysław		Phalanx I	ad
36	Gostków	GOS/M/1	Left M3, right upper cheek tooth	ad
36	Gostków	GOS/M/2	Right upper cheek tooth	ad
46	Jedlina Zdrój-Jedlinka	JZJ/M/1	Left P3	ad
56	Kłodzko-Ustronie	KŁO/M/1	Left M1	ad
56	Kłodzko-Ustronie	KŁO/M/2	Left M2	ad
56	Kłodzko-Ustronie	KŁO/M/3	Left M3	ad
56	Kłodzko-Ustronie	KŁO/M/4	Right M3	ad
57	Kobiór	KOB/M/1	Right m3	ad
83	Mojęcice	MOJ/M/1	Right upper cheek tooth	ad
97	Pawłowiczki	PAW/M/6	Right P2, right P4	ad
100	Piekary Śląskie-Szarlej	PIE/M/1	Left upper cheek tooth	ad
100	Piekary Śląskie-Szarlej	PIE/M/2	Left upper cheek tooth	ad
102	Pietraszyn 11		Long bone fr.	ad
103	Pietrowice Wielkie	PTR/M/1	Left M2	ad
105	Przerzeczyn-Zdrój	PTR/M/2	Right P2	ad
106	Pyskowice	PYS/M/2	Left scapula without dorsal edge	ad
106	Pyskowice	PYS/M/3	Right radius shaft	ad
106	Pyskowice	PYS/M/4	Distal half of right radius	ad
106	Pyskowice	PYS/M/5	Proximal end of right radius	ad
106	Pyskowice	PYS/M/6	Right, damaged pelvis	ad
120	Sobótka	SOB/M/1	Right mtcp III	ad
120	Sobótka	SOB/M/2	Neurocranium with present left and right P2-M3	ad
124	Stary Wielisław	STW/M/1	Right mcp III	ad
126	Strzegom	STG/M/1	Left M2	ad
127	Strzelin	STL/M/1	Right P3	ad
130	Szprotawa	SZP/M/3	Proximal half of left radius	ad
140	Uniemyśl	UNI/M/1	Left, upper cheek tooth	ad
142	Wambierzyce	WAM/M/1	Left M1-M3, right M3	ad
149	Wołczyn	WOŁ/M/1	Right P3	ad
157	Wrocław-Rędzin	WRO/M/1	Neurocranium	ad
153	Wrocław Hallera street 1		37 premolars and molars fr.	ad
154	Wrocław-Oporów		Isolated incisors, right P4, premolars and molars fr., 2 humerus fr., 2 phalangs II	ad
161	Zastruże 4		Radius fr.	ad
165	Ziębice	ZIE/M/4	Right mandible with damaged ramus and symphysis, with p2-m3	ad
165	Ziębice	ZIE/M/5	Left m3	ad
165	Ziębice	ZIE/M/6	Right radius without distal end	ad
165	Ziębice	ZIE/M/7	Right tibia	ad
166	Zimna Woda	ZIM/M/1	Left P2	ad
166	Zimna Woda	ZIM/M/2	Right P2	ad
166	Zimna Woda	ZIM/M/3	Upper, right cheek tooth	ad
166	Zimna Woda	ZIM/M/4	Upper, left cheek tooth	ad
166	Zimna Woda	ZIM/M/5	Upper, right cheek tooth	ad

(*Continued*)

Table 1. (*Continued*).

No	Site	Coll. no	Preservation state	Age
166	Zimna Woda	ZIM/M/6	Upper, right cheek tooth	ad
166	Zimna Woda	ZIM.M/7	Upper, right cheek tooth	ad
166	Zimna Woda	ZIM//8	Upper, left cheek tooth	ad
166	Zimna Woda	ZIM/M/9	Right M3	ad
166	Zimna Woda	ZIM/M/10	Left M3	juv
166	Zimna Woda	ZIM/M/11	Upper cheek tooth fr.	ad
161	Zastruże 4		Radius fr.	ad
174	Żmigród	ZMI/M/2	Left P3	ad
174	Żmigród	ZMI/M/3	Left P4	ad
174	Żmigród	ZMI/M/4	Right P3	ad
174	Żmigród	ZMI/M/5	Left M1	ad
Arctiodactyla				
Rangifer tarandus				
4	Bobrów	BOB/M/1	Antler fragment; fragment of right shed female antler; 2 fragment of left shed female antler	ad
27	Dzierżysław		Isolated M1, M2, M3, p2, p4, m1, m2, 3 × m3	ad
43	Henryków 15		Antler fr.	ad
43	Henryków 15		Rib fr.	ad
153	Wrocław Hallera street 1		Female antler fr	ad
154	Wrocław-Oporów		2 × male antlers fr., 2 × antlers fr.	ad
Alces alces				
101	Pieszków	PIE/M/1	Left antler shed shovel fr., right antler shovel fr.	ad
Megaloceros giganteus				
145	Wierzbice	WIE/M/1	Damaged calvarium	ad
Cervus elaphus				
47	Jelenia Góra	JEL/M/1	Left mtcp	ad
49	Kamiennik	KAM/M/1	Right mtcp	juv
130	Szprotawa	SZP/M/1	mtts fr.	juv
Capreolus capreolus				
13	Chorzów	CHO/M/6	Left horn with skull fr.	ad
133	Świdnica	ŚWI/M/1	Right mtts	ad
Ovibos moschatus				
2	Będzin-Grodziec	BED/M/1	Calvarium fr.	ad
22	Czernicki tunnel	TUN/M/1	2 molars	ad
49	Kamiennik	KAM/M/2	Neurocranium	ad
67	Legnica	LEG/M/1	Calvarium fr.	ad
107	Pyskowice-Dzierżno	PYS/M/1	Calvarium fr.	ad
112	Ruda Śląska/Bielszowice	RUD/M/1	Calvarium fr.	ad
122	Sosnowiec-Milowice	MIL/M/1	4 calvarium fr.	ad
165	Ziębice	ZIE/M/3	Calvarium fr.	ad
Bison priscus				
106	Pyskowice	PYS/M/2	Right talus	ad
130	Szprotawa	SZP/M/2	Right tibia, right mtts	ad
153	Wrocław Hallera street 1		Skulls and mandibles fr., isolated teeth, humerus, mtcp, calcaneus, 2 talus fr., scapholunar	ad
154	Wrocław-Oporów (cf.)		2 molars fr. (juv.)	ad
Bos primigenius				
49	Kamiennik	KAM/M/3	Left humerus, vertebrae, right tibia fr., 2 right mtcp fr., right mtts fr., phalanx	ad
153	Wrocław Hallera street 1		Skull fr.	ad
Sus scrofa				
6	Boguchwałów	BOG/M/1	Calvarium	ad

Gürich 1885, 1893, 1905, 1913). Most of the specimens ended up in private collections, or small, regional museums, where they were displayed as curiosities. Gürich's (1885) compilation of the Silesian fossil fauna lists 21 species of large mammals. Similar lists were published in the first half of the twentieth century (Herr 1924a; Heinke 1926) and numerous finds of mammoths, rhinoceros, and horses from that period were mentioned until the end of World War II (Drescher 1932; Juhnke 1932; Eisenreich 1933; Heinevetter 1933; Bröker 1936; Heinevetter 1937; Lubicz-Niezabitowski 1938; Hoffmann 1941).

The end of World War II proved to be disastrous for the palaeontological collections; most of them were destroyed or lost. The first post-war monograph of Silesian fossil fauna, part of the revision of records from the whole territory of Poland, was primarily based on pre-war German materials (Kowalski 1959). Post-war discoveries are much rarer, and represent mainly woolly mammoth; there are also few remains of horse and rhinoceros (Juhnke 1952; Ryziewicz 1949, 1954, 1955; Jahn 1957; Borsuk-Białynicka 1973). Most of them come from the eastern part of Silesia, between the cities Opole and Czechowice-Dziedzice. It was not until the start of the regular palaeontological and archaeological research in the last 30 years that several open sites were discovered, and it was possible to examine the fossil material in the stratigraphic and taphonomic context (Wojtal 2007; Wiśniewski, Stefaniak, et al. 2009; Wiśniewski, Wojtal, et al. 2009; Wiśniewski et al. 2013).

Material and methods

Material

The fossil material described here is stored in the collection of the Department of Palaeozoology, University of Wrocław (Table 1). The data on location, and the person making the original identification were read from the descriptions on the bones, since the original labels were not preserved. The remains were revised and, when necessary, re-classified and re-described; whenever possible, they were measured. In some cases, unfortunately, not all the information could be retrieved, and sometimes the state of preservation (worse than when the original description was made) did not allow a precise determination. Based on an extensive literature query, it turned out that not all skeletal remains were preserved to this day. The full list of all described specimens is presented below (Table 2).

Methods

Measurements were taken point to point, with an electronic calliper, to the nearest 0.1 mm. Each value given here is the mean of three measurements. Photographs of the fossil material was taken with a camera Canon EOS 5D. The number of bones was specified as NISP (number of identified specimens), while the minimum number of individuals was specified as MNI. The number of specimens was based on the morphological and metric values, stage of preservation, bone colour, etc. The abbreviations used are as follows: c. – century, mtcp – metacarpal bone, mtts – metatarsal bone, ph – phalanx. Osteological and dental terminology follows van der Made (2010) for rhinoceros and von den Driesch (1976) for the other species. The measurements' scheme is shown in Figures 1–3. They follow Argant (2010a) for the lion (Figure 1), van der Made (2010) for the rhinoceros (Figures 2–3), and von den Driesch (1976) for the remaining species (Figures 2–3).

The analysed material of rhinoceros was compared with literature information (Guérin 1980; Fernández and Castells 2007) and with unpublished data from Central European sites (Belarus, Czech Republic, Germany, Poland, Ukraine). The brown bear was compared with measurements obtained by one of the authors (AM) and with data from Reynolds (1906), Degerbøl (1933), Zapfe (1946), Mostecký (1963), Altuna (1973), Ballesio (1983) and Petronio et al. (2003). The lion material was compared with our own measurements and with the literature information (Schütt 1969; Schütt and Hemmer 1978; Argant 1988, 1991). For the chronoforms/chronosubspecies of the Pleistocene lion *Panthera spelaea* the following terms were used:

(1) steppe lion *Panthera spelaea fossilis* (sensu Laučik 2008) for the Middle Pleistocene lions, dated at 700–300 Ka (for details see Marciszak et al. 2014),
(2) intermediate lion *Panthera spelaea* ssp. sensu Argant (2010b) for the late Middle Pleistocene and the Eemian lions, dated at 300–115 Ka, whose morphology shows a mosaic of features of *Panthera spelaea fossilis* and *Panthera spelaea spelaea*. Form so far not described,
(3) cave lion *Panthera spelaea spelaea* for the lions of the Late Pleistocene.

Due to the fact that the woolly mammoth material is stored in numerous, different museums in Poland and is particularly abundant, we decided to exclude many uncertain findings from this paper. Some of the bones and teeth need verification for the possible occurrence of *Palaeoloxodon antiquus* or *Elephas trogontherii* among the very abundant remains of *Mammuthus primigenius*. It requires particular attention and examining of the whole material before the final publication.

The list of open sites with fossil mammals in Silesia was based on works published mostly before World War II with further references and on unpublished revision of old material and new materials (Table 3). Where different authors used various past names for the same locality, we retained the nomenclature from the first publication and the present-day name. Authors mentioned their new finds, but in most cases provided no detailed description, and therefore there are no material descriptions for some sites. For example, from Skarszyn, a significant portion of the woolly rhinoceros remains is only briefly described, and the bear bone is misidentified as a horse bone.

Table 2. List of radiocarbon (C14) dates obtained for specimens from Silesian open sites.

Site	Species	Bone	Lab. no	Uncal. date BP	Cal. date BP	Source
Berzdorfer See	*Bos primigenius*	Calvarium			10,750 ± 35	Tietz 2005
Berzdorfer See	*Bos primigenius*	Calvarium			10,810 ± 50	Tietz 2005
Skarszyn	*Coelodonta antiquitatis*	Scapula	Poz-82384	13,444 ± 226	16,460 ± 90	This work
Skarszyn	*Ursus arctos priscus*	Femur	Poz-82405	37,100 ± 1000	41,857 ± 3425	This work
Dzierżysław	unidentifiable	Fragment	GdA-70	13,220 ± 70		Wojtal 2007
Dzierżysław	unidentifiable	Fragment	GdA-69	13,500 ± 80		Wojtal 2007
Dzierżysław	*Mammuthus primigenius*	Tooth	Poz-10135	13,180 ± 60		Wojtal 2007
Dzierżysław	*Mammuthus primigenius*	Bone	GdA-193	13,370 ± 80		Wojtal 2007
Dzierżysław	*Mammuthus primigenius*	Tooth	Poz-10136	14,150 ± 70		Wojtal 2007
Dzierżysław	*Mammuthus primigenius*	Molar		10,510 ± 650	12,440 ± 180	Markova et al. 2013
Dzierżysław	*Rangifer tarandus*		Poz-26160		13,180 ± 90	This work
Dzierżysław 1	*Equus ferus*		Gd-10233		19,650 ± 200	Fajer et al. 2004
Pyskowice	*Mammuthus primigenius*	M3	OxA-26809	25,420 ± 210	30,293 ± 351	Pawłowska 2015
Pyskowice	*Mammuthus primigenius*	M3	OxA-26810	25,940 ± 230	30,933 ± 369	Pawłowska 2015
Pyskowice	*Mammuthus primigenius*	M3	OxA-26811	28,090 ± 280	32,568 ± 356	Pawłowska 2015
Przewóz	*Mammuthus primigenius*	Molar	OxA-26807	48,600 ± 3500	54,034 ± 5312	Pawłowska 2015
Wrocław Oporów	*Mammuthus primigenius*	Tusk	Gd-10412	18,700 ± 270	19,940 – 20,560	Bluszcz and Pazdur 2003
Zastruże	*Mammuthus primigenius*	Bone	Poz-16042		23,790 ± 160	Wiśniewski, Stefaniak, et al. 2009

Notes: The calibration for two dates obtained for the studied material from Skarszyn was made with the OxCal software (version OxCal v4.2.1 Bronk Ramsey, 2013). Atmospheric data from Reimer et al. (2009). Presented calibrated date with 95.4% probability. A few other samples failed to yield dates because of insufficient collagen content.

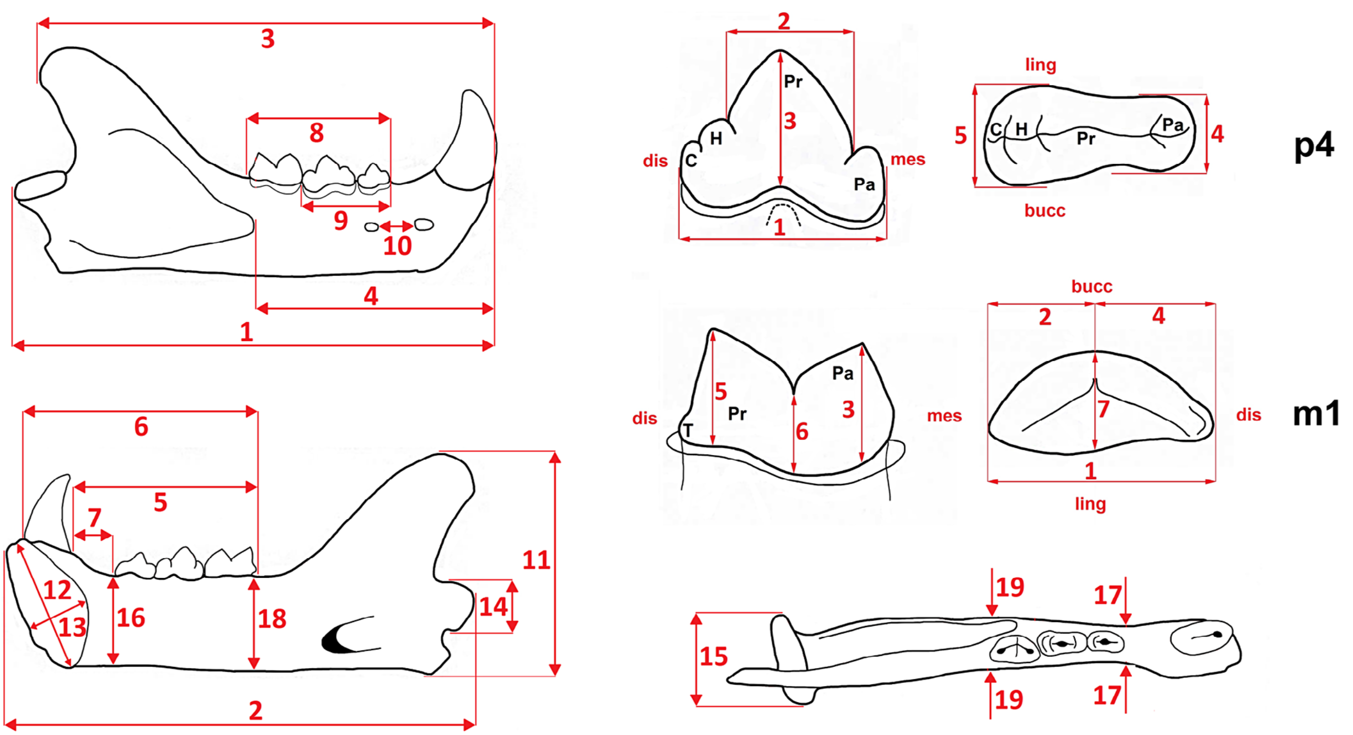

Figure 1. Measurements of lion mandible (according to Argant 1991, changed): **1** – total length (infradentale to condyle), **2** – infradentale to angular process length, **3** – infradentale to coronoid process length, **4** – infradentale to anterior margin of masseter fossa, **5** – anterior margin of c1 to posterior margin of m1, **6** – posterior margin of c1 to posterior margin of m1, **7** – diastema length, **8** – cheek teeth row length (anterior margin of p3 to posterior margin of m1), **9** – premolars row length (anterior margin of p3 to posterior margin of p4), **10** – distance between mental foramina, **11** – angular process to coronoid process height, **12** – symphysis maximal diameter, **13** – symphysis minimum diameter, **14** – condyle height, **15** – condyle breadth, **16** – body mandible height before p3, **17** – body mandible thickness before p3, **18** – body mandible height behind m1, **19** – body mandible thickness behind m1.

Notes: Measurements of felid p3/p4 and m1 (on the right), modified from Schmid (1940). Pa – paraconid, Pr – protoconid, H – hypoconid, T – talonid, C – cingulum, mes – mesial side, dist – distal side, ling – lingual side, bucc – buccal side. Measurements of p3 and p4: **1** – total length, **2** – protoconid length, **3** – protoconid height, **4** – anterior breadth, **5** – posterior breadth. Measurements of m1: **1** – total length, **2** – paraconid length, **3** – paraconid height, **4** – protoconid length, **5** – protoconid height, **6** – incisor height, **7** – breadth.

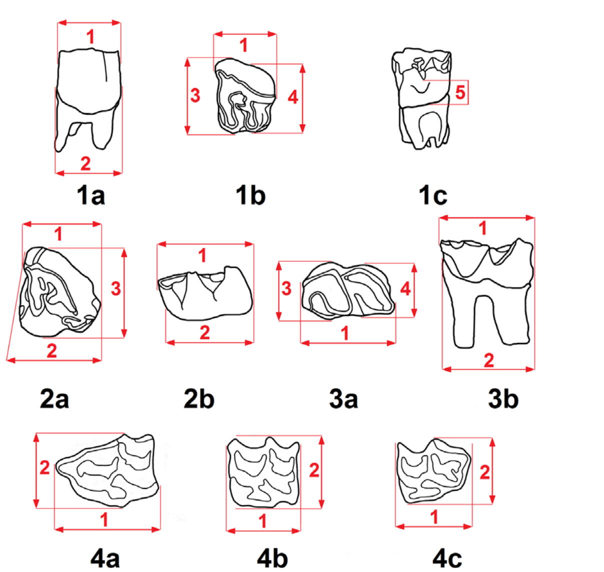

Figure 2. Measurements of rhinoceros teeth (P3 – 1a–1c, M3 – 2a–2b and m1–m3 3a–3b) (according to van der Made 2010, changed): **1** – total length from occlusal side, **2** – total length close to base, at the level where the crown extends most posteriorly, **3** – anterior breadth, **4** – posterior breadth, **5** – height as a distance between the lower border of the crown and the place where the bases of the lingual cusps meet.

Note: Measurements of horse teeth (4a–c): **1** – total length, **2** – total breadth (according to von den Driesch 1976, changed).

Places of finding of the remains are here called sites or localities. For all the locations the names were checked and verified, and the most recent name given. For all the locations also the old German names were given, since till 1945 most of Silesia was a German territory. In some cases they were renamed as a result of city expansion, where former villages in the neighbourhood of a city were incorporated into the city. The name today survives as the name of a street or city district (Table 3).

The names of localities are listed alphabetically. In the first column, the modern name is given, in the second column the old name, which usually featured in earlier publications. In the third column, the geographical location of each site is provided. It was difficult and in most cases even impossible to determine the number of specimens. It would require access to the original material, assuming that it is still preserved in collections (Table 3). Therefore, the list of individuals is qualitative and gives only the name of each bone, and indicates whether it is cranial or postcranial. The fifth column is age, which in most cases is only roughly estimated and cited from earlier papers. The last column lists the main sources of information (Table 3).

Main site

Despite more than three centuries of research of the Silesian fossil fauna, so far the remains from open sites have not been

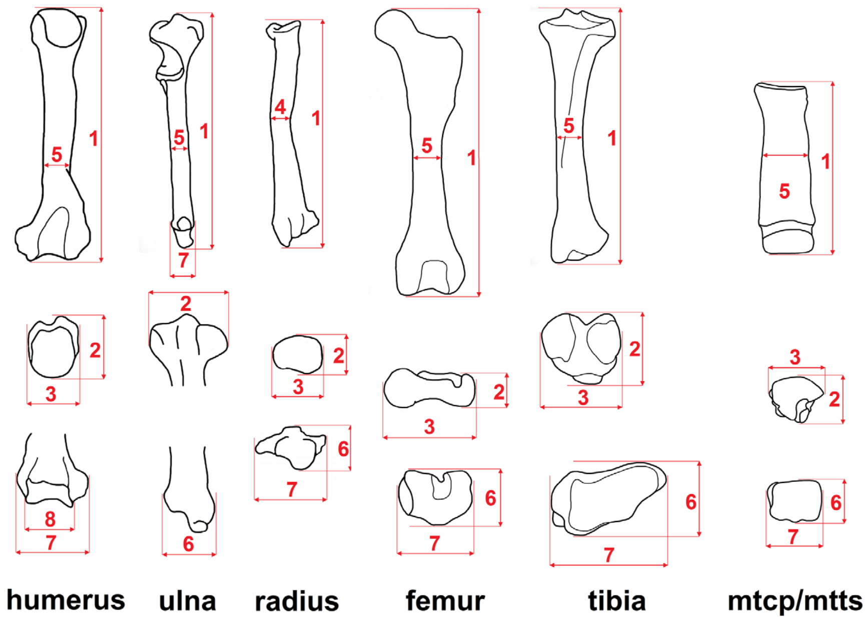

Figure 3. Measurements of postcranial bones: **1** – total length, **2** – proximal epiphysis depth, **3** – proximal epiphysis breadth, **4** – antero-posterior shaft length, **5** – minimal shaft breadth, **6** – distal epiphysis depth, **7** – distal epiphysis breadth, **8** – trochlea breadth.

subject to a synthetic compilation or major revision. In spite of the numerous reports on individual finds (Römer 1870, 1873, 1874, 1875; Remelé 1875; Römer 1879, 1881a, 1881b, 1885, 1886, 1888) or collections (Hensel 1852, 1853a, 1853b; Gürich 1885; Herr 1924a; Heinke 1926; Schwarzbach 1942a; Kowalski 1959; Wolsan 1989; Kubiak 1989; Wiśniewski, Stefaniak, et al. 2009), descriptions of the finds focused on the geological context rather than on the properties of the remains. More comprehensive studies dealt mainly with *Ovibos moschatus* (Kowarzik 1908, 1912; Ryziewicz 1949, 1954, 1955) and with two rare elephants, *Elephas trogontherii* and *Elephas antiquus* (Volz and Leonhard 1896; Volz 1897a, 1897b, 1901; Wüst 1901; Soergel 1913; Juhnke 1932; Soergel 1944; Kulczycki 1955). Partially also *Coelodonta antiquitatis* (Wüst 1922; Zeuner 1934; Borsuk-Białynicka 1973) and *Panthera spelaea* (Lubicz-Niezabitowski 1925, 1938) were studied in detail. In contrast, the studies of fossil material from cave localities are much more detailed (Heller 1937; Zotz 1939; Wiszniowska 1976, 1978; Wiśniewski, Stefaniak, et al. 2009; Wiśniewski, Wojtal, et al. 2009; Marciszak et al. 2016, 2017).

For these reasons we decided to revise the material from open-air sites of Silesia. The main objective was a revision of mammal remains from historical collections from Silesia with particular emphasis on the University of Wrocław. We tried to determine as accurately as possible the geographical location and position of the bones in the profile based on archival descriptions. Thanks to several localities it was possible to assign the remains to geological profiles and determine their approximate stratigraphic position.

Despite the historical importance of Silesian open sites there was no modern compilation of the mammalian remains from these sites, although there were revisions of individual groups and species. Because of the past disagreements between the original discoverers and the subsequent rivalry between private collectors, it seems unlikely that the accounts of Göppert (1830), Hensel (1853b), Gürich (1885), Herr (1924a), Heinke (1926), Heinevetter (1933, 1937) and Kowalski (1959) were based on truly comprehensive surveys of the materials from Silesia. However, the list of species allegedly found has greatly increased since the time of Gürich (1885) or Kowalski (1959).

Some of the early papers contain puzzling discrepancies when compared with the faunas of other cave or open sites. In particular, two faunal assemblages appear to be represented: a warm interglacial fauna, and a cold-adapted glacial fauna, although deposits in particular sites are described as homogenous. Such examples are known, among others, from Imbramowice and Pawłowiczki. It was clear that further minor revisions, without a complete and broad survey of the material, could add little to our knowledge, therefore every collection that could be traced so far was examined, as was the whole of pertinent literature.

The area included in the analysis coincides with the boundaries of Silesia (Provinz Schlesien) as presented by Pax (1921a, 1925) (Figure 4). At present, Silesia covers ca. 40,000 km^2; it extends along the Odra River and is mostly located in Poland, with small parts in the Czech Republic and Germany. Its boundaries changed over time, and till the beginning of the tenth century it was part of Greater Moravia and Bohemia. In the tenth century, Silesia was incorporated into the early Polish state, and after its division in the twelfth century it became a Piast duchy. Later, in the fourteenth century, it became a constituent part of the Bohemian Crown Lands under the Holy Roman Empire. In 1526 Silesia passed to the Austrian Habsburg Monarchy. After two centuries, in 1742 most of Silesia was conquered by Prussia. Up to 1945 Silesia was part of Prussia, the German Empire, the Weimar Republic, and finally the Nazi Germany. In 1945, after World War II, the majority of Silesia became part of Poland. Only the small Lusatian strip west of the Oder-Neisse line, which had belonged to Silesia since 1815, remained in Germany. According to the current regional division adopted in this paper the area includes both Lower and Upper Silesia and the southern part of the Lubuski region and Lausitz fragment (Figure 4) (Czapliński et al. 2007).

Table 3. The list of Silesian open-air sites with faunal assemblages found in their sediments.

Site no.	Current name	Former name	Coordinates	Mammal species
1	Berzdorfer See	Berzdorf	51°5′24″N 14°57′36″E	*Mammuthus primigenius* (1/1), *Coelodonta antiquitatis* (+5/1), *Bos primigenius* (1/1)
2	Będzin-Grodziec		50°21′5″N 19°4′11″E	*Ovibos moschatus* (1/1)
3	Bielice		50°33′26″N 17°29′27″E	*Mammuthus primigenius* (4/1)
4	Bobrów	Boberthal	50°52′35″N 15°50′56″E	*Equus ferus* (1/1), *Rangifer tarandus* (4/1)
5	Bogatynia-Turoszów	Seitendorf-Türchau	50°54′27″N 14°57′14″E	*Alces alces* (2/1)
6	Boguchwałów	Hohndorf	50°8′45″N 17°54′29″E	*Sus scrofa* (1/1)
7	Bolesławiec	Bunzlau	51°15′54″N 15°33′4″E	*Alces alces* (1/1)
8	Brzeg (Odra river)	Brieg (Oder)	50°51′37″N 17°28′2″E	*Mammuthus primigenius* (8/?)
9	Brzeg Dolny	Dyhernfurth	51°16′15″N 16°43′15″E	*Mammuthus primigenius*, *Alces alces*, *Ovibos moschatus*
10	Brzeziny		50°36′19″N 17°26′15″E	*Panthera spelaea spelaea* (1/1), *Mammuthus primigenius* (30/3), *Equus ferus* (2/1), *Coelodonta antiquitatis* (2/1)
11	Budziszyn	Bautzen	51°10′53″N 14°25′26″E	*Mammuthus primigenius* (1/1), *Rangifer tarandus* (1/1)
12	Chobienia	Köben	51°32′36″N 16°26′53″E	*Mammuthus primigenius* (2/1)
13	Chorzów	Königshütte	50°18′4″N 18°57′73″E	*Mammuthus primigenius* (6/2), *Coelodonta antiquitatis* (3/1), *Alces alces* (1/1), *Capreolus capreolus* (1/1)
14	Chorzów-Dąb	Chorzow-Domber	50°17′12″N 18°58′51″E	*Mammuthus primigenius*
15	Chrastava	Kratzau	50°49′1″N 14°58′8″E	*Equus ferus* (1/1)
16	Cyprzanów	Janowitz	50°4′18″N 18°6′55″E	*Equus ferus* (+5/?)
17	Czarnocin	Czarnosin	50°27′0″N 18°14′25″E	*Mammuthus primigenius* (1/1)
18	Czechowice-Dziedzice	Dzieditz	49°54′40″N 19°0′27″E	*Mammuthus primigenius*, *Equus ferus*, *Coelodonta antiquitatis*
19	Czechy	Tschechen	50°56′21″N 16°24′30″E	*Palaeoloxodon antiquus* (1/1), *Mammuthus primigenius* (1/1)
20	Czeladź-Saturn	Tscheljads	50°18′26″N 19°4′12″E	*Ovibos moschatus*
21	Czernica	Czernitz	50°5′1″N 18°24′2″E	*Ovibos moschatus* (2/1)
22	Czernicki tunnel	Czernitz	50°5′1″N 18°24′2″E	*Ovibos moschatus* (2/1)
23	Czerwoniak	Rotherberg	50°24′10″N 16°37′32″E	*Equus ferus* (1/1), *Coelodonta antiquitatis* (2/1)
24	Deutsch Ossig	Deutsch Ossig	51°5′54″N 14°58′39″E	*Equus ferus* (1/1)
25	Dolnik	Schönthal	50°8′36″N 16°41′47″E	*Dama dama* (1/1)
26	Dzierżoniów	Dirschel	50°43′41″N 16°39′4″E	*Dama dama* (1/1)
27	Dzierżysław	Dirschel	50°2′47″N 17°57′52″E	*Mammuthus primigenius* (62/1), *Equus ferus* (1/1), *Sus scrofa* (1/1), *Rangifer tarandus* (11/1)
28	Ebersbach-Neugersdorf	Ebersbach	51°0′30″N 14°35′7″E	*Equus ferus* (1/1)
29	Frączków	Franzdorf	50°32′18″N 17°18′37″E	*Mammuthus trogontherii* (1/1)
30	Gierałtowice	Gieraltowitz	50°16′26″N 18°5′22″E	*Cervus elaphus* (1/1)
31	Gliwice	Gleiwitz	50°17′32″N 18°40′3″E	*Mammuthus primigenius* (+22/?)
32	Gliwice-huta	Gleiwitz	50°17′54″N 18°40′50″E	*Mammuthus primigenius* (+5/1)
33	Gliwice-Łabędy	Laband	50°20′44″N 18°37′44″E	*Mammuthus primigenius*, *Stephanorhinus kirchbergensis*
34	Gliwice-Szobiszowice	Petersdorf	50°19′37″N 18°40′35″E	*Mammuthus trogontherii* (4/2), *Mammuthus primigenius* (8/1)
35	Gorzuchów	Möhlten	50°29′25″N 16°34′38″E	*Coelodonta antiquitatis* (2/1)
36	Gostków	Giesmannsdorf	50°50′53″N 16°12′7″E	*Equus ferus* (2/1)
37	Góra	Guhrau	51°40′5″N 16°32′22″E	*Mammuthus primigenius*, *Alces alces*
38	Góra Świętej Anny	St. Annaberg	50°27′33″N 18°10′6″E	*Mammuthus primigenius* (1/1)
39	Görlitz-Hagenwerder	Görlitz-Nikrisch	51°4′11″N 14°57′47″E	*Megaloceros giganteus* (1/1)
40	Grądy	Perschkenstein	50°29′59″N 17°3′9″E	*Mammuthus primigenius* (1/1)
41	Gródczanki-Kietrz	Ratsch (Katscher)	50°4′3″N 18°3′11″E	*Mammuthus primigenius* (1/1)
42	Hainewalde	Hainewalde	50°54′20″N 14°42′0″E	*Equus ferus* (6/1)
43	Henryków 15	Heinrichau	50°39′9″N 17°0′39″E	*Rangifer tarandus* (2/1)
44	Hrádek nad Nisou	Grottau	50°51′15″N 14°50′35″E	*Equus ferus* (5/1)
45	Imbramowice	Ingramsdorf	50°58′6″N 16°34′0″E	*Palaeoloxodon antiquus* (2/1), *Equus ferus*, *Coelodonta antiquitatis* (1/1), *Stephanorhinus kirchbergensis* (1/1)
46	Jedlina Zdrój-Jedlinka	Tannhausen	50°42′50″N 16°21′42″E	*Equus ferus* (1/1)
47	Jelenia Góra	Hirschberg	50°54′14″N 15°44′11″E	*Mammuthus primigenius* (1/1), *Coelodonta antiquitatis* (1/1), *Rangifer tarandus*, *Cervus elaphus* (1/1)
48	Jerzmanice	Hermsdorf	51°6′56″N 15°52′28″E	*Mammuthus primigenius* (1/1)
49	Kamiennik	Kamnig	50°36′0″N 17°2′40″E	*Cervus elaphus* (1/1), *Ovibos moschatus* (1/1), *Bos primigenius* (8/1)
50	Katowice	Kattowitz	50°15′51″N 19°1′25″E	*Mammuthus primigenius* (2/1)
51	Katowice-Szopienice	Schoppinitz	50°15′58″N 19°5′52″E	*Mammuthus primigenius*
52	Kąty Opolskie	Konty (Stauwerk)	50°33′27″N 17°58′30″E	*Mammuthus primigenius* (1/1)
53	Kąty Wrocławskie	Canth	51°1′51″N 16°46′3″E	*Ursus* ex. gr. *spelaeus* (2/1)
54	Klucz	Klutschau	50°26′8″N 18°16′46″E	*Mammuthus primigenius* (1/1)
55	Kluczbork	Kreuzburg	50°58′23″N 18°12′51″	*Bos primigenius* (3/1)
56	Kłodzko-Ustronie	Halbendorf	50°27′29″N 16°39′13″E	*Equus ferus* (4/1)
57	Kobiór	Kobier	50°3′37″N 18°56′22″E	*Equus ferus* (1/1)
58	Kojęcin	Baumgarten	50°51′36″N 17°5′20″E	*Mammuthus trogontherii* (1/1)
59	Konary	Kuhnern	51°1′28″N 16°23′30″E	*Mammuthus primigenius* (1/1)
60	Kopanie-Kruszyna canal	Koppen-Schönauer Kanal		*Mammuthus primigenius* (1/1)
61	Kotlarnia	Jakobswalde	50°16′38″N 18°22′13″E	*Mammuthus primigenius* (4/1)
62	Kowale	Cavallen	51°17′57″N 16°58′14″E	*Alces alces* (1/1)
63	Kożuchów	Freystadt	51°44′43″N 15°35′40″E	*Mammuthus primigenius*
64	Krapkowice (Oder river)	Krappitz Oderfluss	50°28′29″N 17°58′2″E	*Cervus elaphus* (1/1)
65	Krzyżanowice	Kreuzenort	49°58′57″N 18°16′7″E	*Mammuthus primigenius* (25/3)
66	Kuźnica Warężyńska		50°24′10″N 19°10′53″E	*Mammuthus primigenius* (4/1)

(*Continued*)

Table 3. (*Continued*).

Site no.	Current name	Former name	Coordinates	Mammal species
67	Legnica	Liegnitz	51°12′19″N 16°9′23″E	*Mammuthus primigenius*, *Ovibos moschatus* (1/1)
68	Legnica-Tarninów	Dornbusch	51°11′57″N 16°9′15″E	*Cervus elaphus* (1/1)
69	Leśnica	Leschnitz	50°25′45″N 18°10′52″E	*Mammuthus primigenius*
70	Lędziny	Lendzin	50°8′33″N 19°7′51″E	*Mammuthus primigenius* (16/1)
71	Lubij	Löbau	51°5′40″N 14°40′0″E	*Rangifer tarandus* (1/1)
72	Lubin	Lüben	51°23′51″N 16°12′34″E	*Mammuthus primigenius*, *Coelodonta antiquitatis*, *Bos primigenius*
73	Lubliniec	Loben	50°40′5″N 18°40′45″E	*Ursus* ex. gr. *spelaeus* (1/1)
74	Lwówek Śląski	Löwenberg	51°6′37″N 15°35′5″E	*Mammuthus primigenius*
75	Łaziska Górne	Lazisk	50°9′17″N 18°50′37″E	*Mammuthus primigenius* (1/1)
76	Maciejowice	Matzwitz	50°30′7″N 17°8′24″E	*Mammuthus primigenius*
77	Maciejowice	Matzwitz	50°29′50″N 17°9′28″E	*Mammuthus primigenius* (2/1), *Equus ferus* (1/1)
78	Malerzowice Wielkie		50°35′5″N 17°29′33″E	*Mammuthus primigenius* (1/1)
79	Malschwitz	Kleinsaubernitz	51°14′23″N 14°31′67″E	*Canis lupus* (1/1), *Alces alces* (1/1), *Cervus elaphus* (7/1), *Capreolus capreolus* (3/1)
80	Małowice	Kunzendorf	51°24′29″N 16°28′16″E	*Equus ferus* (+5/?)
81	Masłów	Massel	51°20′22″N 17°7′36″E	*Mammuthus primigenius* (+200/1), *Alces alces*
82	Miękinia	Nimkau	51°11′27″N 16°46′44″E	*Alces alces* (1/1)
83	Mojęcice	Mondschütz	51°18′1″N 16°35′43″E	*Equus ferus* (+5/?), *Cervus elaphus* (1/1)
84	Nieboczowy (Odra)	Niebotschau (Oder)	50°0′31″N 18°20′32″E	*Mammuthus primigenius* (1/1)
85	Nowa Ruda-Słupiec	Schlegel	50°32′46″N 16°33′6″E	*Mammuthus primigenius* (1/1)
86	Nowe Miasteczko	Neustädtel	51°41′27″N 15°44′5″E	*Mammuthus primigenius* (1/1)
87	Nysa	Neisse	50°28′17″N 17°20′2″E	*Mammuthus primigenius* (1/1)
88	Ochranów	Herrnhut	51°1′0″N 14°44′30″E	*Mammuthus primigenius* (1/1)
89	Oleśnica	Oels	51°12′46″N 17°22′59″E	*Mammuthus primigenius* (5/1)
90	Oleśnica-Lucień	Oels-Leuchten	51°12′46″N 17°22′59″E	*Bison priscus* (5/1)
91	Oława	Ohlau	50°56′38″N 17°17′33″E	*Mammuthus primigenius* (1/1), *Bison priscus* (1/1)
92	Opole	Oppeln	50°39′53″N 17°55′37″E	*Mammuthus primigenius*
93	Opole-Groszowice	Groschowitz	50°37′31″N 17°57′38″E	*Mammuthus primigenius* (1/1)
94	Otmuchów	Ottmachau-Künzelberg	50°27′42″N 17°10′3″E	*Mammuthus primigenius* (1/1)
95	Otmuchów	Ottmachau	50°28′4″N 17°11′5″E	*Mammuthus primigenius*
96	Otrębów	Otrembau	49°49′4″N 18°34′58″E	*Mammuthus primigenius*
97	Pawłowiczki	Gnadenfeld	50°14′29″N 18°2′46″E	*Ursus arctos priscus* (1/1), *Palaeoloxodon antiquus* (1/1), *Mammuthus primigenius* (1/1), *Equus ferus* (+5/1), *Coelodonta antiquitatis* (+20/1), *Rangifer tarandus*
98	Perzów	Perschau	51°16′36″N 17°48′48″E	*Coelodonta antiquitatis* (1/1)
99	Pethau	Pethau	50°54′4″N 14°45′56″E	*Mammuthus primigenius* (5/1), *Equus ferus* (8/3), *Coelodonta antiquitatis* (11/1), *Cervus elaphus* (2/1), *Bison priscus* (6/1)
100	Piekary Śląskie-Szarlej	Scharley	50°23′38″N 18°57′95″E	*Mammuthus primigenius* (2/1), *Equus ferus* (6/1), *Bos primigenius* (2/1)
101	Pieszków	Petschkendorf	51°33′33″N 16°23′33″E	*Alces alces* (1/1)
102	Pietraszyn 11	Klein Peterwitz	51°2′1″N 18°5′26″E	*Mustela nivalis* (1/1), *Equus ferus* (1/1)
103	Pietrowice Wielkie	Gross Peterwitz	50°5′3″N 18°5′36″E	*Equus ferus* (1/1)
104	Pogalewo Wielkie	Gross Pogul	51°15′10″N 16°38′12″E	*Ovibos moschatus* (1/1)
105	Przerzeczyn-Zdrój	Dirsdorf	50°41′7″N 16°49′36″E	*Equus ferus*
106	Pyskowice	Peiskretscham	50°23′53″N 18°37′39″E	*Panthera spelaea spelaea* (6/2), *Ursus* ex. gr. *spelaeus* (1/1), *Mammuthus primigenius* (+40/3), *Equus ferus* (5/3), *Ovibos moschatus* (1/1), *Bison priscus* (1/1)
107	Pyskowice-Dzierżno	Sersno	50°22′8″N 18°33′32″E	*Mammuthus primigenius* (+35/?), *Equus ferus*, *Stephanorhinus kirchbergensis*, *Rangifer tarandus*, *Alces alces*, *Capreolus capreolus*, *Ovibos moschatus*, *Bos primigenius*
108	Racibórz (Odra)	Ratibor (Oder)	50°5′31″N 18°13′11″E	*Mammuthus primigenius* (1/1), *Equus ferus* (+7/1), *Bos primigenius* (1/1)
109	Racibórz-Ostróg	Proschowitz	50°5′52″N 18°13′23″E	*Mammuthus primigenius* (5/1), *Coelodonta antiquitatis* (1/1)
110	Radzimów	Bellmannsdorf	51°3′12″N 15°6′34″E	*Alces alces* (1/1)
111	Rakoszyce	Rackschütz	51°5′45″N 16°39′9″E	*Mammuthus trogontherii* (1/1), *Mammuthus primigenius* (+20/1)
112	Ruda Śląska-Bielszowice	Bielschowitz	50°15′46″N 18°51′13″E	*Ovibos moschatus* (1/1)
113	Rusko	Rauske	50°59′28″N 16°27′38″E	*Equus ferus*, *Coelodonta antiquitatis*
114	Rydułtowy-Orłowiec	Orlowietz	50°3′59″N 18°25′15″E	*Ovibos moschatus* (1/1)
115	Rzeczyca	Retzitz	50°21′20″N 18°33′44″E	*Mammuthus primigenius*, *Coelodonta antiquitatis*, *Rangifer tarandus*, *Cervus elaphus*, *Bos primigenius*
116	Sady	Krotzel	50°51′54″N 16°40′17″E	*Equus ferus* (1/1)
117	Schöpstal-Kunnersdorf	Kunnersdorf	51°12′11″N 14°55′33″E	*Ursus* ex. gr. *spelaeus* (1/1), *Equus ferus* (+5/1),
118	Siemonia		50°25′19″N 19°3′8″E	*Mammuthus primigenius* (+15/1), *Coelodonta antiquitatis* (+5/1), *Equus ferus* (+5/1), *Sus scrofa* (1/1)
119	Skarszyn	Skarsine	51°15′15″N 17°9′36″E	*Ursus arctos priscus* (1/1), *Coelodonta antiquitatis* (36/1),
120	Sobótka	Zobten	50°53′57″N 16°44′32″E	*Equus ferus* (1/1)
121	Sosnowiec-Maczki Bór		50°16′36″N 19°8′22″E	*Mammuthus primigenius* (1/1), *Equus ferus* (1/1)
122	Sosnowiec-Milowice	Milowice	50°17′20″N 19°4′52″E	*Panthera spelaea spelaea* (1/1), *Mammuthus primigenius* (+87/?), *Equus ferus* (23/3), *Coelodonta antiquitatis* (49/2?), *Rangifer tarandus* (15/?), *Ovibos moschatus* (5/5)
123	Sosnowiec-Sielec	Sielce	50°16′45″N 19°8′31″E	*Mammuthus primigenius* (1/1)
124	Stary Wielisław	Altwilmsdorf	50°23′57″N 16°33′53″E	*Equus ferus* (1/1)
125	Strzegom	Striegau	50°57′40″N 16°20′40″E	*Mammuthus primigenius*, *Coelodonta antiquitatis*, *Alces alces*

(*Continued*)

Table 3. (*Continued*).

Site no.	Current name	Former name	Coordinates	Mammal species
126	Strzegom	Striegau	50°57′40″N 16°20′40″E	*Equus ferus* (1/1)
127	Strzelin	Striegau	50°57′40″N 16°20′40″E	*Equus ferus* (1/1)
128	Studzienna	Studen	50°4′5″N 18°12′22″E	*Mammuthus primigenius* (1/1)
129	Syrynia	Syrin	50°1′10″N 18°20′44″E	*Coelodonta antiquitatis* (1/1)
130	Szprotawa	Sprottau	51°34′0″N 15°32′12″E	*Equus ferus* (1/1), *Alces alces* (1/1), *Cervus elaphus* (1/1), *Bos primigenius* (6/1)
131	Ścinawa-Kozice	Geissendorf	51°24′40″N 16°25′23″E	*Mammuthus primigenius* (1/1)
132	Środa Śląska	Neumarkt	51°9′50″N 16°35′42″E	*Equus ferus* (1/1)
133	Świdnica	Schweidnitz	50°50′40″N 16°29′30″E	*Capreolus capreolus* (2/1)
134	Święcko	Schwenz	50°29′50″N 16°35′9″E	*Equus ferus* (2/1), *Coelodonta antiquitatis* (5/2)
135	Tarnowskie Góry	Tarnowitz	50°26′44″N 18°51′40″E	*Mammuthus primigenius* (1/1)
136	Trzebnica	Trebnitz	51°18′18″N 17°3′41″E	*Mammuthus primigenius* (+5/1)
137	Trzebnica	Trebnitz	51°18′18″N 17°3′41″E	*Coelodonta antiquitatis* (+10/1)
138	Tworków	Tworkau	50°0′16″N 18°14′9″E	*Mammuthus primigenius* (2/1)
139	Tworków (Odra river)	Tworkau (Oder)	50°0′16″N 18°14′9″E	*Mammuthus primigenius* (1/1)
140	Uniemyśl	Berthelsdorf	50°37′49″N 16°2′28″E	*Equus ferus* (1/1)
141	Uraz	Auras	51°14′40″N 16°51′13″E	*Mammuthus primigenius* (1/1)
142	Wambierzyce	Albendorf	50°29′21″N 16°27′22″E	*Equus ferus* (4/1)
143	Wąsosz	Herrnstadt	51°33′47″N 16°41′31″E	*Cervus elaphus*
144	Węgry	Wengern	50°44′35″N 18°1′8″E	*Panthera spelaea spelaea* (1/1)
145	Wierzbice	Wirrwitz	50°57′20″N 16°53′36″E	*Equus ferus* (1/1), *Megaloceros giganteus* (2/1)
146	Witków	Wittgendorf	51°37′46″N 15°31′11″E	*Panthera spelaea spelaea* (1/1), *Palaeoloxodon antiquus* (1/1), *Mammuthus primigenius* (5/1), *Rangifer tarandus* (1/1), *Alces alces* (1/1), *Megaloceros giganteus* (1/1), *Bos primigenius* (3/1)
147	Wodzisław Śląski	Loslau	50°0′0″N 18°27′45″E	*Mammuthus primigenius* (6/1)
148	Wojnowice	Wannowitz	50°6′48″N 17°52′58″E	*Cervus elaphus* (1/1)
149	Wołczyn	Constadt	50°1′6″N 18°2′53″E	*Equus ferus* (1/1)
150	Wołów	Wohlau	51°20′29″N 16°37′42″E	*Cervus elaphus* (1/1)
151	Wostrowc	Ostritz	51°0′53″N 14°55′56″E	*Mammuthus primigenius* (2/1)
152	Wójcice B	Woitz	50°27′45″N 17°12′44″E	*Mammuthus primigenius* (+20/?)
153	Wrocław Hallera 1		51°5′22″N 16°59′40″E	*Canis lupus* (1/1), *Mammuthus primigenius* (7/1), *Equus ferus* (37/?), *Stephanorhinus kirchbergensis* (3/1), *Rangifer tarandus* (1/1), *Bison priscus* (?/8), *Bos primigenius* (1/1)
154	Wrocław-Oporów	Opperau	51°7′8″N 16°55′34″E	*Mammuthus primigenius* (12/1), *Coelodonta antiquitatis* (3/1), *Equus ferus* (+10/?), *Rangifer tarandus* (4/2), *Bison priscus* (2/1),
155	Wrocław-Osobowice	Breslau-Oswitz	51°8′45″N 16°59′12″E	*Mammuthus primigenius*
156	Wrocław-Ostrów Tumski	Breslau-Kreuzkirche	51°6′51″N 17°2′54″E	*Mammuthus primigenius* (2/1), *Cervus elaphus* (1/1)
157	Wrocław-Rędzin	Ransern	51°10′83″N 16°58′37″E	*Equus ferus*, *Cervus elaphus* (1/1), *Bison priscus*, *Bos primigenius*
158	Wrocław-Widawa	Breslau-Weide	51°10′42″N 17°1′21″E	*Cervus elaphus* (1/1)
159	Wrocław-Żerniki	Breslau-Neukirch	51°7′34″N 16°54′56″E	*Mammuthus primigenius*
160	Zabrze-Makoszowy	Scharnafkatal	50°16′27″N 18°44′56″E	*Mammuthus primigenius*
161	Zastruże 4	Sasterhausen	50°59′8″N 16°30′56″E	*Mammuthus primigenius* (17/1), *Equus ferus* (1/1),
162	Zgorzelec	Görlitz	51°9′1″N 15°0′31″E	*Mammuthus primigenius* (2/1), *Coelodonta antiquitatis* (1/1), *Bison priscus*
163	Zgorzelec-Biesnitzer Strasse	Görlitz-Biesnitz	51°9′1″N 15°0′31″E	*Mammuthus primigenius* (1/1)
164	Zgorzelec-Jewish Cementery	Görlitz-Judenkirchof	51°9′1″N 15°0′31″E	*Mammuthus primigenius* (1/1)
165	Ziębice	Münsterberg	50°36′0″N 17°2′40″E	*Ursus arctos priscus* (1/1), *Mammuthus primigenius* (+7/1), *Equus ferus* (10/1), *Coelodonta antiquitatis* (+5/1), *Ovibos moschatus* (1/1), *Bos primigenius*
166	Zimna Woda	Kaltwasser	51°19′5″N 16°6′35″E	*Equus ferus* (11/?)
167	Zittau	Żytawa	50°53′46″N 14°48′26″E	*Ursus* ex. gr. *spelaeus* (1/1), *Equus ferus* (14/1)
168	Zittau	Żytawa	50°53′41″N 14°48′11″E	*Equus ferus* (1/1)
169	Zittau/Karlstrasse	Żytawa, Karol street	50°54′1″N 14°47′8″E	*Mammuthus primigenius* (+5/?)
170	Zittau-Westpark	Żytawa-Weinau	50°53′50″N 14°46′56″E	*Cervus elaphus* (1/1)
171	Żagań	Sagan	51°37′2″N 15°18′53″E	*Cervus elaphus* (4/1)
172	Żarka	Sercha	51°12′37″N 15°1′6″E	*Equus ferus* (1/1)
173	Żary	Sorau	51°38′12″N 15°8′12″E	*Mammuthus primigenius* (1/1)
174	Żmigród	Trachenberg	51°28′13″N 16°54′18″E	*Equus ferus* (5/1), *Coelodonta antiquitatis* (3/1), *Cervus elaphus* (1/1)

Notes: In brackets are given NISP and MNI, data according to Hermann and Brachvogel (1711), Volkmann (1720), Göppert (1830), Meyer (1835), Otto (1837), Hensel (1852, 1853a, 1853b), Scharenberg (1855), Brandt (1870), Römer (1867, 1870), Virchow (1870), Göppert (1873), Römer (1873, 1874, 1875), Remelé (1875), Römer (1879), Wengen (1879), Struckmann (1880), Römer (1881a, 1881b), Rose (1882), Kunisch (1883), Gürich (1885), Römer (1885, 1888), Gürich (1893), Volz and Leonhard (1896), Volz (1897a, 1897b), Dathe (1899), Wüst (1901), Michael (1902), Gürich (1905), Kowarzik (1908, 1912), Kiernik (1912), Frech (1913), Gürich (1913), Pax (1921), Seger 1922, Herr 1924a, Krause 1925, Pohle 1925, Schulz (1925), Heinke (1926), Anonymous (1932), Juhnke (1932), Heinevetter (1933), Ryziewicz (1933), Zeuner (1934), Frenzel (1936), Konior (1936), Rode (1936), Heinevetter (1937), Hoffmann (1941), Soergel (1944), Ryziewicz (1949), Juhnke (1952), Ryziewicz (1954), Kulczycki (1955), Zieliński (1958), Kowalski (1959), Lewandowski (1998), Wiszniowska et al. (2003), Kazanecka (2004), Wilke (2004), Tietz (2005), Wojtal (2007), Barycka (2008), Wiśniewski, Stefaniak, et al. (2009), Wiśniewski, Wojtal, et al. (2009), Pawłowska (2015), Kardynał et al. (2016), Pawlik (2016).

Mount Czerwoniak (Rotherberg)

Mt. Czerwoniak near Kłodzko was the first reported Silesian site with remains of woolly rhinoceros, where two fragments of rhinoceros and horse long bones were found. The discovery was made in a limestone quarry located ca 60–70 m from the Nysa Kłodzka River, filled with limestone rubble and clays (Otto 1837).

Gorzuchów (Möhlten)

Kunisch (1883) described the discovery of a rhinoceros humerus fragment and two pelvis fragments in the clays ca. 3 m below the ground surface in a limestone quarry between Gorzuchów and Święcko. In recent collections there are no bones marked as coming from Gorzuchów, however, there are remains labelled as originating from Święcko, and they agree with Kunisch's (1883) description, so it is probably the same find. In this area glacial clays from one of the older glaciations (Middle or late Middle Pleistocene) form a thin cover of Pleistocene sediments on crystalline rocks and in them reside remains of Late Pleistocene loess. Probably, as in several other sites described in this paper, the remains may have been present on the loess-clay boundary or in loess-eroded clays.

Imbramowice (Ingramsdorf)

A fragment of rhinoceros right mandible with five teeth was found in the now defunct brickyard in Ibramowice in 1904 (Gürich 1905, 1913). Determination of the age of the carbonate sediments with organic material and rhinoceros remains was extremely problematic In the early twentieth century it was thought that they represented a great interglacial dated at MIS 12 (Juhnke 1932). Only recent research (Mamakowa 1976; Kaczmarska 1976; Mamakowa 1989) showed that the lake sediments formed in the Eemian Interglacial (MIS 5e). In such a situation palynological analysis clearly points to the Eemian age of the remains. In later years, many mollusc remains, rodent teeth, fish remains and four forest elephant teeth were found in the Ibramowice brickyard in gyttia (Juhnke 1932).

Figure 4. Location of Silesia (Poland shaded black, Silesia shaded red) in Europe (A) and Silesia (shaded grey) superimposed on modern national borders (B).
Source: Pictures were made personally by Adrian Marciszak
Note: State boundaries indicated by black lines, administrative boundaries indicated by red lines.

Jelenia Góra (Hirschberg)

Apart from the mention made by Gürich (1885) of the town Jelenia Góra in the compilation of sites with Silesian fossil fauna, with rhinoceros remains, there are no detailed reports on the locality. It may be the same as the place described by Römer (1881a), on the southern edge of Jelenia Góra in the Bóbr valley, where an accumulation of bones of different mammals was found in 1873 during building of a factory. Römer (1881a) stated that the skeletal remains formed a pile 2 feet high and included bones of cattle, mammoth and fragments of deer antlers. In the same report, Römer (1881a) mentioned an earlier find in the area of Jelenia Góra, where in 1865 numerous remains of Pleistocene vertebrates were discovered at the foot of the Chrobry hill (Hausberg). Gürich (1885) mentioned a rhinoceros pelvis. In the recent collection there is such a bone, with an inscription: 'Weltende im Boberthal bei Hirschberg', so probably it is the same site.

Milowice

Site Milowice located in the Krynica valley near Sosnowiec was described by Ryziewicz (1933) and Kozłowska (1933), where numerous remains of mammoth, woolly rhinoceros, and musk ox were found in the bottom part of alluvium of a total thickness of ca. 15 m. The locality was in a sand pit then located on the German side of the border but now used by the Polish mine Saturn. It is interesting that the collection of the Museum of the Polish Geological Institute in Warsaw holds a well-preserved woolly rhinoceros mandible described as coming from the Saturn mine near Katowice. It could not be ascertained whether it came from the collection compiled by Ryziewicz and transferred to the Museum of the Polish Geological Institute in Warsaw in the post-war period with numerous remains from the region of Pyskowice, which was used for the reconstruction of entire skeletons of mammoth and woolly rhinoceros. Perhaps a jaw mentioned already in the nineteenth century was also found in that area because the gravel mine Saturn is only ca. 8 km away from Chorzów.

Otmuchów (Otmachau)

The location indicated by Gürich (1885) as Otmuchów (Otmachau) is likely to be associated with the finds in a quarry in the environs of Maciejowice. The first mention of remains of Pleistocene animals from the area comes from the published report of a pharmacist Welzel from Otmuchów (1842). He described a well-preserved mammoth molar and two bone fragments which were difficult to determine but might be parts of the humerus of the same animal. A large deer antler was also found there. Römer (1873) mentioned finding rhinoceros molars in 1856 on a quarry dump near Otmuchów. Also Drescher (1932) mentioned finding rhinoceros, mammoth and horse remains in the environs of Maciejowice.

Pawłowiczki (Gnadenfeld)

A well-preserved skull of woolly rhinoceros 78 cm long and 33 cm wide (Figure 5) was found in 1877 in Pawłowiczki on the Głubczyce Plateau. According to the description the remains were most probably found in a sand pit on the eastern side of the village. The skull was found ca 6.5 m below the surface of a layer of yellowish-grey clay sands (Römer 1879). Besides, many other skeletal remains of the same individual, among others ribs and scapula fragments, were found in the same site (Römer 1879), as well as a pelvis (Gürich 1885). After the reconstruction, the calvarium from Pawłowiczki became the main attraction of the mineralogical museum of the University of Wroclaw. A picture of this skull exhibited in the Geological Institute of the University of Wroclaw was published by Zeuner (1934). Currently in the collection there is a part of pelvis and possibly a still undetermined scapula and rib fragments described by Römer (1879), as well as a skull fragment. However, it is not certain if it is the skull fragment described above; its post-war fate remains unknown.

Perzów (Perschau)

According to Römer's (1886) brief description, left part of a rhinoceros pelvis was found in 1885 during digging of wells in the mansion located in Perzów near Syców. He did not specify the exact location or depth. It follows from the old topographic maps that a great estate was located in the southern part of the village, and it can be assumed that the wells were dug there. According to the geological map (Winnicki 2002), the area was located in a former small lake, later filled with Holocene sediments. According to the profiles of the holes drilled in the 1970s for water supply within the estate, the thickness of silty clay sediments of the lake reached 11.5 m, and in the bottom part there were about 2 m thick layers of gyttia and lacustrine chalk. The deposits were not stratigraphically examined. Considering the profiles of other fossil lakes in the area, on the southern foreland of the Trzebnicki Bank (Rotnicki and Tobolski 1965, 1969; Kuszell 1997; Winnicki 2002), it can be concluded that they arose from the end of the Eemian through the Vistula glaciation, and even to the early Holocene. Thus it can now be specified that the rhinoceros remains from Perzów embedded in the lake sediments are not older than the Eemian interglacial.

Skarszyn (Skarsine)

The site in Skarszyn, with numerous rhinoceros remains, was described by Römer (1881b). The bones were found in an excavation located on the southern edge of the Trzebnickie Hills between Skarszyn and Bierzyce (formerly Perschutz), at a depth of ca. 5 m, while exploiting clay deposits. The current state of the collection is not compatible with the literature data, because publications of the nineteenth-century fail to mention metacarpals and metatarsals. The bone described as tibia by Gürich (1885) is in fact ulna, a mistake probably made originally by Römer.

According to Römer (1881b), the rhinoceros remains were probably accumulated on the boundary of the loess and the hills. In the geological description of the area, the loess cover in the Trzebnickie Hills has an average thickness of several metres. The stratigraphic position of the find can be determined based on the profiles of loess sediments located 1.5–2 km from the site (sites Skarszyn and Zapręzyn) and surveyed by Jary (1996, 2007). Based on more reliable dating methods C14 and OSL cited by this author, the loess cover was formed mainly in the MIS 2, and its bottom layer, at a depth of 4–5 m, is a complex of 2–3 fossil soils which is difficult to separate and was probably formed from the Eemian till MIS 3. The deposit of the overhang at the base of the compound loess with fossil rhinoceros remains is not younger than the end of MIS 3, but the exact age is impossible to determine. Thus the deposits with the rhinoceros remains embedded

Table 4. Occurrence of mammals in Silesian open-air sites.

Species	Sites
Panthera spelaea spelaea	Brzeziny (10), Pyskowice (106), Sosnowiec-Milowice (122), Węgry (144), Witków (146)
Canis lupus	Malschwitz (79), Wrocław Hallera 1 (153)
Mustela nivalis	Pietraszyn 11 (102)
Ursus arctos priscus	Pawłowiczki (97), Skarszyn (119), Ziębice (165)
Ursus ex. gr. *spelaeus*	Kąty Wrocławskie (53), Lubliniec (73), Pyskowice (106), Schöpstal-Kunnersdorf (117), Zittau (167)
Mammuthus trogontherii	Frączków (29), Gliwice-Szobiszowice (34), Kojęcin (58), Rakoszyce (111)
Palaeoloxodon antiquus	Czechy (19), Imbramowice (45), Pawłowiczki (97), Środa Śląska (132), Witków (146)
Mammuthus primigenius	Berzdorfer See (1), Bielice, Brzeg (Odra river) (3), Brzeg Dolny (8), Brzeziny (10), Budziszyn (11), Chobienia (12), Chorzów (13), Chorzów-Dąb (14), Czarnocin (17), Czechowice-Dziedzice (18), Czechy (19), Dzierżysław (27), Gliwice (31), Gliwice-huta (32), Gliwice-Łabędy (33), Gliwice-Szobiszowice (34), Góra (37), Góra Świętej Anny (38), Gródczanki-Kietrz (41), Jelenia Góra (47), Jerzmanice (48), Katowice (50), Katowice-Szopienice (51), Kąty Opolskie (52), Klucz (54), Konary (59), Kopanie-Kruszyna canal (60), Kotlarnia (61), Kożuchów (63), Krzyżanowice (65), Kuźnica Warężyńska (66), Legnica (67), Leśnica (69), Lędziny (70), Lubin (72), Lwówek Śląski (74), Łaziska Górne (75), Malerzowice Wielkie (78), Masłów (81), Nieboczowy (Odra) (84), Nowa Ruda-Słupiec (85), Nowe Miasteczko (86), Nysa (87), Ochranów (88), Oleśnica (89), Oława (91), Opole (92), Opole-Groszowice (93), Otmuchów (94), Pawłowiczki (97), Pethau (99), Piekary-Śląskie-Szarlej (100), Pyskowice (106), Pyskowice-Dzierżno (107), Racibórz (Odra) (108), Racibórz-Ostróg (109), Rakoszyce (111), Rzeczyca (115), Siemonia (118), Sosnowiec-Maczki Bór (121), Sosnowiec-Milowice (122), Sosnowiec-Sielec (123), Strzegom (125), Studzienna (128), Ścinawa-Kozice (131), Tarnowskie Góry (135), Trzebnica (137), Tworków (Odra river) (138), Uraz (141), Witków (146), Wodzisław Śląski (147), Wostrowc (151), Wójcice B (152), Wrocław Hallera 1 (153), Wrocław-Oporów (154), Wrocław-Osobowice (155), Wrocław-Ostrów Tumski (156), Wrocław Żerniki (159), Zabrze-Makoszowy (160), Zastruże 4 (161), Zgorzelec (162), Ziębice (165), Zittau /Karlstrasse (169), Żary (173)
Equus ferus	Bobrów (4), Brzeziny (10), Cyprzanów (16), Czerwoniak (23), Chrastava (15), Czechowice-Dziedzice (18), Deutsch Ossig (24), Dzierżysław (27), Ebersbach-Neugersdorf (28), Gostków (36), Hainewalde (42), Hrádek nad Nisou (44), Imbramowice (45), Jedlina Zdrój-Jedlinka (46), Kłodzko-Ustronie (56), Kobiór (57), Małowice (80), Mojęcice (83), Pawłowiczki (97), Pethau (99), Piekary Śląskie-Szarlej (100), Pietraszyn 11 (102), Pietrowice Wielkie (103), Pyskowice (106), Pyskowice-Dzierżno (107), Przerzeczyn-Zdrój (105), Racibórz (108), Rusko (113), Sady (116), Schöpstal-Kunnersdorf (117), Siemonia (118), Sobótka (120), Sosnowiec-Maczki Bór (121), Sosnowiec-Milowice (122), Stary Wielisław (124), Strzegom (126), Strzelin (127), Środa Śląska (132), Szprotawa (130), Święcko (134), Uniemyśl (140), Wambierzyce (142), Wierzbice (145), Wołczyn (149), Wrocław Hallera 1 (153), Wrocław-Oporów (154), Wrocław-Rędzin (157), Zastruże 4 (161), Zgorzelec-Biesnitzer Strasse (163), Zgorzelec-Jewish Cementery (164), Ziębice (165), Zimna Woda (166), Żarka (172), Żmigród (174), Zittau (168)
Coelodonta antiquitatis	Berzdorfer See (1), Brzeziny (10), Chorzów (13), Czechowice-Dziedzice (18), Czerwoniak (23), Gostków (35), Imbramowice (45), Jelenia Góra (47), Lubin (72), Otmuchów (94), Pawłowiczki (97), Perzów (98), Pethau (99), Racibórz-Ostróg (109), Rusko (113), Rzeczyca (115), Siemonia (118), Skarszyn (119), Sosnowiec-Milowice (122), Strzegom (125), Syrynia (129), Trzebnica (136), Wrocław-Oporów (154), Zgorzelec (162), Ziębice (165), Żmigród (174)
Stephanorhinus kirchbergensis	Imbramowice (45), Wrocław Hallera 1 (153)
Sus scrofa	Boguchwałów (6), Dzierżysław (27), Siemonia (118)
Rangifer tarandus	Bobrów (4), Budziszyn (11), Dzierżysław (27), Henryków 15 (43), Jelenia Góra (47), Lubij (71), Pawłowiczki (97), Pyskowice-Dzierżno (107), Rzeczyca (115), Sosnowiec-Milowice (122), Witków (146), Wrocław Hallera 1 (153), Wrocław-Oporów (154)
Alces alces	Bogatynia-Turoszów (5), Bolesławiec (7), Brzeg Dolny (9), Chorzów (13), Góra (37), Kowale (62), Malschwitz (79), Masłów (81), Miękinia (82), Pieszków (101), Pyskowice-Dzierżno (107), Radzimów (110), Strzegom (126), Szprotawa (130), Witków (146)
Megaloceros giganteus	Görlitz-Hagenwerder (39), Wierzbice (145), Witków (146)
Dama dama	Dolnik (25), Dzierżoniów (26)
Cervus elaphus	Gierałtowice (30), Jelenia Góra (47), Kamiennik (49), Krapkowice (Oder river) (64), Legnica-Tarninów (68), Malschwitz (79), Mojęcice (83), Pethau (99), Rzeczyca (115), Szprotawa (130), Wąsosz (143), Wojnowice (148), Wołów (150), Wrocław-Ostrów Tumski (156), Wrocław-Rędzin (157), Wrocław-Widawa (158), Zittau-Westpark (170), Żagań (171), Żmigród (174)
Capreolus capreolus	Chorzów (13), Malschwitz (79), Świdnica (133)
Praevibos priscus	Ruda Śląska-Bielszowice (112)
Ovibos moschatus	Będzin-Grodziec (2), Brzeg Dolny (9), Czernicki tunnel (22), Kamiennik (49), Legnica (67), Pogalewo Wielkie (104), Pyskowice (106), Pyskowice-Dzierżno (107), Sosnowiec-Milowice (122), Rydułtowy-Orłowiec (114), Ziębice (165)
Bison priscus	Oława (91), Oleśnica-Lucień (90), Pethau (99), Pyskowice (106), Wrocław Hallera 1 (153), Wrocław-Oporów (cf.) (154), Wrocław-Rędzin (157), Zgorzelec (162)
Bos primigenius	Berzdorfer See (1), Kamiennik (49), Kluczbork (55), Lubin (72), Piekary Śląskie-Szarlej (100), Pyskowice-Dzierżno (107), Racibórz (Odra) (108), Rzeczyca (115), Szprotawa (130), Witków (146), Wrocław Hallera 1 (cf.) (153), Wrocław-Rędzin (157), Ziębice (165)

Notes: In brackets are showed number of sites (data according to Hermann and Brachvogel 1711; Volkmann 1720; Göppert 1830; Meyer 1835; Otto 1837; Hensel 1852, 1853a, 1853b; Scharenberg 1855; Brandt 1870; Römer 1867, 1870; Virchow 1870; Göppert 1873; Römer 1873, 1874, 1875; Remelé 1875; Römer 1879; Wengen 1879; Struckmann 1880; Römer 1881a, 1881b, Rose 1882; Kunisch 1883; Gürich 1885; Römer 1885, 1888; Gürich 1893; Volz and Leonhard 1896; Volz 1897a, 1897b; Dathe 1899; Wüst 1901; Michael 1902; Gürich 1905; Kowarzik 1908, 1912; Kiernik 1912; Frech 1913; Gürich 1913; Pax 1921; Seger 1922; Herr 1924a; Krause 1925; Pohle 1925; Schulz 1925; Heinke 1926; Anonymous 1932; Juhnke 1932; Heinevetter 1933; Ryziewicz 1933; Zeuner 1934; Frenzel 1936; Konior 1936; Rode 1936; Heinevetter 1937; Hoffmann 1941; Soergel 1944; Ryziewicz 1949; Juhnke 1952; Ryziewicz 1954; Kulczycki 1955; Zieliński 1958; Kowalski 1959; Lewandowski 1998; Wiszniowska et al. 2003; Kazanecka 2004; Wilke 2004; Tietz 2005; Wojtal 2007; Barycka 2008; Wiśniewski, Stefaniak, et al. 2009; Wiśniewski, Wojtal, et al. 2009, Pawłowska 2015; Kardynał et al. 2016; Pawlik 2016).

in the bottom of the loess complex are not younger than the end of MIS 3, but their exact age is unknown.

Trzebnica

A skull and limb bones were found ca. 7 m deep, resting under a layer of loess, in clay underlain with gravel in a railway ditch south of Trzebnica (Römer 1888). Considering the site and the loess profile from Trzebnica presented by Jary (1996), it can be said that the remains from the ditch rested within or just above the residual area which was formed poly-cyclically since the Eemian interglacial. Such deposits are commonly found in the area of the Trzebnickie Hills under a loess layer. The large boulders often found at that level are remains of glacial deposits, and the faunal remains on the bench in Trzebnica were discovered at the same level (Pakiet et al. 1993). Rotnicki (1966) estimated that during the Late Pleistocene the height of the hills could decrease by tens of metres due to denudation, especially in a periglacial climate. Besides the layer of pavement erosion, this is also

Figure 5. Complete calvarium of *Coelodonta antiquitatis* found in loess in Pawłowiczki, till 1945 exhibited in the Geological Institute in Wrocław (according to Zeuner 1934, 80, figure 21).
Note: Currently the specimen is lost.

confirmed by the fluvial deposits from the Late Pleistocene, with a thickness of about 50 m, filling the Milicka and Żmigrodzka basins (Krzyszkowski and Kuszell 2007).

Trzebnica-Raszów

A place located about 8 km NW of Skarszyn should also be mentioned while discussing the Trzebnickie Hills. In his explanatory notes to the sheet of Wiese 1:25,000 geological map, Meister (1935) mentioned rhinoceros remains discovered in a ditch during construction of the railway line south of Trzebnica. Referring to Römer's description (without citation, maybe pers. comm.) the author states that a skull and limb bones were found there at a depth of ca. 7 m. Given the state of today's collection (two skull fragments and a part of humerus), this is likely. The remains were spread under a layer of loess on the surface of the pavement, which according to Meister (1935) was formed in the last interglacial.

Ziębice (Münsterberg)

Gürich (1885) mentioned finding a rib or ribs in Ziębice, and later finding further remains of rhinoceros in the town (Gürich 1893). Numerous remains of Pleistocene horse and several bones of rhinoceros were found in a clay pit (Römer 1874). Among the remains, the author mentioned a heavily damaged tibia and a right metacarpal probably belonging to the same individual, suggesting that other parts of the skeleton could be present in the site. Today only metapodia are preserved in the collection.

Żmigród (Trachenberg)

A fragment of rhinoceros skull ca. 40 cm long, foot bones and fragments of ribs were discovered during digging of wells in

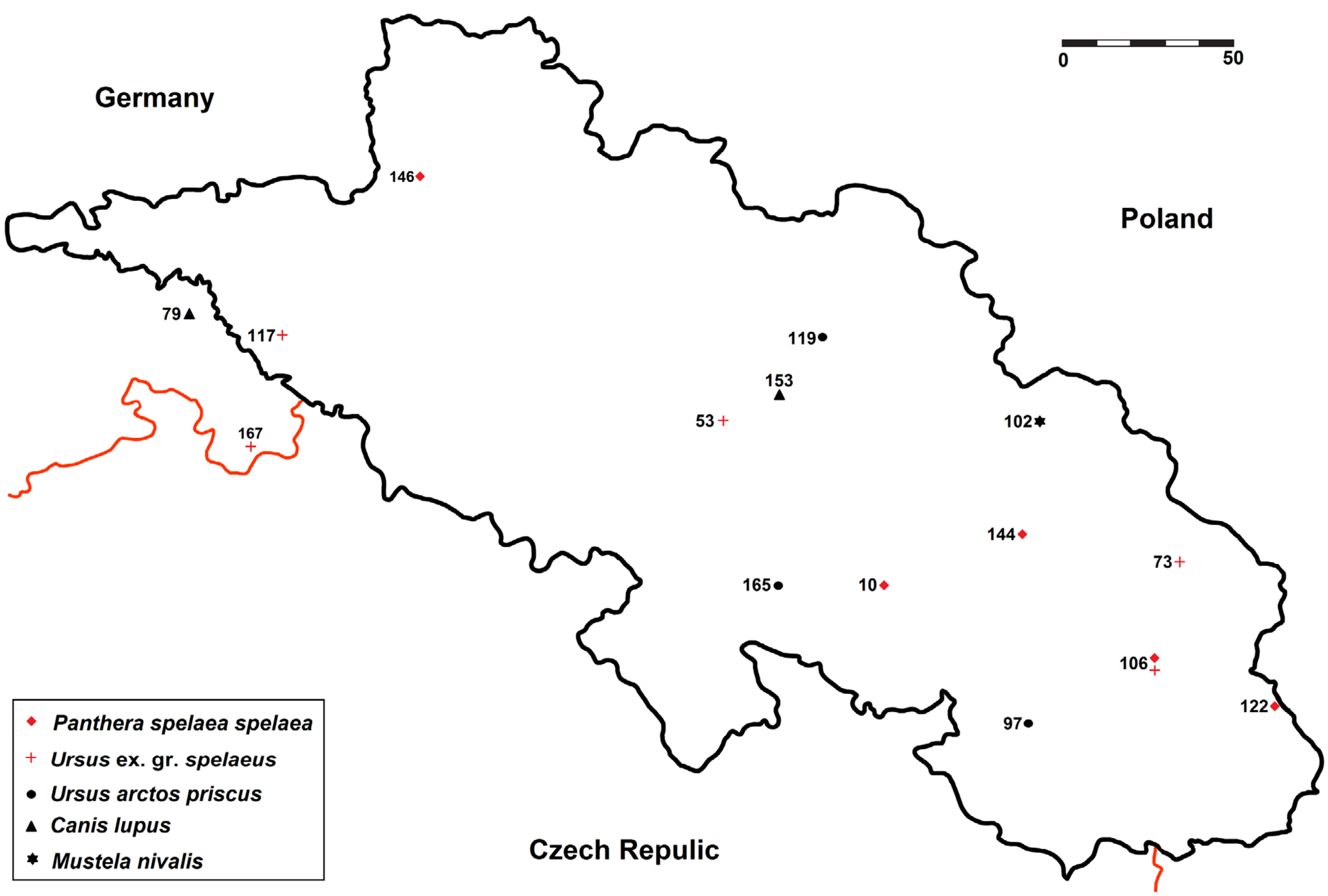

Figure 6. Location of open-air sites with carnivore remains in Silesia.

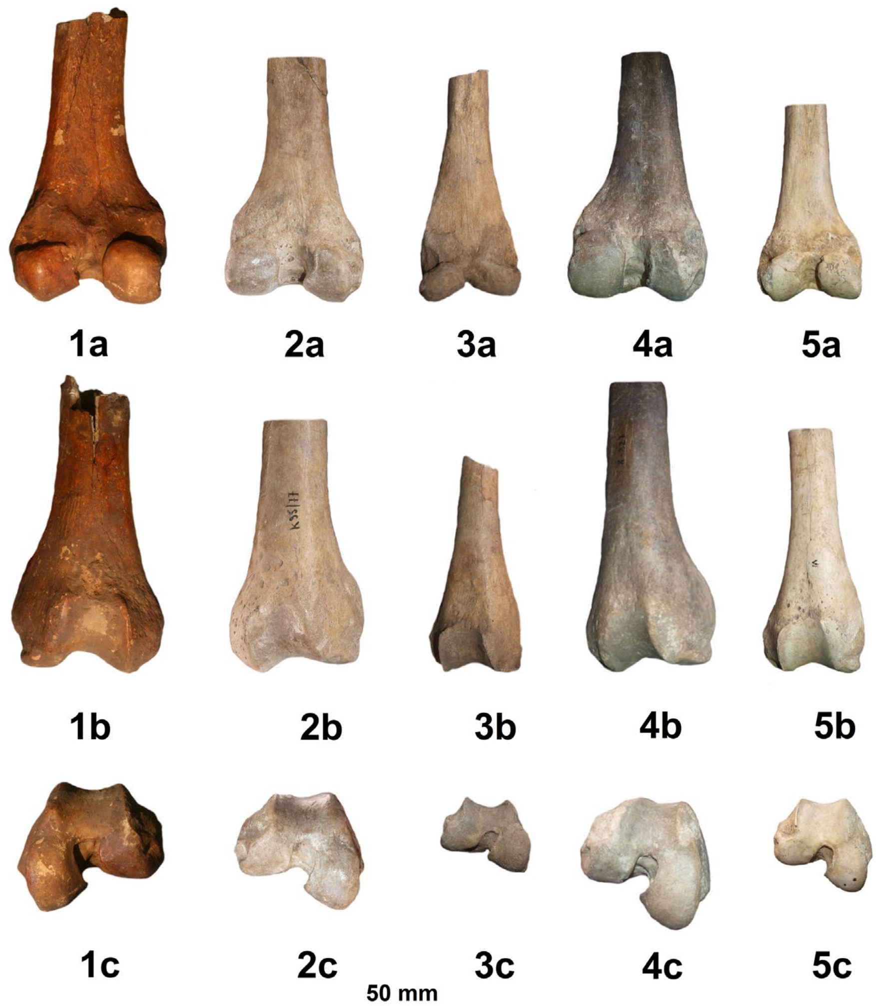

Figure 7. Comparison of femora distal halves of arctoid (1–3) and speleoid (4–5) bears. Steppe brown bear *Ursus arctos priscus*: left femur from Skarszyn SKA/M/Ua/1 (1a–c) and right femur from Niedźwiedzia cave JNK/Ua/71 (2a–c) (confirmed genetically). Eurasian brown bear *Ursus arctos arctos*: left femur from early medieval castle (3a–c). *Ursus ingressus* from Niedźwiedzia cave: male JNK/Us/12541 (4a–c) and female JNK/Us/44541 (5a–c).
Note: Scale bar 50 mm, a – dorsal view, b- ventral view, c – distal view.

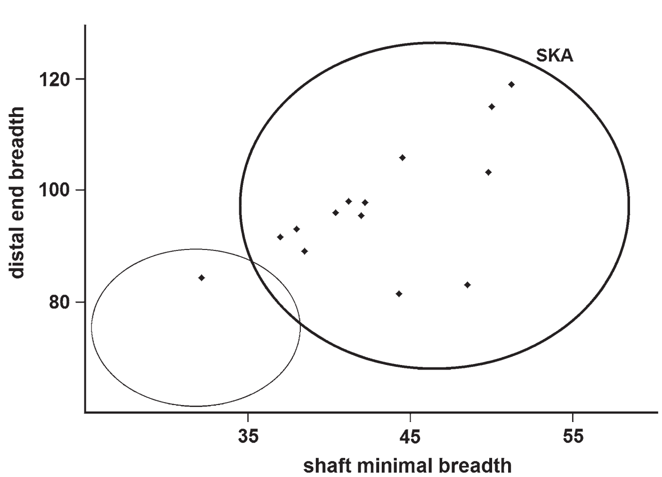

Figure 8. Minimum shaft breadth plotted against distal epiphysis breadth of bear femora.
Notes: Thick elipse – Late Pleistocene *Ursus ingressus*/*spelaeus* from various Polish sites, thin elipse – Holocene and recent *Ursus arctos arctos*, black diamonds – Late Pleistocene *Ursus arctos priscus*, SKA – bear from Skarszyn. Note the immense size of Skarszyn femur, and another two brown bear femora only slightly smaller. For sources see methods chapter.

Żmigród in the now defunct sugar plant (Römer 1873). Based on the number of bones discovered in a small area, Römer guessed that there could be a whole skeleton, but due to some negligence no other remains were recovered. A justification of workers who made the discovery may be the fact that the bones were scattered over a relatively thick layer of 8.5–9 m. The site is located north of the Trzebnicki Bank in the Żmigrodzka Basin, within the Barycz Valley. According to the geological survey, at the depth at which the rhinoceros remains were found, there are river sands and gravels with intercalations of silt and sludge from the Late Pleistocene (Schwarzbach 1942b, Skompski 1983; Michalska 2002; Krzyszkowski and Kuszell 2007). According to the description of benchmark profiles presented by Krzyszkowski and Kuszell (2007) in this part of the Żmigrodzka Basin deposits occurring at a depth of about 15 m were formed in MIS 2 and were dated to the period 22.7–21.2 Ka BP. It should be noted that in Żmigród lacustrine sediments of Eemian age were found relatively close to the surface, at a depth of several metres (Schwarzbach 1942b).

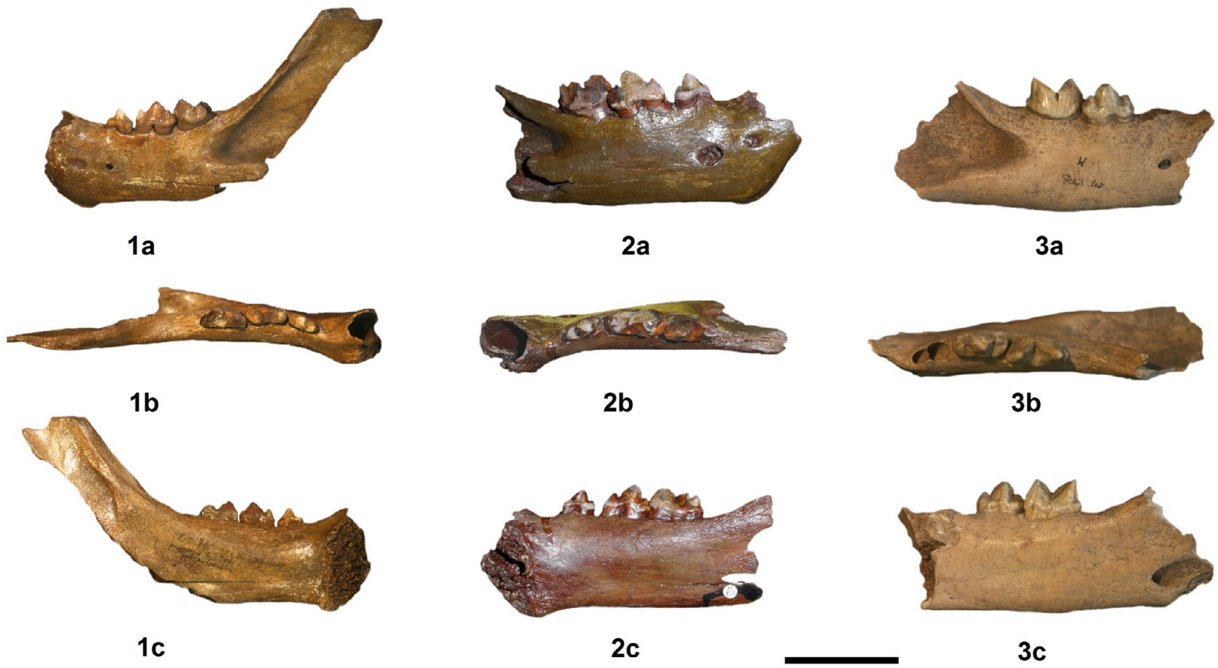

Figure 9. Mandibles of cave lion *Panthera spelaea spelaea* from Silesian open sites: Sosnowiec-Milowice (1a–c), Pyskowice (2a–c) and Węgry (3a–c), a – buccal view, b – occlusal view, c – lingual view.
Notre: All individuals shown to the same scale, scale bar 50 mm.

Results

The revision showed presence of 22 species from 174 Silesian sites, among them *Mammuthus primigenius* (85 sites) and *Equus ferus* (54 sites) are the most numerous species and was found on 85 sites (Table 4). Carnivores are the rarest faunal elements, found only on few localities. The most diverse are artiodactyls, and a single tooth of *Mustela nivalis* is the only exception among these large mammals. Besides this small mustelid, all found species belonged to animals on average heavier than 25 kg (Table 4).

Carnivores

Five carnivore species are mentioned from Silesian open sites: cave lion, wolf, least weasel, cave bear and steppe brown bear, while previously only three species were listed: cave lion, wolf and cave bear (Figure 6). The carnivores are usually represented by isolated remains, with an overwhelming majority constituted by herbivores.

Carnivore remains from Silesian sites have been known for almost 200 years (Göppert 1830; Hensel 1852), however the data are scarce, not very informative and the fauna is represented almost exclusively by large species. This is primarily due to the fact that the remains were mainly found during agricultural work or digging in sand pits, collected when seen and only more spectacular bone material, like skulls or long bones, was taken. Smaller bones or isolated teeth were simply overlooked. However, more recently, during regular archaeozoological or palaeontological excavations, sediments from some profiles were wet-viewed on screens. As a result, for example in the 1980s an isolated P4 of least weasel was found in Pietraszyn 11. Obviously, one isolated tooth cannot provide any reliable information apart from the fact that the species was present in the locality, but it shows that small-sized mammals also occur in open sites.

Among wolf remains only a trigonid of left m1 from Wrocław Hallera 1 was found in the layer dated at the beginning of MIS 3 (Wiśniewski, Stefaniak, et al. 2009). The tooth is metrically and

Table 5. Measurements of *Panthera spelaea spelaea* mandibles from Silesian open sites (dimensions in mm).

	Measurement	Sosnowiec-Milowice	Pyskowice	Węgry
Mandible	5	111.2	124.6	
	6		90.5	
	7	17.4	20.0	
	8	75.4	73.0	
	9	47.5	47.0	87.9
	10	12.1	14.5	55.7
	11			10.2
	12	79.8	79.0	
	13	39.2	35.0	
	16	53.0	49.0	60.3
	17	23.3	23.0	26.4
	18	54.7	58.0	63.0
	19	25.0	24.0	28.2
Teeth	p3 1	17.9		
	p3 2	10.1		
	p3 3	10.4		
	p3 4	6.8		
	p3 5	8.1		
	p4 1	25.5	24.0	30.2
	p4 2	12.5	13.5	14.5
	p4 3	15.3		15.7
	p4 4	9.7		12.7
	p4 5	12.2		15.6
	m1 1	28.2	27.4	33.8
	m1 2	15.4		19.0
	m1 3			18.6
	m1 4			19.7
	m1 5			18.6
	m1 6	7.8		10.1
	m1 7	12.6	13.4	16.8

Table 6. Features of p4 and m1 distinguishing *Panthera spelaea fossilis* and *Panthera spelaea spelaea* (according to Schütt 1969; Hemmer and Schütt 1978) compared with characteristics of the cave lion from Silesian open sites.

	Index	*Panthera spelaea fossilis*	*Panthera spelaea spelaea*	Sosnowiec-Milowice	Pyskowice	Węgry
	2/1	**45.5** (41.5–47.0, *n* = 6)	**47.5** (44.0–54.0, *n* = 17)	49.0	53.3	48.0
	4/1	**43.5** (41.0–46.5, *n* = 6)	**40.5** (36.5–45.5, *n* = 20)	38.0		42.1
	5/1	**51.0** (49.0–54.5, *n* = 8)	**50.0** (46.0–53.5, *n* = 21)	47.8		51.7
p4	4/5	**85.5** (83.0–91.0, *n* = 5)	**81.5** (75.5–89.5, *n* = 20)	79.5		81.4
	L m1/L p4	**101.6** (97.4–105.3, *n* = 3)	**106.5** (96.4–115.9, *n* = 17)	110.6	114.2	111.9
	4/1	**61.5** (59.0–63.5, *n* = 5)	**59.5** (56.5–61.5, *n* = 17)			58.2
	2/1	**55.0** (53.5–57.0, *n* = 5)	**53.5** (50.0–57.0, *n* = 17)	54.6		56.2
	2/4	**89.5** (86.0–97.0, *n* = 5)	**89.0** (83.0–96.0, *n* = 17)			96.5
	7/1	**55.5** (53.5–56.5, *n* = 7)	**51.0** (45.5–55.0, *n* = 17)	44.6	48.7	49.7
	5/1	**57.0** (55.5–59.0, *n* = 4)	**53.0** (51.5–56.5, *n* = 7)		52.5	55.0
m1	5/4	**93.0** (90.0–96.0, *n* = 5)	**89.0** (84.0–95.5, *n* = 17)			94.4
	3/5	**101.0** (98.3–105.7, *n* = 4)	**98.1** (93.0–100.7, *n* = 7)			100.0
	6/1	**36.0** (34.0–38.5, *n* = 5)	**31.0** (29.5–35.0, *n* = 15)	27.7		29.9
	6/7	**65.0** (63.5–68.5, *n* = 5)	**61.0** (56.0–68.0, *n* = 16)	61.9		60.1
	Zigzag structure	Well developed, present on both sides	Reduced, only on lingual side	Reduced, only on lingual side		Minute, only on lingual side
	Talonid	Well developed	Strongly reduced	Strongly reduced	Strongly reduced	Moderately developed
	Cingulum margin[a]	Rises to the talonid	Slightly rises or straight	Almost straight	Slightly rises	Slightly rises
	Lingual bulge	Well developed	Poorly developed	Poorly developed	Poorly developed	Moderately developed

[a]Lower cingulum margin on the buccal side, running from the begining of the protoconid up to the end of the talonid.

morphologically indistinguishable from the large and robust wolf of the Late Pleistocene European palaeo-communities. Of the speleoid bear, only a small canine belonging probably to a female was found in the site near the castle in Lubliniec. So far almost no finds of speleoid bears are known from open sites, and those described previously as belonging to the cave bear (Wojtal 2007) are, in fact, the steppe brown bear, whose linear dimensions often exceed even the largest cave bears. What more, the morphology of its teeth and the postcranial skeleton are a mosaic of arctoid and speleoid features, which makes the precise identification quite difficult (Lipecki and Wojtal 2015).

This bear form, the great arctoid bear *Ursus arctos priscus*, was also found among the revised material and is mentioned from Silesian open sites for the first time. The left maxilla fragment from Pawłowiczki and the left mandible body fragment from Ziębice belonged to large specimens. Both cranial fragments are too small to yield any reliable information, but the alveoles size and their shape clearly indicate the brown bear. While the specimens from Pawłowiczki and Ziębice are large, the distal half of left femur from Skarszyn belonged to a truly immense individual (Figure 7). DNA analysis so far failed to this bone, the metric and morphological characters point to the brown bear. The dimensions are comparable with large specimens of the cave bear, and greatly exceed most of the known recent or fossil brown bear specimens (Figure 8). According to Petronio et al. (2003), the distal breadth of femur of *Ursus arctos* usually does not reach 100 mm; similar data were presented by some other authors (Degerbøl 1933; Zapfe 1946; Altuna 1973; Ballesio 1983). However, it should be borne in mind that in their paper Petronio et al. (2003) used limb bones of the Pleistocene brown bear from the Iberian and Italian Peninsulas, where finds of *Ursus arctos priscus* are extremely scarce (Marciszak et al. 2015, 2017). Single femoral bones of other European fossil brown bear show that much larger specimens are also known, like the femur from Chlupáč cave (Czech Republic), dated at MIS 5e, with dB of 119 mm, or a similar-sized (L of 525 mm, dB = 115 mm) Late Pleistocene femur from the English site Sandford Hill (Reynolds 1906). Using cautious estimations, it can be supposed that the total length of the femur from Skarszyn was somewhere between 550 and 560 mm.

Morphological differences in limb bones between the speleoid and arctoid bears were described in detail by Petronio et al. (2003, p. 145), who found that 'The differences between the two bear species in the distal epiphysis are very light'. In general the femur

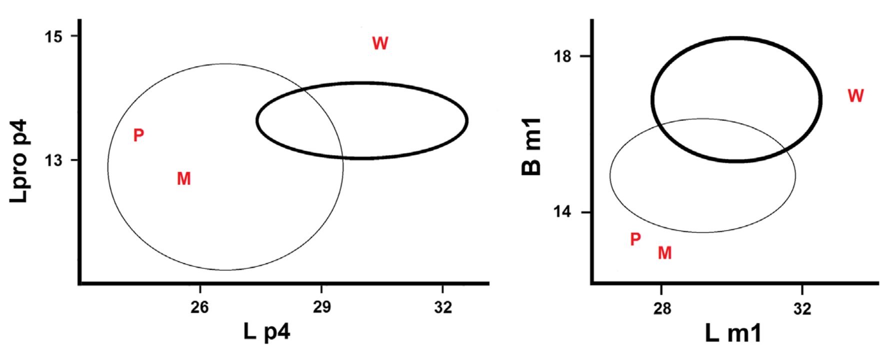

Figure 10. Two plots distinguishing two chronosubspecies of the Pleistocene lion *Panthera spelaea*: length of protoconid of p4 plotted against total length of p4 (left) and length of m1 plotted against m1 breadth (right).

Notes: Letters on plots indicate the position of Silesian lions (P – Pyskowice, S – Sosnowiec-Milowice, W – Węgry). Thick elipse – *Panthera spelaea fossilis*, thin elipse – *Panthera spelaea spelaea* (data according to Schütt 1969; Hemmer and Schütt 1978). For the rest sources see methods chapter.

of *Ursus arctos* is characterised by a slighter build and a more arcuate diaphysis. In the case of the incomplete individual from Skarszyn the conclusions have to be based only on the distal half. The analysis of an extensive series (more than 1500 complete or almost complete femora) from Polish and Czech sites of the speleoid bears shows that there are also some differences in the muscle attachments and condyles shape. The preserved part of the shaft indicates the presence of an elongated, well-developed muscular insertion crest, which ran alongside and reached broad tuberosity of lateral supracondylar. Both condyles are stout (the lateral one is slightly less robust) and well-developed. Between them occurs a broad and deep trochlea ossis femoris, whose margins form thick and well-defined ribs. Both epicondyles are large and elongated, and the lateral one is situated slightly higher than the medial. The intercondyloid fossa is U-shaped in inferior view and directed toward the lateral condyle. The bone differs from the femur of the Holocene *Ursus arctos* in its much larger size and the greater development of condyles, although the size of attachments and the shape of intercondyloid fossa are very similar. The specimen resembles the speleoid bear in its massive condyles and large size but in *Ursus* ex. gr. *spelaeus/ingressus* the intercondyloid fossa is directed toward the medial condyle. Besides, the lateral area of the supracondylar tuberosity is rudimentary (Figure 7).

In the past such great differences in length might warrant description of a new species of fossil bear; however, already Kurtén (1959) showed that the differences in length of long bones in bears were probably a resultant of local, sexual, and individual variation. Although the femur from Skarszyn is significantly larger in almost all measurements than all other known specimens of *Ursus arctos* from Poland, the bone represents the steppe brown bear rather than a speleoid bear. Overall, morphologically the material is well compatible with the specimens described by Reynolds (1906) from Great Britain and by Ballesio (1983) from France (Figure 8). The unusually large specimens from sites of steppe-tundra fauna might correspond to the subspecies/ecomorph *Ursus arctos priscus*. The smaller specimens, associated with more diverse environments, although still large, would then correspond to *Ursus arctos arctos*. It states most probable that the Skarszyn bear was an enormous, mature male (Figures 7–8).

Besides the steppe brown bear, interesting finds are those of the cave lion, whose remains from caves are much more numerous than those from open sites (Kowalski 1959; Barycka 2008). Pre-war publications from Silesia mentioned the presence of the Pleistocene lion only twice. Hensel (1852) described a single, left lower carnassial of considerable size from the marl mine in Witków near Szprotawa. The record was later cited by Gürich (1885) and Kowalski (1959). The second find came from gravel pits in Milowice (now part of the town Sosnowiec), from where Ryziewicz (1933) described a single lower jaw (Figure 9).

The analysis of taxonomic position of the lion individuals from Silesian open sites was based only on teeth morphology and indices of teeth proportions. The morphological and metric characters of the mandible are very variable and in fact do

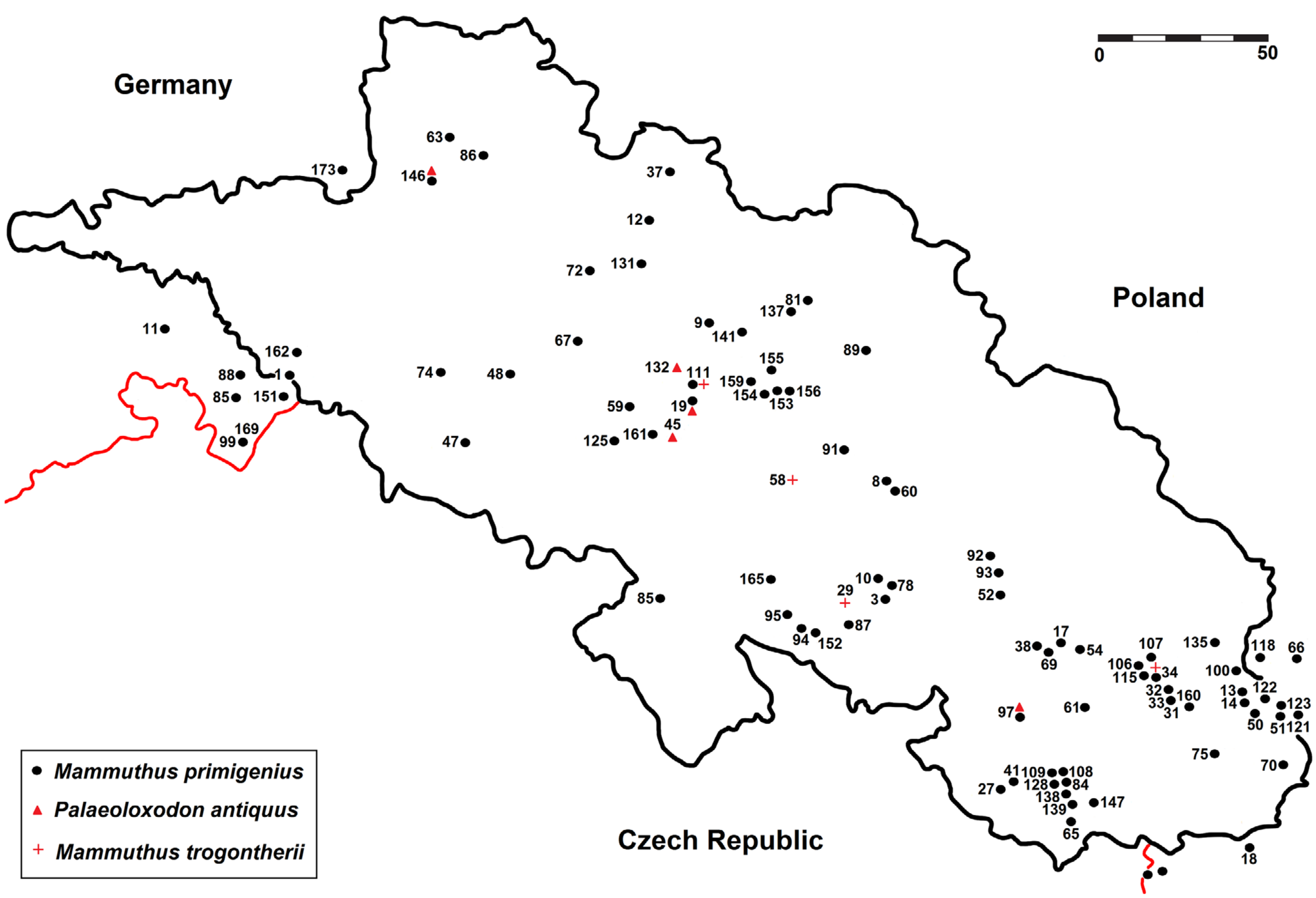

Figure 11. Location of open-air sites with proboscid remains in Silesia.

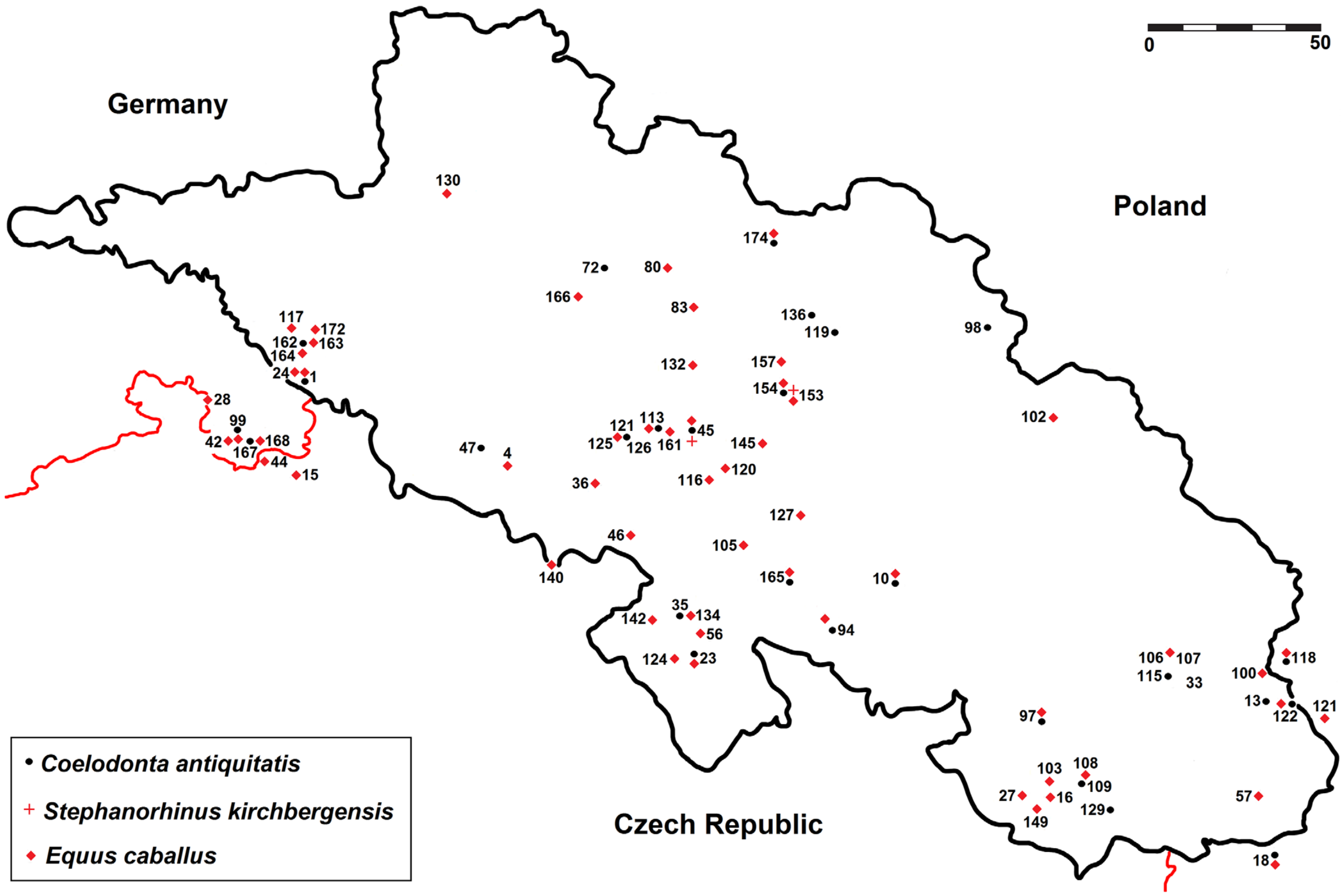

Figure 12. Location of open-air sites with perissodactyl remains in Silesia.

Table 7. Measurements of perissodactyls upper dentition from open-air Silesian sites.

Species	Site	Coll. no	Tooth	1	2	3	4	5
Coelodonta antiquus	Skarszyn	Sksz/M/193/1	M1	47.4	44.7	57.1	47.9	14.2
Coelodonta antiquus	Skarszyn	Sksz/M/193/2	M2	49.7	49.9	51.9	39.1	
Coelodonta antiquus	Skarszyn	Sksz/M/193/3	M2		41.7	58.4	51.8	20.8
Coelodonta antiquus	Skarszyn	Sksz/M/193/4	M2	52.9	51.0	51.4	33.6	
Coelodonta antiquus	Chorzów	Chorz/M/182	M3	45.5		28.6	23.0	
Stephanorhinus kirchbergensis	Wrocław Hallera 1	B 129	M2	[72.0]	[62.0]			
Equus ferus	Bobrowiec	BOB/M/2	P2	39.4	27.7			
Equus ferus	Pawłowiczki	PAW/M/6	P2	36.3	27.0			
Equus ferus	Przerzeczyn-Zdrój	PTR/M/2	P2	39.8	23.9			
Equus ferus	Zimna Woda	ZIM/M/1	P2	37.9	26.1			
Equus ferus	Zimna Woda	ZIM/M/2	P2	38.2	25.8			
Equus ferus	Jedlina Zdrój-Jedlinka	JZJ/M/1	P3	31.7	30.6			
Equus ferus	Strzelin	STL/M/1	P3	29.5	27.8			
Equus ferus	Wołczyn	WOŁ/M/1	P3	33.7	30.2			
Equus ferus	Żmigród	ZMI/M/2	P3	27.7	27.7			
Equus ferus	Żmigród	ZMI/M/4	P3	29.1	27.6			
Equus ferus	Żmigród	ZMI/M/3	P4	24.9	26.4			
Equus ferus	Kłodzko-Ustronie	KŁO/M/1	M1	26.9	27.3			
Equus ferus	Żmigród	ZMI/M/5	M1	29.5	27.7			
Equus ferus	Kłodzko-Ustronie	KŁO/M/2	M2	30.4	28.8			
Equus ferus	Pietrowice Wielkie	PTR/M/1	M2	26.5	23.8			
Equus ferus	Strzegom	STG/M/1	M2	29.6	26.2			
Equus ferus	Gostków	GOS/M/1	M3	22.4	21.0			
Equus ferus	Kłodzko-Ustronie	KŁO/M/3	M3	27.1	25.1			
Equus ferus	Kłodzko-Ustronie	KŁO/M/4	M3	26.8	23.7			
Equus ferus	Zimna Woda	ZIM/M/9	M3	27.1	22.0			

not allow to distinguish between the lion chronosubspecies (von Reichenau 1906; Dietrich 1968; Hemmer 1974; Marciszak et al. 2014). Similarly the great metric and morphological variation of p3 precludes specifying diagnostic features that would allow for unambiguous identification (Barycka 2008; Marciszak and Stefaniak 2010).

Among the teeth, p4 shows the most pronounced differences between the steppe and the cave lion *Panthera spelaea fossilis* has a proportionally shorter and higher protoconid and more robust crown of p4 (Schütt 1969; Schütt and Hemmer 1978). Even if the variation ranges overlap, most of the differences in the metric characters and coefficients are significant (Figure 10) (Kurtén 1960; Schütt 1969; Hemmer 1974) (Figure 10, Tables 5–6).

Most authors point to the robust crownof m1 as one of the basic diagnostic features of the steppe lion, where the breadth (7) to total length (1) ratio in *Panthera spelaea fossilis* is always higher than 50 (Kurtén 1960; Dietrich 1968; Schütt 1969; Hemmer 1974; Schütt and Hemmer 1978; Argant 1988, 1991; Barycka 2008). In the evolutionary lineage of the Pleistocene lion there is a marked trend of narrowing of the crown of m1. In the cave lion the breadth (7) to total length (1) ratio is usually less than or close to 50 (Barycka 2008; Marciszak et al. 2014; Sabol 2014). The examined specimens from Sosnowiec-Milowice, Pyskowice, and Węgry are characterised by narrow crowns, with the breadth/length ratio not exceeding 50; they are within the lower range of variation of the cave lion (Table 6).

The proportions of the lower carnassial main cusps, the paraconid and the protoconid in lions from Sosnowiec-Milowice, Pyskowice, and Węgry are almost indistinguishable from the typical cave lion, with the little height difference between them (Table 6). The paraconid anterior wall and the protoconid posterior wall are not so much expanded anteriorly and posteriorly and they have a strongly reduced talonid. The enamel margin on the buccal side is almost straight and with the rudimentary zigzag enamel structure and lack zigzag structure of the enamel on both crown sides typical for *Panthera spelaea fossilis* (Schütt 1969; Barycka 2008; Marciszak and Stefaniak 2010). Also p4 to m1 length ratio is useful diagnostically in identifying the various lion chronoforms, where *Panthera spelaea spelaea* has proportionally shorter p4 and longer m1 (Schütt 1969; Hemmer 1974; Schütt and Hemmer 1978). In all three specimens from the Silesian open sites the length of m1 markedly exceeds that of p4 (Table 6).

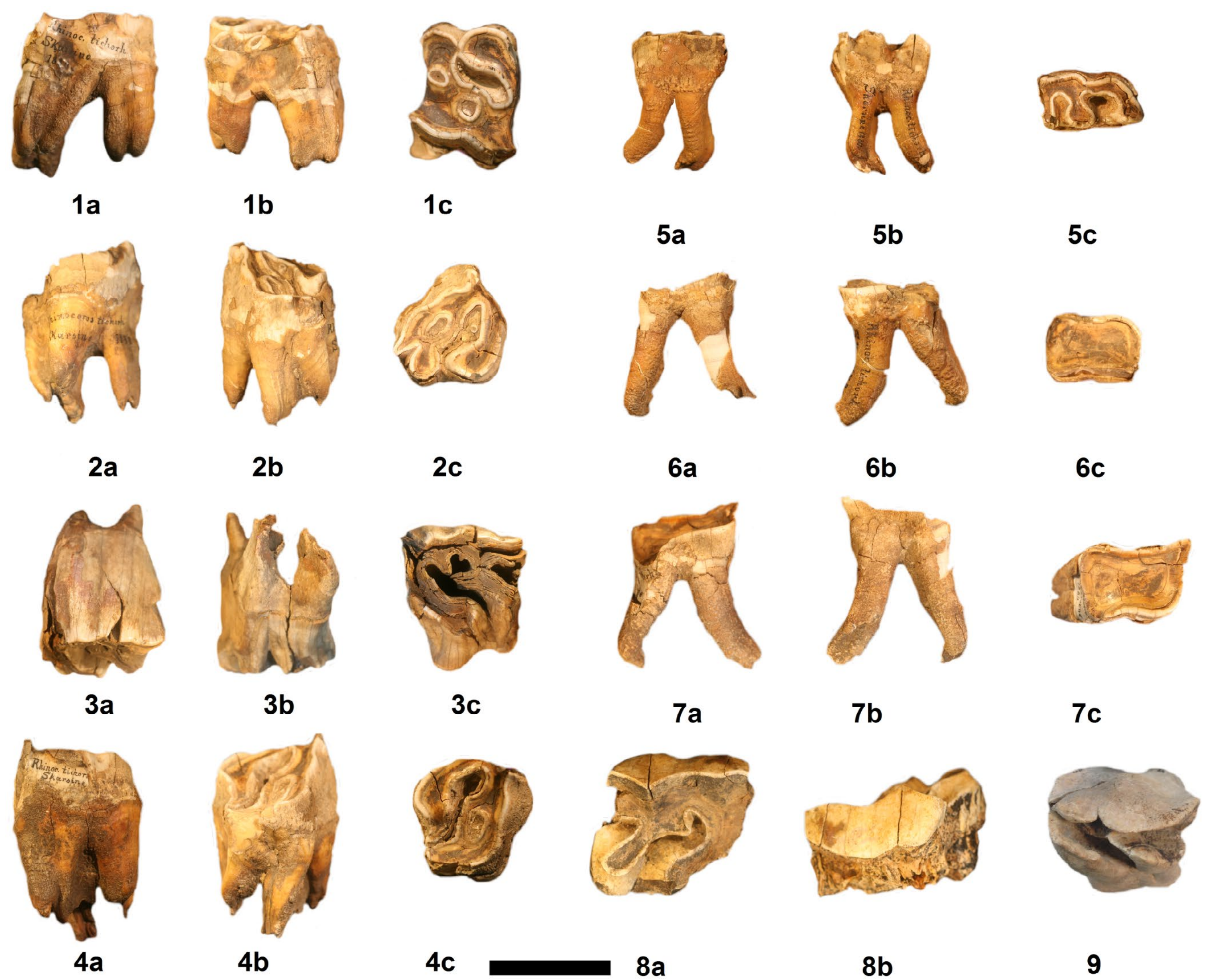

Figure 13. Isolated teeth of rhinos from Silesian open-air sites.

Notes: Scale bar 50 mm. *Coelodonta antiquitatis* from Skarszyn: 1a–c – left M2 (SKA/M/3), 2a–c – right M3 (SKA/M/2), 3a–c – left M1 (SKA/M/1), 4a–c – left M3 (SKA/M/4), 5a–c – right m2 (SKA/M/5), 6a–c – right m1 (SKA/M/6), 7a–c – left m1 (SKA/M/7). *Stephanorhinus kirchbergensis* from Wrocław Hallera 1 street: 8a–b – right M2 (B 129), 9 – left M1 or M2.

Proboscids

The list of mammal remains includes three elephant species from more than 100 localities in Silesia (Figure 11). There are, however, still many isolated teeth and bones from sites that are not precisely known. In such cases the location given is just 'Silesia', with no exact data. It is also likely that there are unstudied materials in many private or small local (church, school) museums and collections not included in any inventory. Such finds could not be included here. A good example is a humerus shaft with both epiphyses, with not yet fully fused and closed sutures, of an unusually large animal, whose morphology indicates a forest elephant. However, no precise location is specified, apart from Silesia (an indistinct inscription on the bone). Also milk dentition requires a detailed revision to ascertain which elephant species it actually represented.

More than 97% of the remains were identified as *Mammuthus primigenius*, the most common and best-known proboscidean species. In Silesia its remains were mostly found in sand and gravel pits, during road and engineering constructions, cartographic and regulatory river works etc. They are mainly isolated teeth, tusk fragments or molars; sometimes also postcranial elements were found. However, during the 300 years of history of Silesian palaeontology also more or less complete skeletons came to light. One of such spectacular finds was the almost complete skeleton of an unusually large individual, found during construction of a cemetery in Trzebnica; another comes from Masłów, and the bones were later exhibited in local churches as curiosities

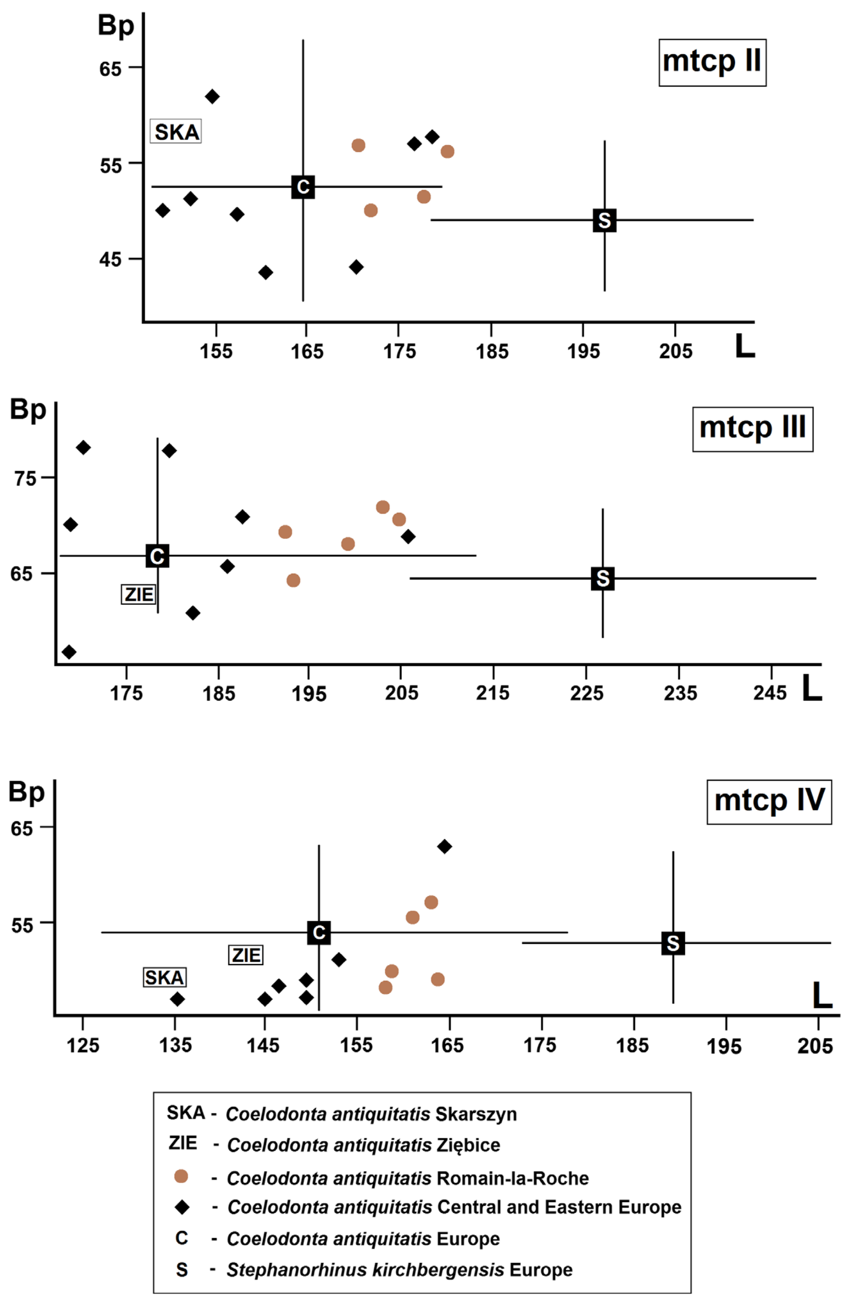

Figure 14. Bivariate diagram of metacarpals and metatarsals of *Coelodonta antiquitatis* and *Stephanorhinus kirchbergensis* from late Middle and Late Pleistocene European sites. Data after Guérin (1980, 2010) and unpublished data from Central and Eastern European Late Pleistocene localities.

(Hermann 1711; Volkmann 1720). More recently, 60 bones of one individual were found in Zastruże (Wiśniewski, Stefaniak, et al. 2009, Wiśniewski, Wojtal, et al. 2009), or 57 bones of another specimen in Dzierżysław (Wojtal 2007; Wiśniewski, Stefaniak, et al. 2009). In both sites the material was composed predominantly of postcranial elements. However, despite such abundance, the remains of this species from Silesian sites were never described in detail. Even at present our knowledge of woolly mammoths of Silesia is still incomplete and scanty, and needs further detailed research. In fact, still many undiscovered mammoth remains are held in private hands and many sand mines are still active.

Perissodactyls

Stephanorhinus kirchbergensis was very rarely mentioned from Silesia, where pre-war occurrence was reported from three localities (Gürich 1913; Heinevetter 1933, 1937), however, its presence was nowhere confirmed for sure (Figure 12). Apart from Imbramowice, where Gürich (1905) listed a find from Imbramowice: a left mandible fragment with the symphysal part present and with five teeth, and identified it as *Rhinoceros* sp., all Silesian records are based on broken, isolated teeth. The single post-war record from Silesia was based on three isolated teeth from Wrocław Hallera 1 (Wiśniewski, Stefaniak, et al. 2009). Teeth resembles *Stephanorhinus* in relatively small proportion of a cement, absent of the anticrochet typical of *Coleodonta* and the smooth enamel texture (Figure 13(8a–b)).

Among the material of the woolly rhinoceros from Skarszyn there are seven isolated teeth (Figure 13(1)–(7)), which most probably belonged to one, senile female. Three lower molars (Figure 13(5a–c)–(7a–c)) have worn crowns and present roots. They were attributed to *Coelodonta* according to relatively small dimensions and morphology, with rough, 'shagreen' structure of enamel, broad anterior lobe and proportionally high crowns. Also four upper (Figure 13(1a–c)–(3a–c)) teeth, less damaged that the lower, and are indistinguishable from *Coleodonta* equal teeth in thin, 'shagry' enamel, proportionally large portion of cementum, placed more posteriorly metacon, presence of

Figure 15. Metapodials of *Coelodonta antiquitatis* from Silesian open-air sites.
Notes: Scale bar 50 mm. Skarszyn: 1a–d – right mtcp II (SKA/M/31), 2a–d – SKA/M/32 left mtcp IV, 3a–d – left mtcp II SKA/M/30. Ziębice: 4a–d – right mtcp IV (ZIE/M/2) and 5a–d – right mtcp III (ZIE/M/1).

Table 8. Measurements of postcranial bones of carnivores and perissodactyls from open-air Silesian sites.

Species	Site	Coll. no	Bone	1	2	3	4	5	6	7	8
Ursus arctos priscus	Skarszyn	SKA/M/Ua/1	Femur				41.5	53.7	106.7	124.2	
Coelodonta antiquus	Skarszyn	SKA/M/28	Ulna						64.8	43.5	
Coelodonta antiquus	Ziębice	ZIE/M/1	mtcp III	177.4	48.0	61.7	54.6	25.5		61.8	
Coelodonta antiquus	Ziębice	ZIE/M/2	mtcp IV	142.0	41.4	53.4	22.5	39.5		47.1	
Coelodonta antiquus	Skarszyn	SKA/M/30	mtcp II	150.3	47.8	58.3	24.8	45.0		44.2	
Coelodonta antiquus	Skarszyn	SKA/M/31	mtcp II	151.4	47.2	59.7	25.4	43.4	42.7	51.4	
Coelodonta antiquus	Skarszyn	SKA/M/32	mtcp IV	134.0	47.8	51.5	25.3	43.0		55.8	
Equus ferus	Święcko	ŚWI/M/4	Humerus							91.3	52.5
Equus ferus	Szprotawa	SZP/M/3	Radius			86.1				41.6	
Equus ferus	Ziębice	ZIE/M/6	Radius			79.2		35.6			
Equus ferus	Ziębice	ZIE/M/7	Tibia	372.7	75.9	100.3		42.5	46.9		
Equus ferus	Sobótka	SOB/M/1	mtcp III	256.7	62.0	63.7		43.6	28.3	42.4	
Equus ferus	Stary Wielisław	STW/M/1	mtcp III	238.3	52.3	49.6		33.0		33.0	

ectoloph and metaloph, thickier and more pronounced cristas and crochets and broader vallyes.

The state of preservation of most of the teeth precludes precise measurements, only the size can be estimated with high probability. The isolated M1 (SKA/M/1) and the left M2 (SKA/M/3) belonged to a medium-sized animal. Both the M3 (SKA/M/3 and SKA/M/4) belonged to a small rhinoceros, with the dimensions slightly below the mean value of M3 for *Coelodonta antiquitatis* and much smaller than the isolated M2 of *Stephanorhinus kirchbergensis* from Wrocław Hallera 1 (Guérin 2010) (Table 7).

The analysis of metapodials from Skarszyn showed that they belonged probably to one individual, characterised by proportionally short but thick bones (Figures 14–15). Both the mtcp II from Skarszyn (SKA/M/30 and SKA/M/31) belonged to a small animal (Figure 15(1a–d) and (3a–d)), with the total length of ca. 150–151 mm and thus close to the minimum value for the species. At the same time the bones are proportionally very massive. The single mtcp IV from Skarszyn (SKA/M/32) is small and narrow (Figure 15(2a–d)), while the mtcp IV from Ziębice (ZIE/M/2) is slightly larger and somewhat more massive (Figure 15(5a–d)). Finally, the measurements of mtcp III (ZIE/M/1) from Ziębice are almost exactly in the middle of the range for *Coelodonta antiquitatis*, but with a slighter build (Figures 14–15(4a–d)). The sexual dimorphism is relatively poorly expressed in the woolly rhinoceros (in recent rhinoceros males are usually slightly bigger than females) so it can be suspected (with caution, however), that the bones from both sites, Skarszyn and Ziębice, belonged to small females. The dimensions of all the above metacarpals and metatarsals from Skarszyn and Ziębice are much below the minimum values for *Stephanorhinus kirchbergensis*. Metacarpals and metatarsals of *Stephanorhinus kirchbergensis* are significantly larger and narrower (Guérin 2010). The other remains: long bones, pelvis or cranium fragments, are incomplete and their state of preservation precludes a more detailed analysis (Figure 16(1–4)); only some measurements can be taken (Table 8). Based on the presented analysis, it can be concluded that the woolly rhinoceros from Silesian open sites represented the typical form from the last glacial: a moderately large, robust animal with proportionally short and massive limbs and classified as *Coelodonta antiquitatis antiquitatis*.

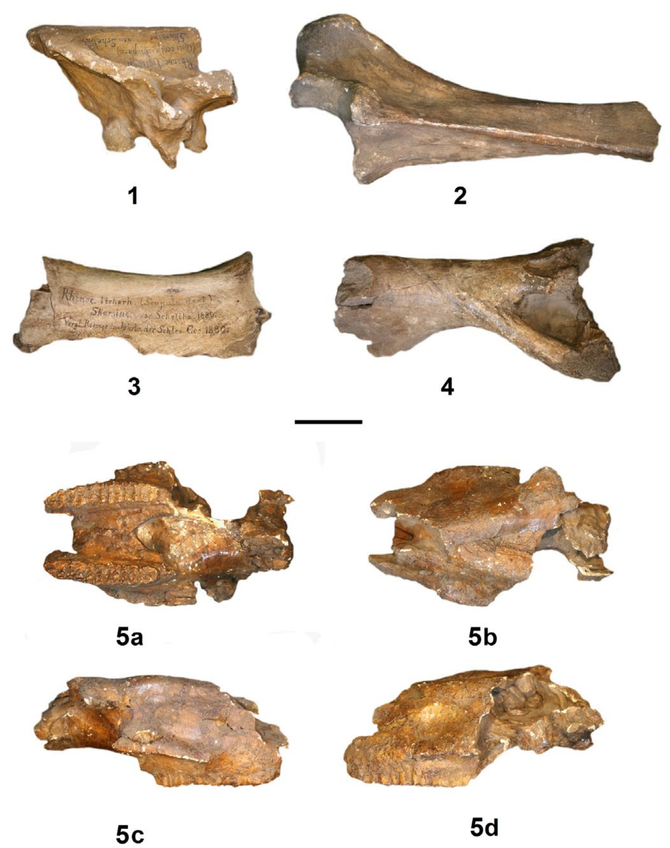

Figure 16. Perrisodactyls crom Silesian open-air sites.

Notes: Scale bar 100 mm. *Coelodonta antiquitatis* from Skarszyn: 1 – right neurocranium fragment from Skarszyn (SKA/M/10), 2 – left ulna (SKA/M/28), 3 – right scapula (SKA/M/25), 4 – left humerus (SKA/M/26). *Equus ferus* from Sobótka: 5a–d – calvarium (SOB/M/2).

Horses were only preliminarily studied during this work, since many new finds are still coming to light and many more can be expected. In the future, we plan a substantial revision of the material from Pyskowice, where horse remains are especially abundant. However, the fossil material from this locality is stored in more than dozen voivodeships and local museums and in more than ten private collections. Overall, it can be said that all the remains known so far seem to be homogeneous. They represent medium and large-sized specimens with dental morphology typical of caballoid horses (Figure 16(5a–d)). The postcranial elements are large and robust. Only the horse from Ziębice seems to be slightly smaller and more slightly build than a medium-sized recent horse (Tables 7–8). Similar data were presented by German researchers; for example Soergel (in Herr 1924) in his description of horse material from Lausitz mentioned a huge, robust caballoid horse. According to some earlier researchers, some finds might be older than the Late Pleistocene, but the age is very uncertain, and in general many horse remains are quite young, of a Holocene age (Gürich 1893).

Pre-war German publications also mentioned the presence of a relatively small stenoid horse *Equus hydruntinus* (Herr 1924b; Heinke 1926). It differs from *Equus ferus* in a smaller size, some specific dental features and in a more slender build (Forsten and Dimitrijević 2004). However, our revision failed to detect the presence of this form in the analysed material.

Artiodactyls

Though the most numerous, artiodactyls are however less informative than the other mammals from the Silesian open sites (Figures 17–18). There exist numerous pre-war records of cervids, mostly found in alluvium sediments or peat and represented by antlers or their fragments. In some cases, skull fragments, isolated teeth or single bones of postcranial skeleton were found. All the cervid remains are metrically and morphologically indistinguishable from modern species. Silesia must have been occupied by the red deer in spring when red deer stags shed their antlers, since most of the antler bases found were naturally shed. Their rounded bases show that they were not broken off. The fact indicates the season of the year when the remains were deposited. The possible Late Pleistocene records of red deer may suggest that the species migrated into Silesia only during woodland interstadials, or it may have adapted to treeless herb vegetation, possibly in the form of a distinct ecotype (Wiśniewski, Stefaniak, et al. 2009).

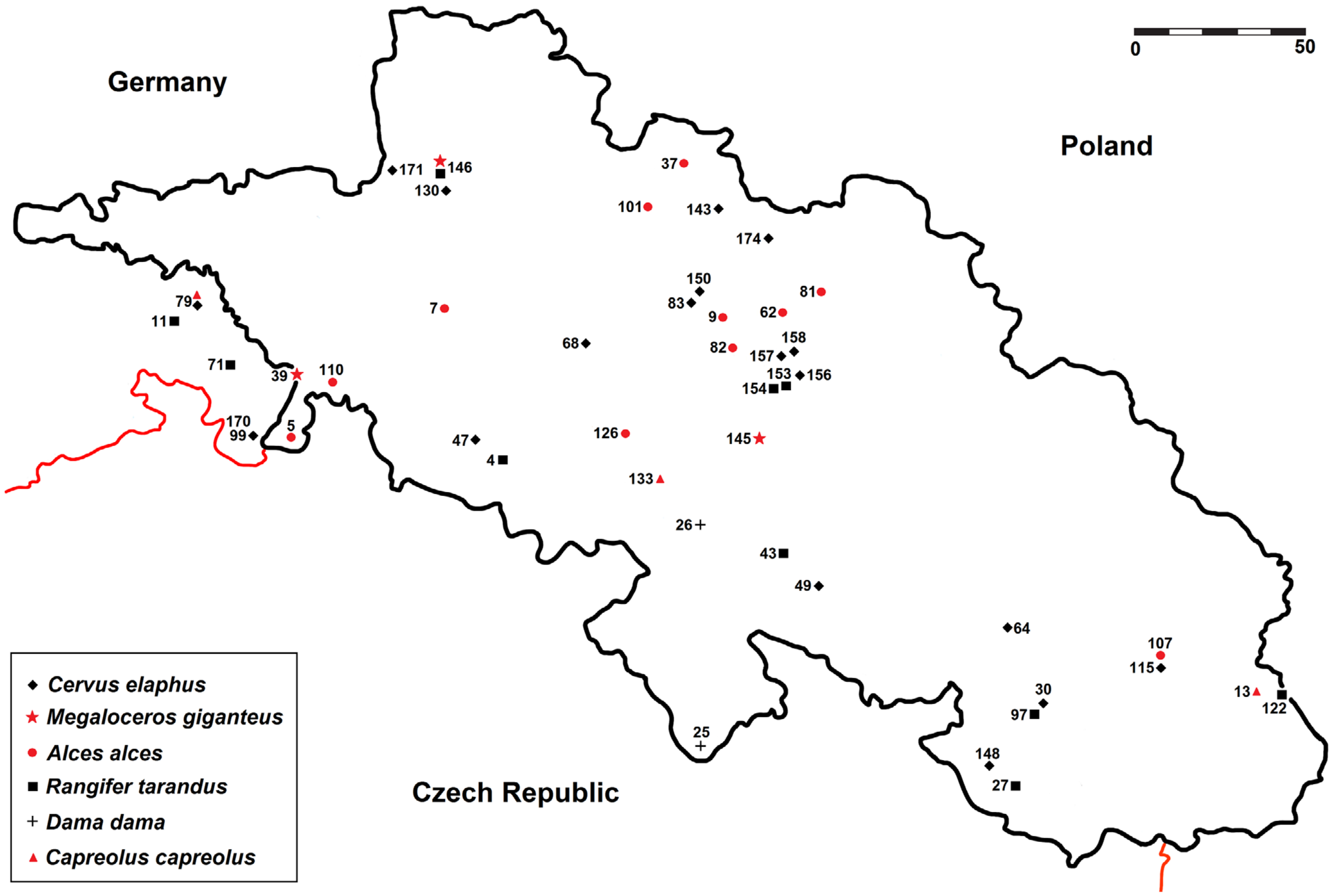

Figure 17. Location of open-air sites with cervid remains in Silesia.

Bovids are represented by two big and massive species, the cold-adapted *Bison priscus* and the more thermophilous *Bos primigenius*, both tending to inhabit open grasslands. In the material so far examined we found no smaller forms with morphological features of domesticated animals, which excluded animal-human relations. Among suids, only an unusual calvarium of wild boar, most probable of Holocene age, from Boguchwałów was rediscovered.

Another well represented artiodactyl is *Ovibos moschatus*, a northern, cold-adapted species whose material comprised mainly calvaria and their fragments. This is partly due to the species being probably quite common in lowland Silesia, and partly to its particularly robust and compact skull structure (Figure 19). Noteworthy is the find of *Praevibos priscus* from Ruda Śląska-Bielszowice (Michael 1902), which to date is the only record of this form in Poland (Ryziewicz 1955; Kowalski 1959; Mol et al. 1999). Since all the revised materials of *Ovibos moschatus* were already described in detail by earlier authors (Kowarzik 1908, 1912; Ryziewicz 1933, 1949, 1954, 1955) and no new bones were found, we did not analyse the material in broader metrical and morphological view.

Discussion

Palaeobiology

The fossil material from the vast majority of Silesian open sites was probable accumulated through natural processes and there is no evidence of human activity. It applies even to the recognised archaeological sites, where the accumulation of remains may be an outcome of natural or catastrophic death, slope or fluvial processes, activity of carnivores and some additional factors (Wiśniewski, Stefaniak, et al. 2009).

There are only a few sites where the accumulation of bones could be related to human activity: Wrocław Hallera Street 1, complex A/B, where traces of fractions were found on four bones among the rich bovid material and were interpreted as resulting from butchering by humans (Wiśniewski, Stefaniak, et al. 2009). Also, the single horse bone from Pietraszyn 11 was interpreted as a tool (Foltyn 2003) and related to the Gravettian hunters locality Henryków 15, where a reindeer antler with cut marks was discovered. Another Gravettian campsite, Dzierżysław, was the site with a few bones with traces of human activity (Wojtal 2007; Wiśniewski, Stefaniak, et al. 2009, Wiśniewski, Wojtal, et al. 2009).

Based on palaeontological data, it is possible to assume that Silesia (mainly its lowland part) played an important role as a corridor for migrating animals, which moved from east to west and in the opposite direction. This area also played a major role in north-south migrations, especially during glacials and stadials, where more thermophilous species retreated to the south. The route they took, to the territory of the present-day Czech and Slovak Republics, led through some gaps in the Carpathian Arch, such as 'The Moravian Gate', situated between the Sudetes in the west and the Carpathians in the east. So far, due to the scarcity

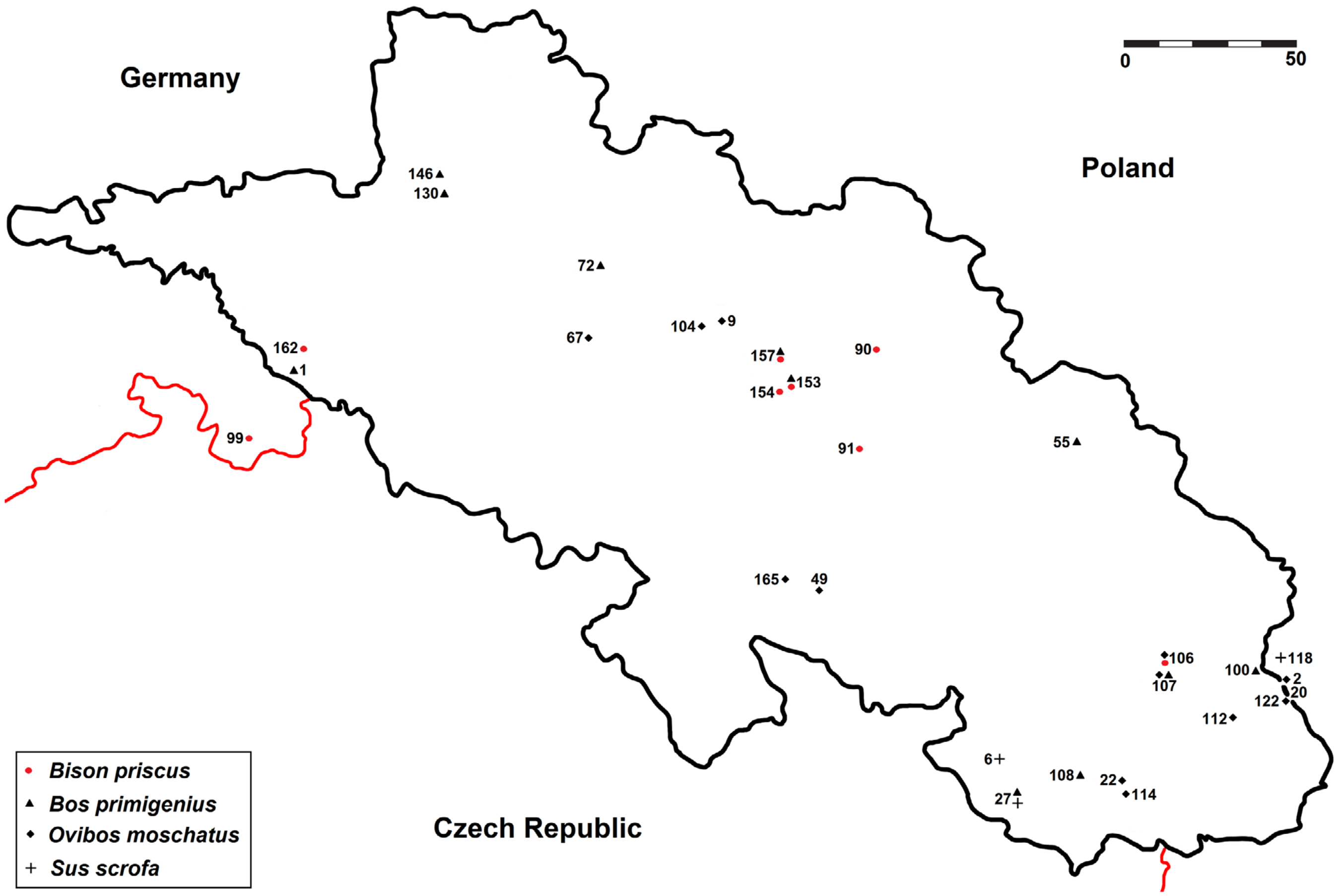

Figure 18. Location of open-air sites with bovid and suid remains in Silesia.

of faunal remains, Silesia remained a white patch on the map of the European Late Pleistocene. All the theories on the history of its fossil fauna were based on analogies from adjacent areas, which may, however, be characterised by different ecological and environmental conditions.

The detailed review of 174 open sites of Silesia shows that the fossil mammal fauna was dominated by large herbivores, members of the mammoth steppe fauna, dated at the Late Pleistocene. Among them, *Mammuthus primigenius* greatly outnumbered the other forms, followed by *Equus ferus* and *Coelodonta antiquitatis*. Others ungulates, such as *Rangifer tarandus*, *Megaloceros giganteus*, *Ovibos moschatus* and *Bison priscus*, co-occurred with them. Overall, ungulates form the vast majority in the studied material, while single carnivores accompany them in some sites or are represented by isolated finds. The mammoth steppe is regarded as one of the most extensive biomes, with cold, dry climate and plant biomass dominated by palatable high-productivity grasses, herbs and willow shrubs (Adams et al. 1990; Guthrie 1990; Zimov et al. 2012). The animals were adapted to surviving in low temperatures, but not to moving in deep, loose snow. The large, massive and short-legged woolly rhinoceros or musk ox, not being adapted to deep snow, avoided areas with permanent, thick snow cover.

In postglacial times the cold, dry climate changed to a warmer and wetter one which, among other things, resulted in a much greater snowfall which hindered movement and reduced food supply. As a result, the main members of the mammoth steppe fauna: *Mammuthus primigenius*, *Coelodonta antiquitatis*, *Bison priscus* and *Megaloceros giganteus*, entirely disappeared. Other species, like *Rangifer tarandus* or *Ovibos moschatus*, retreated to the north and east, while still other, most flexible forms like *Equus ferus* or *Ursus arctos* significantly changed their morphology. Both species evolved into more generalised, smaller forms of slighter build which needed smaller food resources than their Late Pleistocene relatives.

In horse evolution, the postglacial size decrease is a well-documented trend (Kurtén 1968; van Asperen and Stefaniak 2011; van Asperen et al. 2012). *Equus ferus przewalskii* (L. S. Poliakov, 1881) appeared in Europe in the Late Glacial, probably as an eastern immigrant. It was relatively small, but robust. Latter, as a result of size decrease *in situ*, it was replaced by a similar-sized, but much lighter built tarpan *Equus ferus ferus* Boddaert, 1785, which survived in Silesia till the late Holocene (Herr 1924a; Heinke 1926).

The history of the brown bear was similar. With its opportunistic behaviour, extremely broad diet, ability to adapt to various habitats ranging from semi-deserts to Arctic tundra, including arid and mountain areas, it could survive and adapt to the new environmental conditions (Baryshnikov 2007; Pacher 2007; Marciszak et al. 2017). Despite their scarcity, the brown bear remains from lowland Silesian open sites document the occurrence of a very particular kind of bear. This giant bear, called steppe brown bear *Ursus arctos priscus*, was a rare but permanent member of open grasslands mammal palaeocommunities

(Thenius 1956; Musil 1964; Pacher 2007; Rabeder and Frischauf 2016; Marciszak et al. 2016, 2017). It is very characteristic that this form is always strangely difficult to find not only in open sites but also in caves. Because it is uncommon, metric and morphological studies of this species suffer from paucity of fossil material (Baryshnikov 2007; Pacher 2007). Compared to other carnivores, the steppe brown bear was never common in one locality and tended to be a solitary scavenger (rather than hunter), which required large expanses of open grassland (Sabol 2001). This bear was a scavenger and kleptoparasite, whose huge size gave it advantage over other predators. It also probable followed herds of herbivores and took animals which died naturally or in another way (Musil 1996; Marciszak et al. 2017).

Isotopic analysis shows that brown bears were highly carnivorous till the late glacial and became more omnivorous with the change of climate and environmental conditions(Baryshnikov and Boeskorov 2001; Krajcarz et al. 2014; Xenikoudakis et al. 2015). The last postglacial warming brought about a shrinkage of open grasslands, disappearance of ungulate herds and expansion of forests. The largest species like mammoths, rhinoceros, and some bovids became entirely extinct, other forms lived in smaller herds or small groups, and carcasses were much harder to obtain than previously (Musil 2010). The density was much lower, and the amount of available food much smaller (Cooper et al. 2015; Wojtal et al. 2015; Rabanus-Wallace et al. 2017). There was not enough food and space for such a huge bear. During the postglacial times, the brown bear slowly dwarfed, and also smaller bears similar to the nominate subspecies entered from the south and southeast (Kurtén 1968). The dwarfing process, however, was not the same in entire Europe, since in some regions large, robust bears of *priscus*-type survived longer. The form sometimes known as *Ursus arctos nemoralis* (one of the synonyms of *Ursus arctos priscus*) is only a smaller descendant of the Late Pleistocene form (Baryshnikov 2007; Pacher 2007). which occurred till the early Holocene over the coast of the North and Baltic Seas as well as in some parts of Germany and Poland (Müller 1872; Degerbøl 1933; Hilzheimer 1937; Ruprecht 1965, 1992). Some populations slowly retreated to the northeast, while others were genetically swamped by the modern European bear (Baryshnikov 2007). Finally, in the early Holocene, the modern brown bear appeared and became the sole bear species in Europe (Kurtén 1957, 1968; Marciszak et al. 2017).

Biochronology

The data presented here are a result of an extensive revision of the fossil and partially subfossil material from Silesia known to date. The paper provides information on the large mammal remains found in Poland during the last 300 years. After a long time, this summary is the first comprehensive account of the available fossil material from Silesia. The work includes both quantitative and qualitative updates. However it is neither exhaustive nor complete. It is very likely that there are still many finds that have not been reported to scientific institutions or museums, or else remain in private collections. The size and rarity of some palaeontological finds, especially mammoth remains, deer antlers or big carnivore skulls, are noteworthy. They were often found by local searchers and may have been sold on account of their great value and/or rarity. Material from some sites, for example, Pyskowice or Milowice, is scattered over many museums and still contains hundreds of bones to be studied.

Silesia holds many more mammal finds, and they are much more varied than previously thought. Considering the extent of the ice sheet during the Late Pleistocene, it should assume that these are the bones of animals that inhabited the area during that time. Some of them occurred in the secondary context, but these need further verification and confirmation provided by taphonomic analysis. In the future, it is planned to conduct to broad-based query in national and regional museums as well as in private collections to prepare a database of all fossil and subfossil mammals from Silesian open sites. Also, it is planned to check the age of the remains with C14 and UTh dates as well as DNA and isotopic analyses. This may provide a complete insight into the past world of Silesian lowlands which, despite some synthesis and broad revisions like this paper, is still mostly unknown and only briefly described.

There is little doubt that the principal reason for the errors found during the revision of the Silesian fauna is the past misidentification, and all too often the errors remained in the list because subsequent authors had not seen the original material. Some of the undeterminable remains were in the past ascribed to species or even subspecies while actually, it is even difficult to assign them to a family with any certainty. Nomenclatural difficulties also played a part in the confusion, as can be seen from a large number of synonyms listed in the earlier revisions of Silesian fauna. Finally, it should also be noted that more than 15% of the specimens seen cannot be precisely attributed to specific sites since only the name Silesia was preserved on the bones. We did not comment on all such cases, except when they pertained to critical species.

This biochronological investigation is based on a number of bone remains to represent 22 mammalian species and almost 174 sites from the territory of Silesia. The remains represent extant species as well as species now locally or even globally extinct. Among five carnivores species (*Panthera spelaea spelaea*, *Canis lupus*, *Mustela nivalis*, *Ursus arctos priscus* and *Ursus* ex. gr. *spelaeus*) the most informative are the remains of the cave lion. Mandibles from Pyskowice and Sosnowiec-Milowice belonged to moderately large individuals of advanced morphology: narrow p4 with proportionally long protoconid is shorter than m1, and narrow m1 without zigzag enamel and lingual bulge and with considerably reduced talonid. The represented typical for the Late Pleistocene lion form, which occurred in Europe till the final extinction of the species at the beginning of the MIS 1 (Barnett et al. 2009). The morphology of robust lion from Węgry also classified it as *Panthera spelaea spelaea*, even if the specimen still retains some primitive features like slightly broadened crowns of p4 and m1 and m1 with the still present lingual bulge and less reduced talonid. In *Panthera spelaea* evolution size decreased slowly since MIS 6, however despite the general trend the situation seems to be more complicated (Argant et al. 2007; Marciszak et al. 2014). Since MIS 5 moderately large individuals with progressive morphology already occurred, large lions hold some primitive features similar to Węgry specimen still existed during MIS 6-5 (Altuna 1981; Argant 1991; Baryshnikov and Tsoukala 2010; Sotnikova and Foronova 2012; Marciszak et al. 2014). Pleistocene lions with progressive morphology closer to first appeared in western Asia, eastern and south-east Europe

(Sabol 2011). Somewhere between 48 and 45 Ka BP, *Panthera spelaea* populations rapidly declined, and their genetic variability was dramatically reduced, which caused a genetic bottleneck (Barnett et al. 2009). This period, due to a massive stadial within MIS 3, affected haplotype loss, strongly pronounced size decline, and decreasing massiveness (Marciszak et al. 2014). This last period covers MIS 3 and 2 and is characterised by the presence of many small or even dwarf specimens, comparable in size with medium-sized modern lions. Another explanation is the ecological response of the local, surviving populations to harsh environmental conditions and declination in prey abundance (Marciszak et al. 2014).

The Pleistocene lion was widely distributed across Poland in the timespan between MIS 10-3 (Kowalski 1959; Barycka 2008; Marciszak et al. 2011) So far there is not confirmed the occurrence of this species in sediments younger than MIS 3. From many sites remains of this species are quite rare and their stratigraphic position is more or less uncertain and should be confirmed by direct radiocarbon dates (Nadachowski et al. 2015). Concluding it can be said that Silesian lion remains do not document periods older than Late Pleistocene age.

Wolf remains from Wrocław Hallera 1 was found in the layer dated at the beginning of MIS 3 (Wiśniewski, Stefaniak, et al. 2009), while the calvarium from Malschwitz seems to be more probable postglacial or Holocene age. The occurrence of the steppe brown bear *Ursus arctos priscus*, immense member of open grasslands mammal palaeocommunities is so far restricted to the Late Pleistocene (Baryshnikov 2007; Pacher 2007; Rabeder and Frischauf 2016; Marciszak et al. 2015, 2017). The occurrence of robust brown bears with speleoid features in dental morphology was documented by the whole Late Pleistocene between MIS 5-1 (Wojtal 2007; Nadachowski et al. 2015; Wojtal et al. 2015). The single finds in sites with remains of somewhat older elements, dated at the Eemian interglacial, such as *Palaeoloxodon antiquus* or *Stephanorhinus kirchbergensis*, in Imbramowice or Pawłowiczki, might indicate the presence of another form, closely related to the steppe brown bear. The Taubach bear *Ursus arctos taubachensis* Rode, 1935, which appeared already in the late Middle Pleistocene, is a characteristic component of European interglacial faunas like Taubach, Weimar Ehringsdorf, Kent's Cavern or Tornewton Cave (Kurtén 1957; Sabol 2001; Baryshnikov 2007). Sometimes synonymised with Ursus arctos priscus, it differs nevertheless in some metric and morphological features (Baryshnikov 2007), which points to a distinct form (Marciszak et al. 2017). The problem needs further aDNA analysis, which may resolve the presence of other bear forms in Silesian open sites.

Among proboscides *Mammuthus primigenius* was recorded from 87 Silesian open-air sites, while in Poland in 2015 258 sites with remains of the woolly mammoth were known (Pawłowska 2015). Those localities documented the presence of this species in Poland, also in Silesia between MIS 5b and MIS 2 (Wojtal 2007; Wiśniewski, Stefaniak, et al. 2009, Wiśniewski, Wojtal, et al. 2009, Nadachowski et al. 2015). This occurrence was not uninterrupted during the whole Late Pleistocene, and two gaps during MIS 3 were observed between approximately 43.2 and 40.6 Ka BP and about 34.8 and 32.6 Ka BP (Nadachowski et al. 2011, 2015; Pawłowska 2015). That may be explained by the succession of forests in these periods and what has influenced them to reduce the number of this species and made the migration difficult. At the end of MIS 3, approximately 31.5–29.0 Ka BP the number of obtained dates is increasing significantly. It probably involves increasing the number of the mammoth populations not only in Poland (Nadachowski et al. 2011), but throughout Europe (Ukkonen et al. 2011; Markova et al. 2013) during periods of severe cooling, as evidenced by studies. It was also supported by isotopic analysis of mammoth teeth (Pryor et al. 2013). Second longer hiatus or decreasing in the occurrence of mammoths in Poland was during a significant cooling during LGM (MIS 2) and ranges between 27.5 to 25.0 Ka BP and 23.5 to 18.0 Ka BP. During that period there are known only three dates between 24.5 and 23.5 Ka BP. This gap was also noted in most

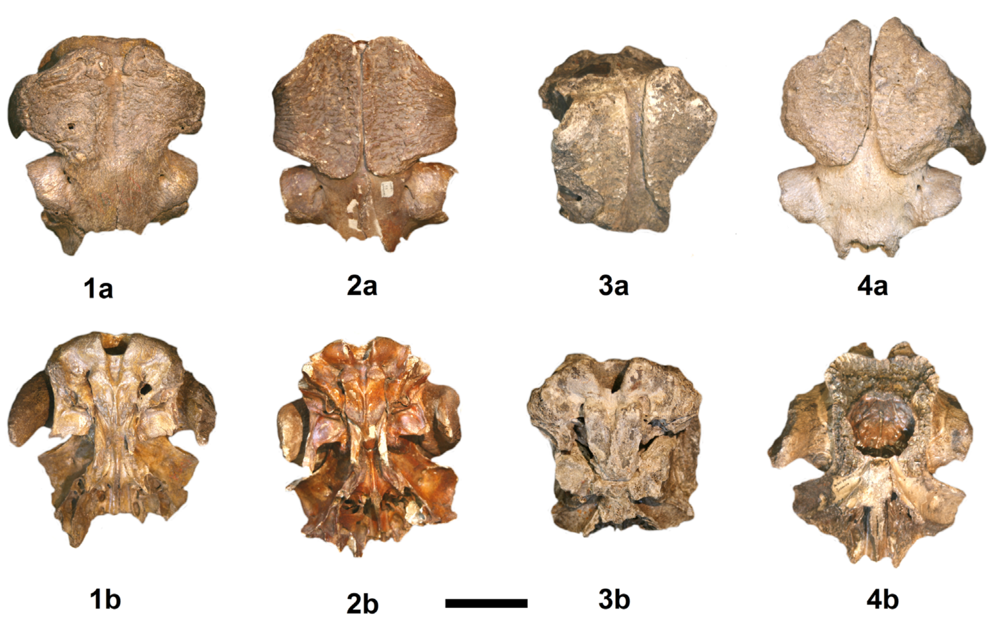

Figure 19. Skulls of *Ovibos moschatus* from Silesian open-air sites: 1a–b – Sosnowiec-Milowice (MIL/M/1), 2a–b – Pyskowice-Dzierżno (PYS/M/1), 3a–b – Kamiennik (KAM/M/1), 4a–b – Ziębice (ZIE/M/3), a – top view, b – bottom view, scale bar 100 mm.

the territory of Europe (Stuart et al. 2004; Ukkonen et al. 2011; Nadachowski et al. 2015). The return of *Mammuthus primigenius* to Poland occurs at about 18.0 Ka BP and the species finally extinct in most the territory of Poland before bølling-allerød warming ca. 16.5–15.0 Ka BP (Nadachowski et al. 2015). After that, only two relict populations survived, one of them in the in the vicinity of the Moravian Gate in the Upper Odra valley. It is documented by an Upper Paleolithic site Dzierżysław 35 (Wojtal 2007; Wiśniewski, Stefaniak, et al. 2009; Wiśniewski, Wojtal, et al. 2009; Nadachowski et al. 2011, 2015). Obtained C14 dates confirmed the occurrence of the species between 14.1 and 13.1 Ka BP (Wojtal 2007). Even younger date 10 510 ± 650 BP (call. 12 440 ± 180) was obtained from the molar from this site (Markova et al. 2013) is sometimes questioned because of the small amount of collagen in dating material (Nadachowski et al. 2011, 2015). This confirmed that southern Silesia might me regard as one of the last refugia of *Mammuthus primigenius* north of the Carpathian arch. Secondly, all obtained so far radiocarbon dates support the conclusion, that the species was the most widespread in Silesia, as in the whole Poland, at the end of MIS 3 (31.5–29.0 Ka BP) (Pawłowska 2015).

As to the two another Silesian elephantid species are incomparably rarer, with four sites with *Mammuthus trogontherii* remains and five localities, where fossil material of *Palaeoloxodon antiquus* has been found. These are all finds from the nineteenth and early twentieth century, almost exclusively represented by isolated teeth and bones and were recorded without stratigraphic evidence. The only Polish record of *Mammuthus trogontherii* found in geological context came from Bełchatów dated to MIS 11-9, where additionally were found evidence of human exploitation (Pawłowska et al. 2014). Similarly, the history of the occurrence of a *Palaeoloxodon antiquus* in Poland is difficult to reconstruct because most of the dating of his remains failed due of insufficient collagen in the bones. The species has survived the longest in Iberian Penninsula to the first, the relatively warm phase of MIS 3 ca. 48–45 Ka BP (Stuart 2005). Simultaneously it can, therefore, assume that this largest European land mammal survived in in Central Europe only to Eemian interglacial (MIS 5e) (Nadachowski et al. 2015). In this context, it can be only said that it is not impossible but highly improbable, that Silesian records of *Palaeoloxodon antiquus* are younger than MIS 5e.

Coelodonta antiquitatis is known from 26 Silesian sites and in most of them was found together with other members of steppe-tundra faunas like *Mammuthus primigenius*. Presence of this species was confirmed from more than 100 Polish sites (Kowalski 1959), which are dated to MIS 8-2 (Wojtal 2007; Stefaniak and Marciszak 2009; Nadachowski et al. 2015). It was widespread in the Late Pleistocene in almost whole Poland (except mountains), but since the end of MIS 3 (35–30 Ka BP) has gradually reduced its number and range elsewhere in Europe until the final extinction ca 14.0–13.5 Ka (Stuart and Lister 2012; Kahlke 2014). In the Central and Eastern Europe this species survived until 17.0–15.5 Ka BP (Nadachowski et al. 2015) and among the youngest woolly rhinos is also a female from Skarszyn, dated ca. 16.5 Ka. Metrical and morphological analysis showed that Silesian woolly rhinos are represented by the typical for the Late Pleistocene form large, robust animal with proportionally short and massive limbs classified as *Coelodonta antiquitatis antiquitatis* (Guérin 2010). It seems, that similarly to *Mammuthus primigenius*, Silesia or some their parts can be regarded as a refugium for the last populations of *Coelodonta antiquitatis*, which finally disappeared in Central Europe just before bølling-allerød warming (Nadachowski et al. 2015).

Stephanorhinus kirchbergensis is known only from two Silesian records, both correlated with MIS 5e, which is regarded as its dissapearence time of the species. Another Polish findings of this species are also dated between MIS 8-5e, as recently found excellently preserved skeleton from Gorzów Wielkopolski (Badura et al. 2017). As was noted by van der Made (2010, p. 496, 497): '*S. kirchbergensis* may have survived till the beginning of the last glacial stage, but if truly an interglacial species, its survival till the end of this cold stage would be surprising'. However Silesian data for this species are so far to scare to give any more reliable data and it can be only suppose that suggested already by previous authors (Gürich 1905, 1913; Wiśniewski, Stefaniak, et al. 2009) Eemian age or maybe slightly older seems to be the most probable.

Horses from Silesian open-air sites are represented by medium and large-sized specimens with dental morphology typical of caballoid horses. Only the specimens from very few localities like Ziębice seems to be slightly smaller and more slightly built than a medium-sized recent horse. For most of the findings were given Late Pleistocene, postglacial or Holocene age, however according to some earlier researchers, some individuals might be even older than the Late Pleistocene (Gürich 1893; Herr 1924a; Heinke 1926; Wiśniewski, Stefaniak, et al. 2009). But the age is very uncertain, and in general, many horse remains are quite young, of Holocene age. In Silesian horses only direct dating methods can give a reliable data, as in case of horse from Dzierżysław 1, which gave age somewhat older (ca. 19.7 Ka BP) (Fajer et al. 2004) than other bones (between 14.1 and 13.2 Ka BP [Wojtal 2007]).

Finally, the numerous species of artiodactyls are usually to scare, despite the number of sites, to give the reliable data., except single date of reindeer from Dzierżysław, the documented presence of the species ca. 13.2 Ka BP. Most of the specimens described or mentioned by pre-war authors were not found, and these who survived until recent scare. In many of them, light color and poorly fossilisation suggested their subfossil character. As in case of horses, only direct C14 dates can give in the future the answer about the age of particular specimens. Concluding, it can say that most of the findings from Silesian open-air sites seem to be Late Pleistocene age. Some of them maybe are however younger, postglacial or Holocene age. Single records of thermophilous faunal elements like *Palaeoloxodon antiquus* or *Stephanorhinus kirchbergensis* may represent interglacial fauna from Eemian or even older.

Stratigraphic and palaeoenvinronmental context of finds

The review includes 174 sites with the occurrence of remains of the large Pleistocene mammals in Silesia in the context of their stratigraphic position. It can be clearly seen that with respect to the depositional environment two types of localities prevailed: those in which the bones were buried under or within alluvial deposits associated mainly with the last glaciation and those in which the remains were found near or in the lower layers of loess cover. Both site types are correlated with the period of MIS 2-MIS 4.

The Głubczyce Plateau as well as the Trzebnickie Hills are covered with a several metre layer of loess formed primarily during MIS 2. The site in Pawłowiczki is ca. 17 km away from Głogówek but in a similar geological situation (Jary 1996, 2007); it can be surmised that the rhinoceros remains found on a bench in Pawłowiczki occurred at a similar level as in the case of the site in Skarszyn. They were probably located within the bottom of a less layer within a compound of several uneven-aged fossil soils from the Eemian interglacial (MIS 5e) to the middle pleniglacial of Vistula glaciation (MIS 3).

Selected geological profiles illustrating the most common location of the remains of Pleistocene fauna showed presence of two main site types (Figure 20). A compact loess-covered area, with thickness of several metres, stretches across the foreground of the Sudetes, from Zgorzelec to the southern part of Opole region and further to the Silesian Upland. Loess covers the glacitectonically piled Trzebnickie Hills. Deposits of the last glaciation occur across all the river valleys of the area, ranging in thickness from a few metres to 30 m in the river valleys of Upper Silesia or even to 50 m in the Barycz Valley. In some valleys these deposits form distinct terraces, today rising from a few to ca. 20 m above the river bottom. Preservation of skeletal remains on the surface requires a suitable environment, so that the bones can be quickly isolated from the destructive influence of climatic factors, especially the cycles of freezing and thawing, which lead to their total disintegration. Reasonably good preservation of bone remains within the valleys required them to be deposited in cavities filled with silty-clay or organic deposits.

A good example of this situation is the site Milowice (Ryziewicz 1933), where numerous skeletal remains were preserved in good condition in a layer of peaty silt from the remnants of tundra flora (Kozłowska 1933). Liquefied or unfrozen

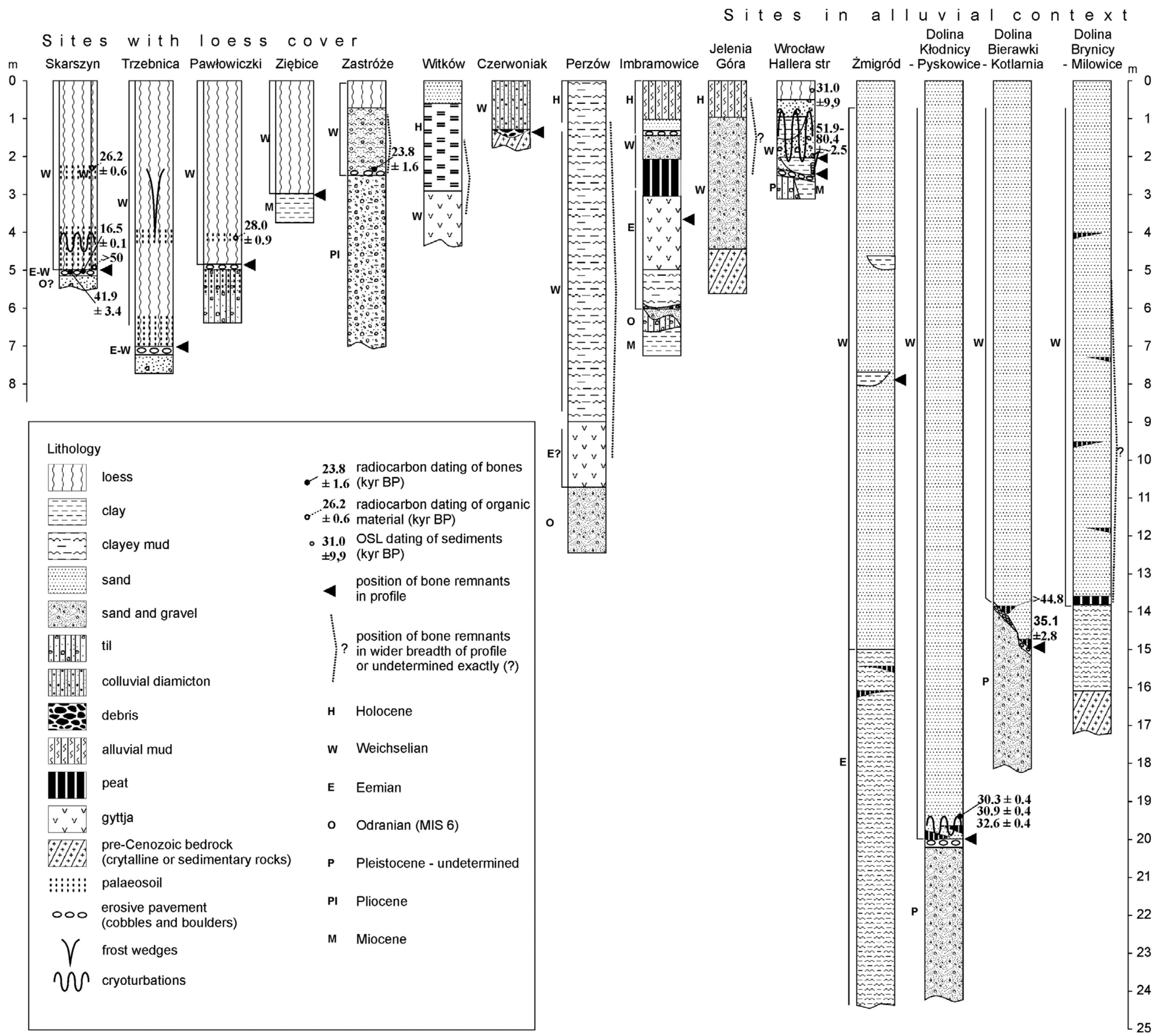

Figure 20. Selected geological profiles illustrating the most common location of the remains of Pleistocene fauna in Silesia.

sediments, before they were covered by loess, ensured adequate isolation of parts of the skeleton. The sites within the river valleys are much richer in bone remains. This is partly due to the original environmental conditions in which animals, especially gregarious, often lived in the valleys. In the case of sites with the most abundant Pleistocene fossil fauna, such as Brynica, Kłodnica or Bierawski valleys, the great numbers result from the fact that the remains were collected over vast areas of open-cast mines, often exceeding 1 km^2. The origin of some of the localities is associated with karst, as described by Herr (1924a) who found remains of a cave bear in Kunnersdorf north of Zgorzelec. However, it was not a cave, but a rather small karst sinkhole or crater, filled with remains. It is possible that the rhinoceros and horse material found in the limestone quarry at Mt. Czerwoniak near Kłodzko is also of karstic origin (Otto 1837).

Among the analysed profiles, unfortunately, there are no sites which would support any considerations on the variation of the faunal composition during the Late Pleistocene. The remains found in most localities represent the same time interval, without possibility to extract more bones, no variation in species composition or no possibility to precisely define their stratigraphic position.

Conclusions

It is assumed that the Silesian mammals represent a Late Pleistocene cold-adapted fauna, with possible admixture of rare elements of thermophilus fauna such as *Palaeoloxodon* or *Stephanorhinus*. The Silesian faunal assemblages are similar in many respects to those of a considerable number of Late Pleistocene sites in Europe. The associations of different species indicate moderately cold but relatively moist climate conditions, capable of sustaining large herbivore populations. The substantial river system, especially the Odra with its tributaries, provided suitable conditions for the massive herbivore herds.

On the whole the mammals from Silesian open-air sites have received relatively little attention. Consequently the number of reliably stratified and dated records of fossil mammals at present available is not adequate as a basis for any detailed analysis of faunal changes during the Late Pleistocene. In view of the emerging complex patterns of climate and vegetation changes during the Late Pleistocene this lack data if unfortunate, since it seems very probable that the history of the mammal fauna was correspondingly complex.

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