

THE LEOPARD (*PANTHERA PARDUS*), THE RARE HUNTER OF THE ALPINE AREA DURING THE UPPER PLEISTOCENE

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Abstract

The paper presents a revision of leopard remains in the Alps with special focus on the Eastern Alpine area and Switzerland. The oldest evidence comes from the Middle Pleistocene of Hundsheim, Austria, followed by remains from Repolust-cave, Styria, Austria. During the Upper Pleistocene the leopard also reached the high Alps. The highest elevated finds come from the Drachenloch, Switzerland. Nonetheless, its distribution into the Eastern Alpine area is limited, especially at higher elevations. The leopard reached the Alpine area only occasionally with exception of the southern French Alps and Liguria, Italy.

Samenvatting

Dit artikel presenteert een herziening van de gevonden luipaardresten in de Alpen met een speciale focus op het Oostelijk Alpengebied en Zwitserland. Het oudste bewijsmateriaal komt uit het Midden-Pleistoceen van Hundsheim (Oostenrijk), gevolgd door resten uit de Repolustgrot in Styria (Oostenrijk). Gedurende het Laat-Pleistoceen bereikte het luipaard ook het Alpengebied. De hoogst gelegen vondsten komen van de Drachenlochgrot in Zwitserland. Toch is de distributie in het Oostelijk Alpengebied beperkt, vooral bij grotere hoogtes. Het luipaard bereikte slechts incidenteel het Alpengebied met uitzondering van de zuidelijke Franse Alpen en Ligurië (Italië).

INTRODUCTION

Remains of the leopard (*Panthera pardus*) are rare finds in Alpine bear caves. However, two recently revised sites, the Wildkirchli-cave (1,420m) at the Säntis, Switzerland and Merkenstein-cave (441m) near Baden, Lower Austria reveal more numerous remains of the rare hunter of the Pleistocene with twenty-two in the former respectively six identified skeletal elements in the latter cave. This gives us the opportunity to compile and audit Alpine leopard evidence published so far.

The oldest known remains in the Eastern Alpine area come from the Middle Pleistocene of Hundsheim, which have first been described as *Felis pardus* var. *tulliana* foss. (Freudenberg 1914) and later on included in the taxonomic discussion of Pleistocene leopards (eg. Hemmer & Schütt, 1970; Diedrich, 2013; Hemmer *et al.*, 2003). Our aim, however, is to summarize possible occurrences of Pleistocene leopards in the Alps and to compile metrical data. Special focus is given on a revision of material from the Eastern Alpine area and Switzerland.

REVISION OF SITES

The oldest remains of leopards in the Eastern Alpine area come from the Middle Pleistocene of Hundsheim, first mentioned in Freudenberg (1909). Later on, Freudenberg (1914) listed and figured eleven remains among them a distal phalanx subsequently identified as first evidence of the cheetah (*Acinonyx intermedium* n. sp.) at Hundsheim (Freudenberg 1914, Fig.XVIII:1r, Thenius, 1953). The revision of the material from Hundsheim at the Natural History Museum Vienna confirms sixteen specimens. Neither the third metacarpal fragment mentioned by Freudenberg (1914) nor the figured navicular bone was found. Two remains are currently housed

at the collection Weinfurter at the Institute of Palaeontology Vienna (table 2, table 4-8, plate 1).

The mountain area near Graz yielded chronologically older remains, as well as several finds attributed to the Upper Pleistocene. All mentioned cave sites lie at moderate elevations from 440m a.s.l. (above sea level) to 650m a.s.l.

The leopard remains from Repolust-cave near Graz, Styria are most likely from the transition of the Middle Pleistocene towards the Upper Pleistocene based on stratigraphy and additional faunal elements (Pacher, 2014). Two proximal phalanges, one canine, one fourth metacarpal (LMJ 54613) and a pelvic fragment (LMJ 54612) from the auburn phosphate soil are mentioned (Mottl, 1951:65-66, Fig.23). The canine and phalanges, one with inventory number LMJ 57434 could not be found at the museum "Joanneum" in Graz. However, one mt3 (LMJ 57433) and a mandible fragment of a juvenile (LMJ 58978) is attributed to *Panthera pardus*. The mandible possesses the dc (L-13.6, B- 9.5mm), dp3 (L-10.8, B-14.0mm), dp4 (L-14.1, B-5.0mm) and germs of deciduous teeth (table 4).

Probably of similar chronological age are the leopard remains from Badl-cave opposite of Repolust-cave, separated only by a small stream. One pelvic-fragment (LMJ 57435), one third metacarpal (LMJ 58280) listed as metatarsal in Mottl (1953) and one proximal phalanx (LMJ 57436) are confirmed. An additional proximal phalanx (LMJ 55949) was assigned to the lynx (*Lynx lynx*) but shows close affinities to the leopard in size (table 8).

Several caves in the mountain area near Graz yield single finds, whose identification is not always clear. At Holzinger-cave, one cervical vertebra (LMJ 22648) and one middle phalanx (LMJ 58278), originally classified as lynx, are assigned to the leopard (Fladerer, 1997b:). A patella from the

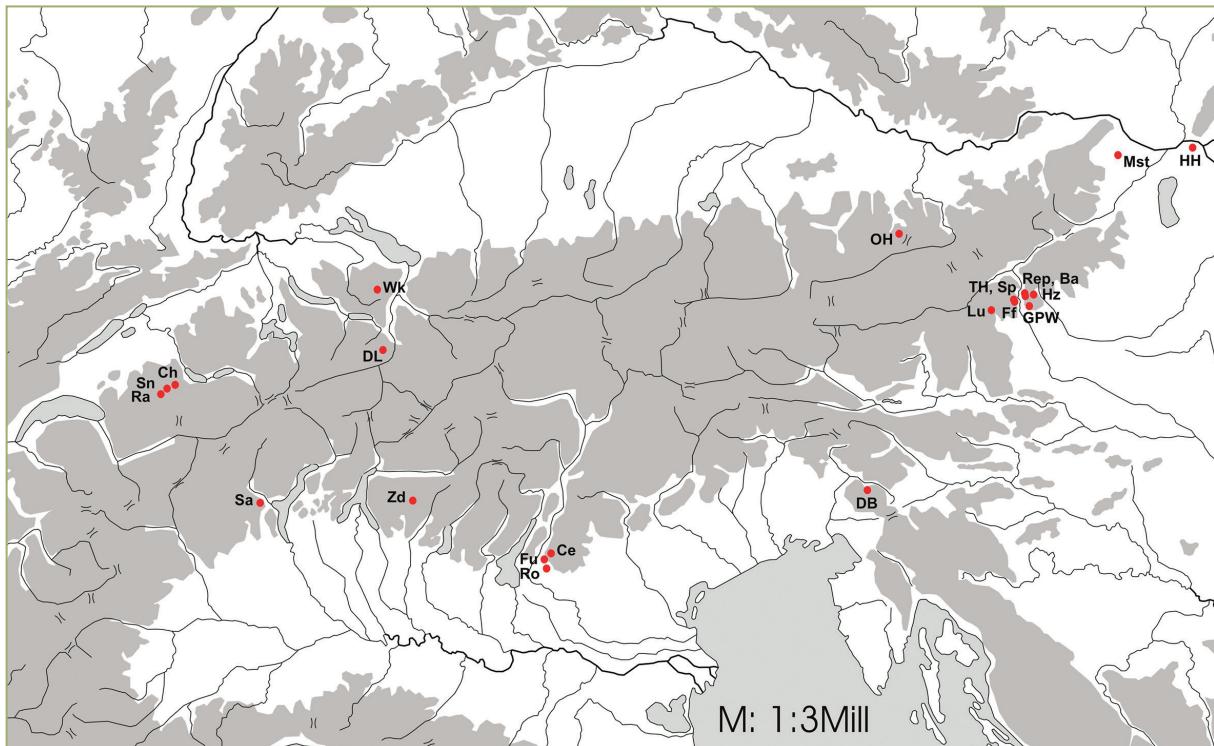


Figure 1: Cave sites with *Panthera pardus* remains from the Eastern Alpine area and Switzerland (Abbreviations as in Table I)

Figuur 1: Grotten met *Panthera pardus* overblijfselen in het oostelijk Alpengebied en Zwitserland (Afkortingen als in Tabel I)

Luegloch (LMJ 58533) was referred to as lynx but the leopard is more likely because of its dimensions. With a greatest breadth of 18.7mm, a greatest length of 31.4mm and a depth of 8.8mm the specimen falls within the range of leopards (Fladerer, 1997d.). The same holds true for a distal metapodial fragment (LMJ 58281) from the Fünffenstergrotte (Fladerer, 1997c). *Panthera pardus* is also mentioned at the Kugelstein-Tropfsteinhöhle, based on a small-sized proximal phalanx (Fladerer & Frank, 1997) and listed for the Große Peggauerwandhöhle (Fladerer, 1997a). The remains were not available at the collection of the museum "Joanneum" in Graz. In addition, a middle phalanx from Spalten-cave (LMJ 58909) labeled as male lynx is assigned to the leopard due to its size (table 8).

Undoubted leopard remains come from Merkenstein-cave, Lower Austria. This cave lies again at lower elevation with its entrance at 441m a.s.l.. One lower p4 and a proximal phalanx have already been classified as leopard (Wettstein & Mühlhofer, 1938:537, fig.5; Nagel, 1997). Both remains were not available for this study. The dimensions of the p4 are on the lower range of values and are even small when compared to modern leopards (Nagel, 1997). A recent revision yielded an additional pelvic-fragment, whose dimensions clearly argue for *Panthera pardus* (table 6), an upper incisor, and a right first tarsal bone. One distal humerus fragment from a leopard probably corresponds to the mentioned element of lynx (Wettstein & Mühlhofer, 1938). Surprisingly, the preservation is different from the other Pleistocene elements at the site. Its dimensions (distal breadth (db) = 40.4mm, breadth of trochlea (btr) = 29.0mm) exceed the values from the leopard of Cerè cave (Ghezzo *et al.*, 2014) db = 34.7mm, btr = 24.4mm).

The most numerous remains at the high Alps are reported from the Wildkirchli-cave, Switzerland. In course of a revision of the cave bear remains from three Swiss Alpine sites Drachenloch, Wildkirchli and Wildenmannlisloch, financed by the Naturmuseum St. Gallen, Switzerland, the interesting large mammal remains were also examined.

In course of this revision, twenty-one leopard remains are confirmed at Wildkirchli-cave (table 3); some of them have already been figured by Bächler (1936: Fig.32, 1940: plate

CXI). Evidence of an upper M1 is based on Schmid (1940, table 19). New elements are labeled "WKV" for finds studied in Vienna. Two remains from Drachenloch are mentioned and figured in Bächler (1940: 213 and plate CXIII:1-2). The canine is also labeled with "Drachenloch". The maxilla fragment was not available. The second metacarpal labeled "AB 4-6 P.E." comes also from the Drachenloch-cave and was found within bear metapodials in the museum.

The upper canine from Drachenloch is figured in Diedrich (2013: fig. 6-5) among the Wildkirchli finds. The preserved total height of the incisors, 33mm and 36mm (Diedrich 2013: fig. 6-3, 6-4), argues for *Panthera spelaea*, and the heavily abraded proximal radius (Diedrich 2013: fig. 6-10) shows affinities to a small-sized bear.

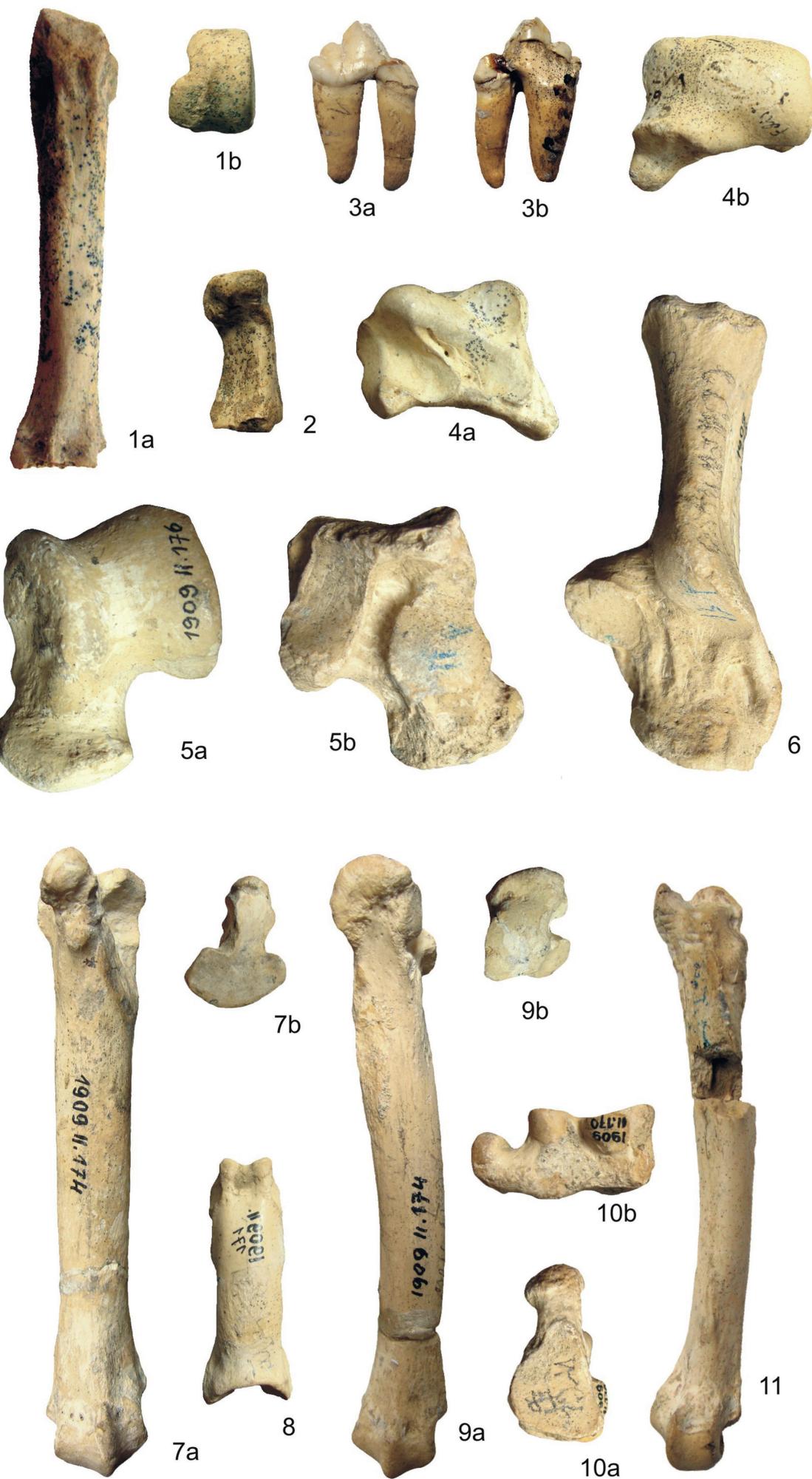
Bächler (1936; 1940) ascribed the leopard remains from Wildkirchli to *Felis pardus* var. *spelaea*. These finds were the first evidence of the Pleistocene leopard in Switzerland. Nonetheless, the highest elevated occurrence lies at the Drachenloch (2,475m a.s.l.) followed by the Ranggiloc (1,845m a.s.l.) and the Chilchiloch (1,810m a.s.l.). In the Eastern Alpine area the highest elevated evidence comes from the Ochsenhalthöhle (1,660m a.s.l.), Styria. Apart from Wildkirchli (1,477m a.s.l.), remains of the leopard are scarce in Alpine sites and sometimes not well confirmed.

At Ranggiloc, the fragment of a phalanx is assigned to the leopard because of its dimensions (Koby, 1964). At Chilchi-cave, the fragment of an upper P4 was as clearly identified as a right lower p3 from Schnurenloch (Koby, 1964:156, Fig. 31).

In the Austrian High Alps, the leopard is only listed at Ochsenhalt-cave with a left distal fragment of an upper P4 (Geyer, 2007:72, Fig. 5). The element was not available for this study.

In the Southern Alpine area, the leopard is known from Divje babe I, Slovenia. Toškan (2007) mentioned a lower m1 (length of paraconid = 9.8mm), a vertebra, a carpal bone, three medial phalanges and two distal phalanges from *Panthera pardus*.

ICBS PROCEEDINGS



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Based on literature, evidence stays scarce in the Italian Alps and is mainly restricted to sites at the southern Alpine fringe. Previous compilations of European finds show a limited number of sites in this area with one site mentioned by Schmid (1940) and Fischer (2000). Three localities are listed in Diedrich (2013) and five in Sauqué & Cuenca-Bescós (2013). Following the previous compilations and own research leopards are confirmed at the Middle Pleistocene from Cerè cave (Ghezzo *et al.*, 2014) and Serbaro di Romagnano (Kotsakis & Palombo, 1979). The proposed evidence at Soave-Monte Tenda and Soave-Sentiere have recently been attributed to a lion-like cat, *Panthera fossilis* (Bona & Sardella, 2012). The Upper Pleistocene from Grotta di Fumane yielded two remains (Tagliacozzo *et al.*, 2013) in addition to Zandobbio (Vialli, 1957) and Grotta di Sambughetto (Kotsakis & Palombo, 1979). Leopards get considerably more abundant in the Ligurian Alps and the southern French Alps starting from Early Pleistocene remains at Vallonnet (Echassoux, 2004) towards numerous Middle to Upper Pleistocene sites (eg. Valensi & Pasthi, 2004; Bonifay, 1971).

CONCLUSION

The leopard was a scarce element in the Eastern Alpine area and Switzerland during the Upper Pleistocene. It probably reached higher elevated sites such as Wildkirchli and Drachenloch only occasionally, whereas leopards found better living conditions at the southern fringe of the Alps. Given the number of sites with a considerable number of remains in southern Europe, such as Vraona, Greece (Nagel, 1999), Trigalnata cave, Bulgaria (Spassov & Raychev, 1997), Jaurens, France (Ballesio, 1980), sites in Spain (see Sauqué & Cuenca-Bescós, 2013) and especially at Equi, Italy (Ghezzo & Rook, 2015), it seems that the Pleistocene leopard favored moderate climatic conditions through time and migrated into the Alpine area and more northern regions only occasionally. Unfortunately, the nearly complete absence of direct radiocarbon dates on *Panthera pardus* remains hamper a detailed time resolution of the leopard distribution throughout Europe. A direct date on leopard bones from Vraona gave a conventional age of 17,805+-1000 BP and 24,490+-1350 BP (Rabeder & Symeonidis, 1995) and a sample from Equi, Apuan Alps dated at 33,000+-260 BP and hence confirms its occurrence during MIS 3 (Ghezzo & Rook, 2015), while Sauqué & Cuenca-Bescós (2013) suggest an Upper Pleistocene refuge area for *Panthera pardus* in Spain. The discussed Holocene survival of leopards in Europe is based on unclear dated finds only (eg. Galik *et al.*, 2012; Spassov & Raychev, 1997).

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Plate 1: Selected elements of *Panthera pardus* from Hundsheim (IPUW Institute of Palaeontology, University of Vienna, NHMW Natural History Museum of Vienna). All photos lifesize pictured

Plaat 1: Geselecteerde elementen van *Panthera pardus* uit Hundsheim. Alle foto's levensgroot afgebeeld

1a: metacarpale 4, palmar view (IPUW coll. Weinfurter); 1b: metacarpale 4, proximal view (IPUW coll. Weinfurter); 2: middle phalanx (IPUW coll. Weinfurter); 3a: P3sup, buccal view (NHMW 1909-II-167); 3b: P3sup, lingual view (NHMW 1909-II-167); 4a: scaphoid, proximal view (NHMW 1909-II-169); 4b: scaphoid, distal view (NHMW 1909-II-169); 5a: talus, dorsal view (NHMW 1909-II-176); 5b: talus, plantar view (NHMW 1909-II-176); 6: calcaneus, dorsal view (NHMW 1909-II-176); 7a: metatarsal 3 plantar view (NHMW 1909-II-174); 7b: metatarsal 3, proximal view (NHMW 1909-II-174); 8: proximal phalanx (NHMW 1909-II-171); 9a: metatarsal 4, plantar view (NHMW 1909-II-174); 9b: metatarsal 4, proximal view (NHMW 1909-II-174); 10a: tarsal 3, proximal view (NHMW 1909-II-170); 10b: tarsal 3, medial view (NHMW 1909-II-170); 11: metatarsal 5, plantar view (NHMW 1909-II-174+175)

REFERENCES

- Bächler, E. (1936) *Das Wildkirchli*. Buchdruckerei Tschudy & Co. St. Gallen.
- Bächler, E. (1940) *Das alpine Paläolithikum in der Schweiz im Wildkirchli, Drachenloch und Wildenmannisloch. Die ältesten menschlichen Niederlassungen aus der Altsteinzeit des Schweizerlandes*. Verlag Birkhäuser, Basel.
- Ballesio, R. (1980) Le gisement Pléistocène supérieur de la grotte de Jaurens a Nespolu, Corrèze, France: Les Carnivores (Mammalia, Carnivora) II. Felidae. *Nouvelles Archives du Muséum de Histoire naturelle de Lyon* 18, 61-102.
- Bona, F., R. Sardella (2012) The Middle Pleistocene large felids (Mammalia) from Brecce di Soave (Verone, N-E Italy). *Rivista Italiana di Paleontologia e Stratigrafia* 118, 193-199.
- Bonifay, M.F. (1971) Carnivores quaternaires du sud-est de la France. *Mémoires du Muséum National d'Histoire naturelle n.s. sér. C, XXI*, 44-377.
- Diedrich, C.G. (2013) Late Pleistocene leopards across Europe – northernmost European German population, highest elevated records in the Swiss Alps, complete skeleton in the Bosnia-Herzegovina Dinards and comparison to Ice Age cave art. *Quaternary Science Reviews* 76, 167-193.
- Echassoux, A. (2004) Étude taphonomique, paléoécologique et archéozoologique des faunes de grands mammifères de la seconde moitié du Pléistocène inférieur de la grotte du Vallonnet (Roquebrune-Cap-Martin, Alpes-Maritimes, France). *L'Anthropologie* 108, 11-53.
- Fischer, K.H. (2000) Ein Leoparden-Fund (*Panthera pardus* L., 1758) aus dem jungpleistozänen Rixdorfer-Horizont von Berlin und die Verbreitung der Leoparden im Pleistozän Europas. *Mitteilungen des Museum für Naturkunde in Berlin Geowissenschaftliche Reihe* 3, 221-227.
- Fladerer, F. (1997a) Große Peggauerwandhöhle. in: Döppes, D., G. Rabeder (Eds.) *Pliozäne und pleistozäne Faunen Österreichs. Mitteilungen der Kommission für Quartärforschung der Österreichischen Akademie der Wissenschaften* 10, 320-325.
- Fladerer, F. (1997b) Holzingerhöhle. in: Döppes, D., G. Rabeder (Eds.) *Pliozäne und pleistozäne Faunen Österreichs. Mitteilungen der Kommission für Quartärforschung der Österreichischen Akademie der Wissenschaften* 10, 311-312.
- Fladerer, F. (1997c) Fünfenstergrotte. in: Döppes, D., G. Rabeder (Eds.) *Pliozäne und pleistozäne Faunen Österreichs. Mitteilungen der Kommission für Quartärforschung der Österreichischen Akademie der Wissenschaften* 10, 308-310.
- Fladerer, F. (1997d) Luegloch bei Köflach. in: Döppes, D., G. Rabeder (Eds.) *Pliozäne und pleistozäne Faunen Österreichs. Mitteilungen der Kommission für Quartärforschung der Österreichischen Akademie der Wissenschaften* 10, 312-316.
- Fladerer, F., C. Frank (1997) Tropfsteinhöhle am Kugelstein. in: Döppes, D., G. Rabeder (Eds.) *Pliozäne und pleistozäne Faunen Österreichs. Mitteilungen der Kommission für Quartärforschung der Österreichischen Akademie der Wissenschaften* 10, 342-348.
- Freudenberg, W. (1909) Die Fauna von Hundsheim in Niederösterreich. *Jahrbuch der kaiserlich-königlichen geologischen Reichsanstalt* LVIII(2), 197-222.
- Freudenberg, W. (1914) Die Säugetiere des älteren Quartärs von Mitteleuropa, mit besonderer Berücksichtigung der Fauna von Hundsheim und Deutsch-Altenburg in Niederösterreich nebst Bemerkungen über verwandte Formen anderer Fundorte. *Geologisch-Paläontologische Abhandlungen N.F.* 12(4-5), 375-391.
- Galik, A., B. Horejs, B. Nessel (2012) Der nächtliche Jäger als Beute. Studien zur prähistorischen Leopardenjagd. *Prähistorische Zeitschrift* 87(2), 261-307.

- Geyer, E. (2007) 10 Jahre Forschungen im Weißenbach-Höhlenprojekt. *Die Höhle* 59(1-4), 69-73.
- Ghezzo, E., L. Rook (2015) The remarkable *Panthera pardus* (Felidae, Mammalia) record from Equi (Massa, Italy): taphonomy, morphology, and paleoecology. *Quaternary Science Reviews* 110, 131-151.
- Ghezzo, E., D.F. Berté, B. Sala (2014) The revaluation of Galerian Canidae, Felidae and Mustelidae of the Cerè Cave (Verona, Northeastern Italy). *Quaternary International* 339-340, 76-89.
- Hemmer, H., R.D. Kahlke, T. Keller (2003) *Panthera onca gambaszoegensis* (Kretzoi 1938) aus den frühmittelpleistozänen Mosbach-Sanden (Wiesbaden, Hessen, Deutschland). Ein Beitrag zur Kenntnis der Variabilität und Verbreitungsgeschichte des Jaguars. *Neues Jahrbuch für Geologie und Paläontologie Abhandlungen* 229, 31-60.
- Hemmer, H., G. Schütt (1970) Körpergrösse und Extremitätenmasse ältest- und altpleistozäner europäischer Pantherekatzen (genus *Panthera*). *Mainzer naturwissenschaftliches Archiv* 9, 132-146.
- Koby, F. E. (1964) Die Tierreste der drei Bärenhöhlen. in: Andrist, D., W. Flükiger, A. Andrist (Eds.) *Das Simmental zur Steinzeit. Acta Bernensia III*, 149-160.
- Kotsakis, T., M.R. Palombo (1979) Un cranio di *Panthera pardus* (L.) del Pleistocene medio superiore de Monte Sacro (Roma). *Geologica Romana* 18, 137-155.
- Mottl, M. (1951) Die Repolusthöhle bei Peggau (Steiermark) und ihre eiszeitlichen Bewohner (mit einem Beitrag von V. Maurin).
- Mottl, M. (1953) Die Erforschung der Höhlen. in: Mottl, M., K. Murban (Eds) Eiszeitforschungen des Joanneums in Höhlen der Steiermark. *Mitteilungen des Museums für Bergbau, Geologie und Technik am Landesmuseum Joanneum* 11, 14-58.
- Nagel, D. (1997) *Panthera pardus* und *Panthera spelea* (Felidae) aus der Höhle von Merkenstein/Niederösterreich. *Wissenschaftliche Mitteilungen des Niederösterreichischen Landesmuseums* 10, 215-224.
- Nagel, D. (1999) *Panthera pardus vraonensis* n. ssp., a new leopard from the Pleistocene of Vraona/ Greece. *Neues Jahrbuch für Geologie und Paläontologie, Monatshefte* 3, 129-150.
- Pacher, M. (2014) Die eiszeitliche Tierwelt der Repolusthöhle (Steiermark, Österreich) – Erste Ergebnisse der paläontologischen Untersuchungen. *Schild von Steier* 26, 2013/2014, 238-254.
- Rabeder, G., N. Symeonidis (1995) Stratigraphie und Chronologie der Höhlensedimente von Vraona (Attika, Griechenland). in: Symeonidis, N., G. Rabeder (Eds.) *Das Jungpleistozän in der Höhle von „Vraona“ auf Attika in Griechenland. Annales Géologiques de Pays Helléniques* 36, 107-109.
- Sauqué, V., G. Cuena-Bescós (2013) The Iberian Peninsula, the last European Refugium of *Panthera pardus* Linnaeus 1758 during the Upper Pleistocene. *Quaternaire* 24(1), 35-48.
- Schmid, E. (1940) Variationsstatistische Untersuchungen am Gebiss pleistozäner und rezenter Leoparden und anderer Feliden. *Zeitschrift für Säugetierkunde* 15, 1-179.

Abbrev.	Site	A.s.l	Chronology	NISP	References
Ba	Große Badlhöhle	495m	MP/UP	3+1?	Mottl, 1953, own data
Ce	Grotte del Cerè	750m	MP	5	Ghezzo et al., 2014
Ch	Chilchihöhle	1,810m	UP	1	Koby, 1964
DB	Divje babe	450m	UP	8	Toškan, 2007
DL	Drachenloch	2,445m	UP	3	Bächler, 1940, own data
GPW	Gr. Peggauerwandhöhle	510m	UP	2?	Fladerer, 1997a
Fu	Grotta di Fumane	350m	UP	2	Tagliacozzo et al., 2013
Sa	Grotta di Sambughetto		UP		Kotsakis & Palombo, 1979
Hz	Holzingerhöhle	650m	UP	2?	Fladerer, 1997b
HH	Hundsheim	270m	MP	17	own data
Ff	Fünfenstergrotte	441m	UP	1?	Fladerer, 1997c
Lu	Luegloch	550m	UP	1?	Fladerer, 1997d
Mst	Merkenstein	441m	UP	6	Nagel, 1997, own data
OH	Ochsenhalthöhle	1,660m	UP	1	Geyer, 2007
Ra	Ranggiloch	1,845m	UP	1	Koby, 1964
Rep	Repolusthöhle	525m	MP/UP	5+1?	Mottl, 1951, own data
Sn	Schnurenloch	1,230m	UP	1	Koby, 1964
Ro	Serbaro di Romagnano		MP		Kotsakis & Palombo, 1979
Sp	Spaltenhöhle	~490m	UP	1?	own data
TH	Tropfsteinhöhle	482m	UP	1?	Fladerer & Frank, 1997
Wk	Wildkirchli	1,477m	UP	22	Schmid, 1940, own data
Zd	Zandobbio	370m	MP	1	Vialli, 1957

Table 1: List of cave sites with *Panthera pardus* remains from the Alpine area
Tabel 1: Lijst van grotten met *Panthera pardus* resten in het alpiene gebied

Tagliacozzo, A., M. Ronadini, I. Fiore, M. Gala, M. Peresani (2013) Animal Exploitation Strategies during the Uluzzian at Grotta di Fumane (Verona, Italy). in: Clark, J.L., J.D. Speth (Eds.) *Zooarchaeology and Modern Human Origins: Human Hunting Behavior during the Later Pleistocene, Vertebrate Paleobiology and Paleoanthropologie*. Springer Science & Business Media, Dordrecht, 129-150.

Thenius, E. (1953) Gepardreste aus dem Altquartär von Hundsheim in Niederösterreich. *Neues Jahrbuch für Geologie und Paläontologie Monatshefte* 5, 225-238.

Spassov, N., D. Raychev (1997) Late Wurm Panthera pardus remains from Bulgaria: the European leopards and the question of the probable species survival until the Holocene on the Balkans. *Historia naturalis bulgarica* 7, 71-96.

Toškan, B. (2007) Remains of Large Mammals from Divje babe I: stratigraphy, taxonomy and biometry. in: Turk, I. (Ed.) *Divje babe I Upper Pleistocene Palaeolithic site in Slovenia. Part I: Geology and Palaeontology. Opera Instituti Archaeologici Sloveniae* 13, 221-278.

Valensi, P., E. Psathi (2004) Faunal Exploitation during the Middle Palaeolithic in South-eastern France and North-western Italy. *International Journal of Osteoarchaeology* 14, 256-272.

Vialli, V. (1957) I vertebrati della breccia ossifera dell'interglaciale Riss-Würm di Zandobbio (Bergamo). *Atti della Società Italiana di Scienze naturali e del Museo Civico di Storia naturale in Milano XCVI*, 51-79.

Wettstein, O.V., F. Mühlhofer (1938). Die Fauna der Höhle von Merkenstein in N.Ö. *Archiv für Naturgeschichte N.F.* 7(4), 514-558.

Element	Inventory number	Comment	Freudenberg (1914)
P3 sup	1909-II-167		table XVIII:2c-d
Mt2 dex proximal	1909-II-174		
Mt3 dex	1909-II-174		table XVIII:3b
Mt4 sin	1909-II-174		table XVIII:3a
Mt5 dex	1909-II-174+175	rearticulated	
Metapodial distal	1909-II-174		
Scapholunatum dex	1909-II-169		table XIX:F
Astragalus dex	1909-II-169		
Astragalus sin	1909-II-176	articulated	table XVIII:3h-i
Calcaneus sin	1909-II-176	articulated	table XVIII:3h-i
Naviculare sin	1909-II-176	articulated	table XVIII:3h-i
Tarsal III sin	1909-II-170		
Tarsal III dex	1909-II-170	as Machairodus	table XVIII:3f
Proximal phalanx	1909-II-171	as medial phalanx	table XVIII:3e
Proximal phalanx	1909-II-172-1		
Caudal vertebra	1909-II-168		
Middle phalanx	IPUW-coll. Weinfurter		
Mc4 sin	IPUW-coll. Weinfurter		

Table 2: Revised list of leopard remains from Hundsheim

Tabel 2: Gereviseerde lijst van luipaardvondsten uit Hundsheim

Material	Labeled	Element	Side	Bächler (1940)
DL	H3 P5 12/IX/1921 4S..	Csup	dex	Taf. CXIII
DL	HIII 5,5 Sch.4 1m? (80cm) 4.5.20	maxilla+P4	sin	Taf. CXIII
DL	AB4-6 P.E	mc2	sin	
Wk-1	K 2,9m	maxilla+p3+p4	dex	Taf. CXI
Wk-2	W WH m2 33 2,7m	C sup	sin	
Wk-3	WH m2 40 1,6m	C sup	dex	
Wk-4	WH AI 2,3m	C sup	dex	
Wk-5	K 2,9m	P4 sup	sin	Taf. CXI
Wk-6	---	thor.-vertebra		
Wk-7	I 2,10m	ulna	dex	Taf. CXI
Wk-8	K 2,60m	mc4	dex	Taf. CXI
Wk-9	K 3m	mc5	dex	Taf. CXI
Wk-10	K 1,5m	astragalus	dex	Taf. CXI
Wk-11	A4 1,3m	calcaneus	dex	Taf. CXI
Wk-12	AIII 1,80m	calcaneus	sin	Taf. CXI
Wk-13	K 3m	mt5	dex	Taf. CXI
Wk-14	K 1m	ph1 antIV		
Wk-15	I 2,30m	ph1 postIV		
Wk-16	I 2,3m	ph3		
Wk-17	WKV-59	P3 sup	dex	
Wk-18	WKV-70	ph1 postIV		
Wk-19	WKV-341	ph2		
Wk-20	WKV-37	ph2		
Wk-21	---	M1 sup	?	Schmid (1940)

Table 3: Revised list of *Panthera pardus* finds from Drachenloch (DL) and Wildkirchli (Wk)Tabel 3: Gereviseerde lijst van *Panthera pardus* vondsten uit Drachenloch (DL) en Wildkirchli (Wk)

Site	Element	L	B	Bme	Bm	Bdi	Comment
DL	C sup dex	13.8	10.8				
Wk-3	C sup dex	--	--				corroded
Wk-4	C sup dex	--	10.4				Schmid, 1940: table 19 + own
Wk-2	C sup sin	13.7	10.7				Schmid, 1940: table 19 + own
HH	P3 sup	18.0					
Wk-1	P3 sup (Max.)	18.7	--	7.5	--	8.9	Schmid, 1940: table 19
Wk-1	P4 sup (Max.)	25.9	--	13.5	9,6	9.1	Schmid, 1940: table 19
Wk-5	P4 sup sin	25.8	--	13.6	9,6	9.0	Schmid, 1940: table 19
Wk-21	M1 sup	7.8	4.4				Schmid, 1940: table 19
DL	P4 sup (Max.)	25.0	--				after Bächler, 1940: plate CXIII
Mst	p4 inf (?)	15.6	8.8	--	7.4	8.1	Nagel, 1997: 216, table 1
Sn	p3 inf	19.4		8.7	9.2	9.4	Koby, 1964:155
Rep	m1 inf	19.0	8.8				germ

Table 4: Measurements of teeth from *Panthera pardus* from the revised sites (L = length, B = breadth, Bme = mesial breadth, Bm = breadth in the middle of the tooth, Bdi = distal breadth)

Tabel 4: Maten van tanden van *Panthera pardus* van de gereviseerde sites (L= lengte; B = breedte; Bme = mesiale breedte; Bm = breedte over het midden van de tand; Bdi = distale breedte)

Site	Inv.	Elem	gl	pb	pd	SD	db	dcb	dd	After
Ba	LMJ 58280	Mc3	70.5	14.8	16.6	9.3	14.5	12.6	13.3	
Ce	V.5108-1	Mc2	62.6	13.5			13.3			Ghezzo et al., 2014: 84
DL	AB4-6 P.E.	Mc2	66.9	12.0		9.0	14.5	13.2	13.4	
HH	IPUW	Mc4	75.0*	14.8	17.6	9.6	15.2			
Rep	LMJ 54613	Mc4	76.0			10.8	16.3	14.4		
Wk-8		Mc4		14.0	17.2					
Wk-9		Mc5	69.7	17.8	17.9	10.1	16.2	15.0		
HH	1909-II-174	Mt2		15.0	18.5					
HH	1909-II-174	Mt3	94.4	18.0	23.0	11.8	16.1	14.6	14.7	
Rep	LMJ 57433	Mt3	84.8	15.9	21.0	11.8	14.8	12.8		
HH	1909-II-174	Mt4	96.0	15.0	19.0	10.8	14.8	13.9	15.0	
HH	1909-II-175	Mt5	99.0	16.1		9.5	14.9			
Wk-13		Mt5	96.6	17.0		9.9	13.7	13.0		

Table 5: Measurements of metapodials from *Panthera pardus* from the revised sites (gl = greatest length, pb = proximal breadth, pd = proximal depth, SD = smallest diaphyseal breadth, db = distal breadth, dcb = distal condyle breadth, dd = distal depth), *reconstructed

Tabel 5: Maten van metapoden van *Panthera pardus* van de gereviseerde sites (gl = grootste lengte, pb = proximale breedte, pd = proximale diepte, SD = kleinste diafysebreedte, db = distale breedte, dcb = distale breedte van de condyle, dd = distale diepte), *gereconstrueerd

Site	Inv.	LA	LAR	SH	SB	SC
Ba	LMJ 57435	29.0		37.0	17.0	98.0
Mst	NHMW-GP	32.3	41.5	35.3	17.7	90.0
Rep	LMJ 54612	26.0	31.4	25.1	9.5	64.0

Table 6: Measurement of pelvic bones from *Panthera pardus* from the revised sites (LA = length of acetabulum, LAR = length of acetabulum on rim, SH = smallest height of ilium shaft, SB = smallest breadth of ilium shaft, SC = smallest circumference at ilium shaft)

Tabel 6: Maten van het bekken van *Panthera pardus* van de gereviseerde sites (LA = lengte van acetabulum, LAR = lengte van acetabulum op rand, SH = kleinste hoogte van ilium schacht, SB = kleinste breedte van ilium schacht, SC = kleinste omtrek van ilium schacht)

Site	Inv.	Element	gb	gl	baf	depth	After
HH	1909-II-169	Scapholun.	27.3	24.7	26.5	16.4	own data
HH	1909-II-176	Astragalus	31.6	39.0	23.5	23.3	own data
HH	1909-II-176	Calcaneus	33.5	69.2	29.2	33.0	own data
HH	1909-II-176	Navicular	29.9	26.0		10.0	Freudenberg, 1914:191
HH	1909-II-170	tarsal 3	13.6	28.1		13.9	own data
HH	1909-II-170	tarsal 3	16.0	29.5		14.4	own data

Table 7: Measurements of additional elements from *Panthera pardus* from the revised sites (gb = greatest breadth, gl = greatest length, baf = breadth of articular surface)

Tabel 7: Maten van overige elementen van *Panthera pardus* van de gereviseerde sites (gb = grootste breedte, gl = grootste lengte, baf = breedte van articulatievlak)

Site	Inv.	Element	gl	pb	pd	SD	db	After
Ba	LMJ 57436	Ph1	42.7	16.3	12.5	12.0	12.1	own data
Ba*	LMJ 55949	Ph1	38.0	13.9		10.7		own data
HH	171	Ph1	39.3	14.5	12.3	10.0	11.8	own data
HH	172-1	Ph1	39.4		13.2	10.0	11.9	own data
Mst	--	Ph1	41.4	13.4		8.3	10.3	Nagel, 1997:218, table 2
Rep	LMJ 57434	Ph1 post	41.0	15.0	11.5			Mottl, 1951:66
TH		Ph1 ant	16.1	10.1			8.5	Fladerer & Frank, 1997
Wk-14		Ph1 ant	45.5	16.3		10.3	12.8	own data
Wk-15		Ph1 post	40.4	16.7		9.8	13.6	own data
Wk-18	WKV-70	Ph1 post	38.5	15.3	12.7	9.5	11.9	own data
Ce	V.5078-50	Ph2	30.3	11.4	9.5	7.3	10.9	Ghezzo et al., 2014
HH	IPUW	Ph2	26.0	12.1		8.4	11.0	own data
Hz*	LMJ 58279	Ph2	(20.8)	(9.0)		5.4	8.0	juvenile, own data
Sp*	LMJ 58909	Ph2	29.0	10.7	9.6	5.5	8.6	own data
DB		Ph2	27.5				10.7	Toškan, 2007:231, Fig.11-12
DB		Ph2	30.5				11.3	Toškan, 2007:231, Fig.11-12
DB		Ph2	31.6				13.0	Toškan, 2007:231, Fig.11-12
Wk-19	WKV-341	Ph2	31.9	13.5	17.0	7.2	12.5	own data
Wk-20	WKV-37	Ph2	23.0	11.1		7.1	11.0	own data

Table 8: Measurements of phalanges from *Panthera pardus* from revised sites (gl = greatest length, pb = proximal breadth, pd = proximal depth, SD = smallest diaphyseal breadth, db = distal breadth) *originally identified as lynx

Tabel 8: Maten van falangen van *Panthera pardus* van de gereviseerde sites (gl = grootste lengte, pb = proximale breedte, pd = proximale diepte, SD = kleinste breedte van diafyse, db = distale breedte) *aanvankelijk gedetermineerd als lynx