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2.3. Studies on a raw material. The Eurasian elk in Central Europe at the end of the Pleistocene

Abstract: The chapter reports on morphometric analysis of an object made of antler of the Eurasian elk (*Alces alces*), found at Rusinowo, Pomerania, dated as the Allerød--Younger Dryas transition (10 700 ± 60 BP, or 10 780-10 610 BC). This is the earliest record confirming the occurrence of the elk after the retreat of the glacier from the present-day territory of Poland. The analysis shows that the material of the object is antler of a relatively large size, from an animal aged approximately 10-15 years. Microstructural studies reveal that at the time of the animal's death the antler was in its growth stage (spring-summer), and thus belonged to an elk killed during a hunt or dead from some other cause. The Eurasian elk (*Alces alces*) was one of the pioneer species which, after the extinction or withdrawal of large Pleistocene mammals from Poland at the end of the Ice Pleistocene played a major role in the human diet and in religious rituals.
Keywords: *Cervalces*, *Alces*, Middle Pleistocene, Upper Pleistocene, Poland

Introduction

Here we present the results of morphometric and histological examination of the elk antler object found at Rusinowo, Pomerania, and dated as the Allerød-Younger Dryas transition (10 700 ± 60 BP, or 10 780-10 610 BC). In an earlier contribution (Płonka *et al.* 2011) we focused on the species identification of the object. Histological analysis and a comparison with antlers of similar size identified as the giant elk *Megaloceros giganteus* (Blumenbach, 1799) helped to identify the investigated artefact as antler of the Eurasian elk, *Alces alces* (Linnaeus, 1758). Microstructural studies showed that the antler of which the artefact was made was in its growth period, and as such was obtained in spring or summer from an animal killed during a hunt or dead from some other causes (Figs. 3-5). The radiocarbon date determined the age of the antler as the transition from the Allerød to the Younger Dryas which is compatible with the species identification proposed earlier. At that time the giant elk no longer occurred in Poland (Croitor *et al.* 2014; Van der Made *et al.* 2014). The aim of the study was to determine the age of the animal which had yielded the antler and to compare its size with other antlers from fossil elk of Eurasia.

Results and discussion

The artefact represents a fragment of elk antler consisting of the beam and a portion of the paddle; its detailed description was included in the earlier study (Płonka *et al.* 2011). Changes resulting from tooling, for example, removal of the burr, prevented taking most of the standard measurements, and those given here are most probably inaccurate. The only measurements taken by us, using digital callipers and measuring tape, were the antero-posterior measurement of the beam - 60 mm, the latero-medial measurement of the beam (transverse measurement) – 45 mm; its circumference was 167 mm, the maximum length 220 mm. The measurements followed van den Driesch (1976). The results were compared

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with published data for modern and fossil elk (Szymczyk 1973a, c; Alekseeva 1980; Chaix, Desse 1981; Sosnowski 1981; Breda 2001; Foronova 2001; Breda *et al.* 2002. Vasil'ev 2002; 2005; 2011; Stefaniak *et al.* 2014), and with measurements taken by us in museums in Kiev and Minsk (Table 1, Figs. 1, 2).

The only criterion for assessing the age of the elk and the original size of its antler are the approximate measurements of the artefact. According to Vasil'ev (2002), the length range of the beam in mature elk is 175–225 mm; for our artefact it may be estimated at over 200 mm, which identifies the animal as

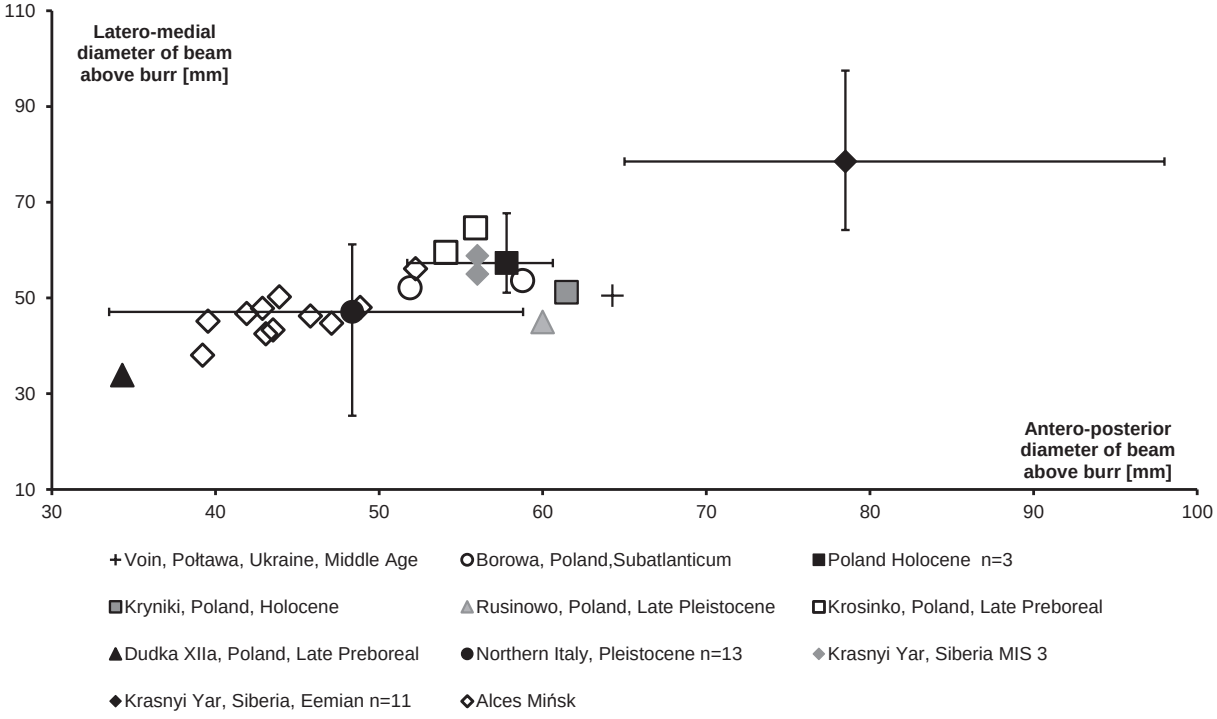

Fig. 1. Antero-posterior and the latero-medial antler beam measurements in Eurasian elk (*Alces alces* Linnaeus, 1758)

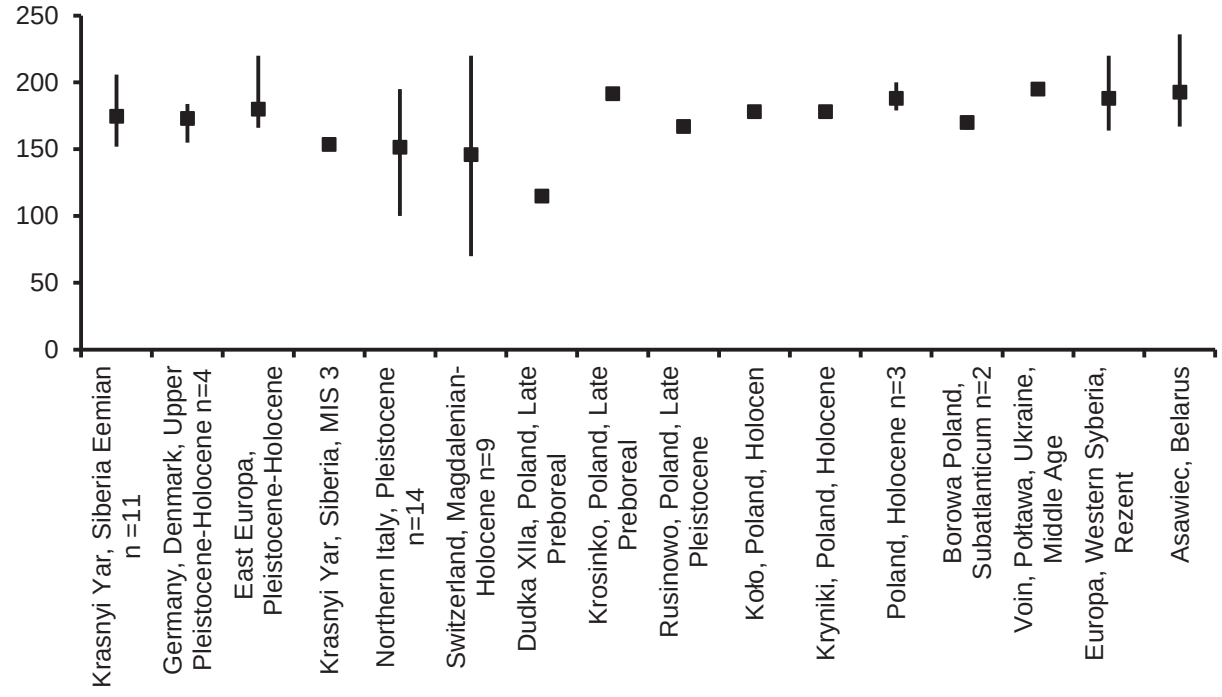

Fig. 2. Variation of antler beam measurements in Eurasian elk (*Alces alces* Linnaeus, 1758)

Tab. 1. Eurasian elk antler measurements (*Alces alces* Linnaeus, 1758)

Measurement	Site	Country	Stratigraphic age	N	Value [in mm]	Average value	Source
Antero-posterior diameter of beam above burr	Voin, Poltava	Ukraine	Mediaeval	1	64.26	-	Own research
	Borowa near Chodzież	Poland	Subatlantic	2	51.9-58.78	55.34	Own research
	Three sites	Poland	Holocene	3	52.7-61.6	57.8	Sobociński, Godynicki 1975; Sobociński 1977, 1985; Sosnowski 1981
	Kryniki	Poland	Holocene	1	61.45	-	Own research
	Koło	Poland	Holocene	1	52.27	-	Own research
	Zacennie, Asaviec	Belarus	Atlantic	2	45.28-48.61	46.94	Own research
	Rusinowo	Poland	Late Pleistocene	1	60.0	-	Own research
	Krosinko	Poland	Late Preboreal	2	54.8-55.9	55.35	Stefaniak *et al.* 2014
	Dudka XIIa	Poland	Late Preboreal	1	34.3	-	Own research
	Smarhon`	Belarus	Upper Pleistocene-Holocene	16	39.21 – 52.3	44.83	Own research
	Several sites	Italy	Pleistocene	13	33.5-58.8	48.36	Breda 2001; Breda *et al.* 2002
	Krasnyi Yar, Siberia	Russia	Pleistocene MIS 3	2	56.0	56.0	Vasil'ev 2002, 2005
	Several sites	Germany, Denmark	Upper Pleistocene-Holocene	4	43.0-55.0	48.3	Chaix, Desse 1981
	Krasnyi Yar, Siberia	Russia	Eemian	11	65.0-98.0	78.5	Vasil'ev 2002, 2005
	Voin, Poltava	Ukraine	Medieval	1	50.49	-	Own research
	Ostrówki near Chodzież	Poland	Subatlantic	1	52.11-53.63	52.87	Own research
	Borowa near Chodzież	Poland	Subatlantic	2	51.1-67.7	57.3	Own research
	Three sites	Poland	Holocene	3	51.1-67.7	57.3	Sobociński, Godynicki 1975; Sobociński 1977, 1985; Sosnowski 1981
Latero-medial diameter of beam above burr	Kryniki	Poland	Holocene	1	51.17	-	Own research
	Koło	Poland	Holocene	1	54.1	-	Own research
	Zacennie, Asaviec	Belarus	Atlantic	2	46.03-47.53	46.78	Own research
	Rusinowo	Poland	Late Pleistocene	1	45.0	-	Own research

Measurement	Site	Country	Stratigraphic age	N	Value [in mm]	Average value	Source
	Krosinko	Poland	Late Preboreal	2	59.5-64.6	62.05	Stefaniak *et al.* 2014
Latero-medial diameter of beam above burr	Dudka XIIa	Poland	Late Preboreal	1	33.9	-	Own research
	Smarhon'	Belarus	Upper Pleistocene-Holocene	16	24.79-56.08	44.0	Own research
	Several sites	Italy	Pleistocene	12	25.4-61.2	47.09	Breda 2001; Breda *et al.* 2002
	Krasnyi Yar, Siberia	Russia	Pleistocene MIS 3	2	55.0-58.8	56.5	Vasil'ev 2002, 2005
	Krasnyi Yar, Siberia	Russia	Eemian	11	64.2-97.5	78.5	Vasil'ev 2002, 2005
	Europe	Europe	Modern	3	113.5-148.5	136.66	Own research
	Several sites	Europe, Western Siberia	Modern	40	164.0-220.0	188.1	Vasil'ev 2002, 2005
	Voin, Poltava	Ukraine	Mediaeval	1	195.0	-	Own research
	Borowa near Chodzież	Poland	Subatlantic	2	165.0-175.0	170.0	Own research
	Three sites	Poland	Holocene	3	179.0-200.0	188.0	Sobociński, Godynicki 1975; Sobociński 1977, 1985; Sosnowski 1981
Circumference of beam above burr	Kryniki	Poland	Holocene	1	142.89	-	Own research
	Koło	Poland	Holocene	1	178.0	-	Own research
	Zacennie, Asaviec	Belarus	Atlantic	2	132.0-151.0	141.5	Own research
	Rusinowo	Poland	Late Pleistocene	1	167.0	-	Own research
	Krosinko	Poland	Late Preboreal	2	187.0-196.0	191.5	Stefaniak *et al.* 2014
	Dudka XIIa	Poland	Late Preboreal	1	115.0	-	Own research
	Several sites	Switzerland	Magdalenian-Holocene	9	70.0-220.0	145.88	Chaix, Desse 1981
	Smarhon'	Belarus	Upper Pleistocene-Holocene	17	108.0-180,0	151.82	Own research
	Several sites	Italy	Pleistocene	14	100.0-195.0	151.43	Breda 2001; Breda *et al.* 2002
	Krasnyi Yar, Siberia	Russia	Pleistocene MIS 3	2	152.0-155.0	153.5	Vasil'ev 2002, 2005
	Several sites	Eastern Europe	Pleistocene-Holocene	5	166.0-220.0	180.0	Stefaniak 2015
	Several sites	Germany, Denmark	Upper Pleistocene-Holocene	4	155.0-184.0	173.0	Chaix, Desse 1981
	Krasnyi Yar, Siberia	Russia	Eemian	11	152.0-206.0	174.6	Vasil'ev 2002, 2005

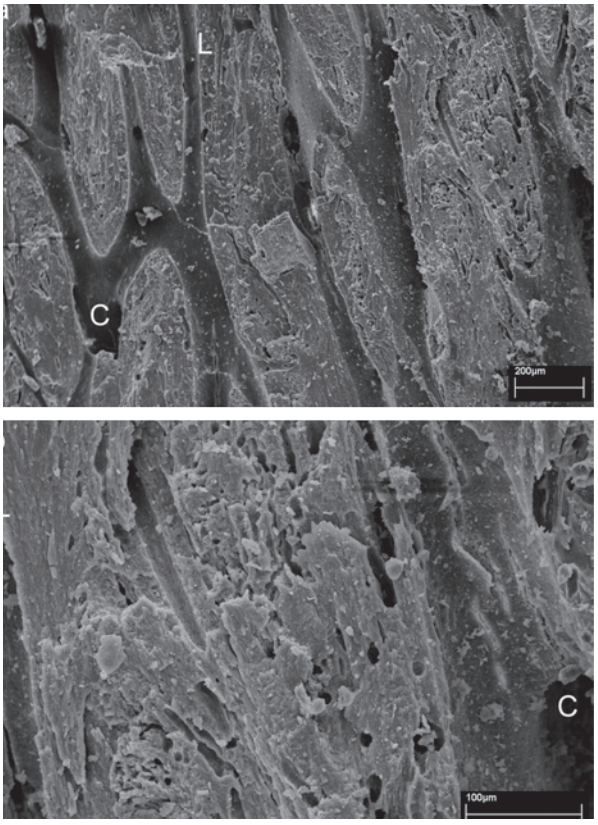

Fig. 3. Rusinowo. Ultrastructure of the artefact (a) SEM × 150; (b) SEM × 500. C – vascular canal; L – bone lamella

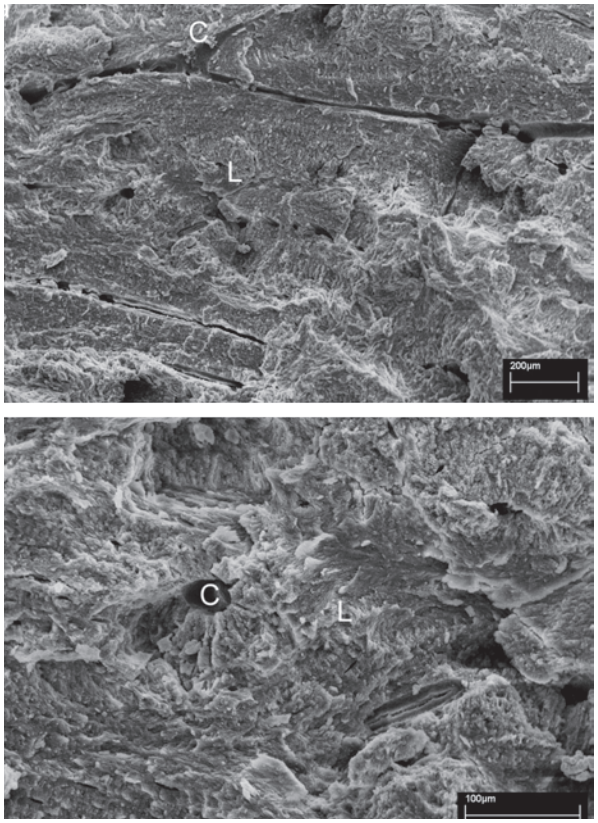

Fig. 4. Ostrówka near Chodzież. Ultrastructure of the tissue of Eurasian elk antler *Alces alces* (L.) (a) SEM × 150; (b) SEM × 500. C – vascular canal; L – bone lamella

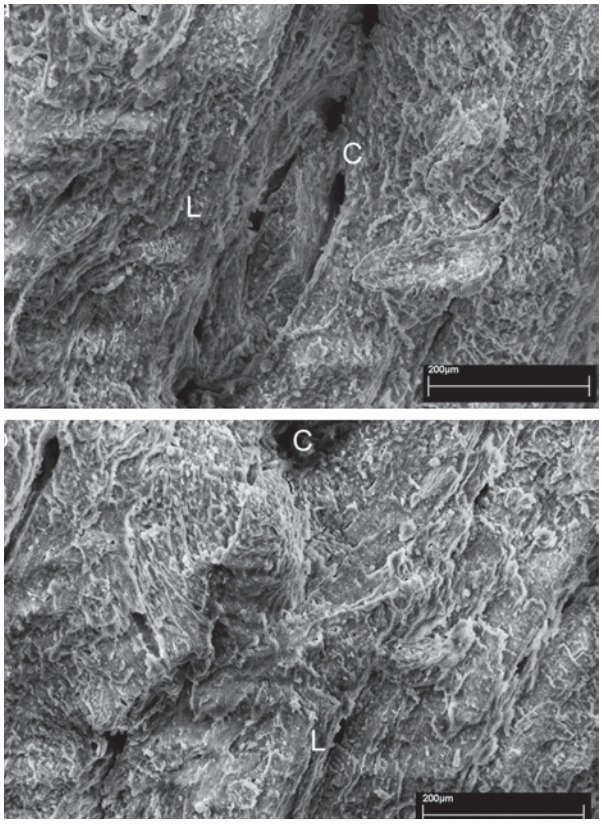

Fig. 5. Biśnik Cave. Ultrastructure of the tissue of giant elk antler, *Megaloceros giganteus* (Blumenbach, 1797) (a) SEM × 150; (b) SEM × 350. C – vascular canal; L – bone lamella

a mature individual. The length of the examined fragment indicates that the elk was a middle-aged individual.

In her thorough study of elk antler beam circumference, Alekseeva (1980) distinguished the following age classes: maximum circumference 110 mm – 0–3 years; circumference 110-140 mm – 3–5 years; circumference 140–170 mm – 5-10 years; circumference 170–200 mm – 10–15 years; circumference over 200 mm – over 15 years (Vasil'ev 2005). Given the surviving circumference of the beam of the antler object from Rusinowo (167 mm), prior to tooling of the antler surface, it is safe to assess the original circumference as over 170 mm. Thus, the animal's age was 10–15 years. The antero-posterior and latero-medial measurements of elk antler beams show that the dimensions of the specimen from Rusinowo correspond to the elk from the end of the Pleistocene and from the Holocene of Europe (Fig. 1). The antler from Rusinowo is the closest to the specimens from Kryniki (Holocene) and from Borowa near Chodzież (Subatlantic period), and also to the mediaeval specimen from Voin near Poltava in Ukraine. The specimens from Krosinko (late Preboreal period) are wider. The Rusinowo antler is definitely smaller than those from the last interglacial of Siberia but slightly

larger than in an elk originating from the same site Krasnyi Yar dating to the Grudziądz interstadial (MIS 3). The specimen from Rusinowo has a more robust beam than the antlers from the last glacial and the Holocene (Smarhon'), the Atlantic period (Zacennie and Asaviec) of Belarus, from Italy (Upper Pleistocene) and from Dudka (late Preboreal period).

The antler beam circumference in the Rusinowo specimen, like the above measurements, is within the size range established for the elk antlers from the late Pleistocene and the Holocene of Europe. The beam circumference of the Rusinowo specimen is closest to that recorded for the specimens from Kryniki, Koło, and Borowa (Subatlantic period), smaller than that of the antler from Krosinko (Preboreal) and from the mediaeval site Voin near Poltava (Ukraine). Moreover, its circumference is also close to the average values recorded for the specimens from Krasnyi Yar (Siberia, MIS 5e), from the Late Glacial and the Holocene of Germany and Denmark, and from the same period of the site Smarhon' (Belarus), as well as those of the modern elk from Europe and Eastern Siberia. It is slightly larger than the average circumference values from Smarhon' (Belarus, Upper Pleistocene and Holocene) and from Asaviec and Zacennie (Belarus, Atlantic period), those recorded for the specimens from Switzerland, from the Magdalenian period and the Holocene, and for the Pleistocene elk from northern Italy. It is also much larger than in the specimen from Dudka (Preboreal Period).

Fossil elk remains from the Pleistocene of Poland and Europe

Despite quite a long period of research, records of fossil elk remains from the present-day territory of Poland are relatively few. The remains described to date represent the genus *Cervalaces* Scott, 1855, with *Cervalces carnutorum* (Laugel, 1862) from the Lower Pleistocene (Otwock stadial/Celestynów interglacial) site Żabia Cave near Podlesice (Cracow-Częstochowa Jura) (Stefaniak 2007, Stefaniak *et al.* 2009a, Nadachowski *et al.* 2011), with an assemblage of more than forty teeth and limb bone fragments attributed to two individuals (one mature, one juvenile). Further specimens dated from the Middle Pleistocene and represent the largest fossil elk – *Cervalces latifrons* (Johnson, 1874). The species is known from two sites: Kozi Grzbiet near Kielce (Podlasie interglacial, MIS 19-17), where a single tooth, P^2, attributed to an individual aged 17–20 months was found, and Sitkówka near Chęciny, with the right mandible of an adult individual, more than 10 years old, assigned to *Cervalces* sp. Based on the size of the mandible from Sitkówka, the elk discovered there belonged to the large form of its species which was characteristic of the middle stage of the Middle Pleistocene (Stefaniak *et al.* 2015). The last occurrence of the genus *Cervalces* was recorded from the Upper Middle Pleistocene sediments (layers 19-15, MIS 8 or 8/7-6, Krzna glaciation to Odra glaciation) of the Biśnik Cave near Wolbrom (Cracow-Częstochowa Jura) (Stefaniak 2007; Stefaniak *et al.* 2014); it was represented by two upper premolar teeth and an upper molar M^3 (Stefaniak *et al.* 2014).

In Poland, the modern Eurasian elk *Alces alces* (Linnaeus, 1758) appeared during the Eemian interglacial. The specimens from that period are single, isolated teeth found in the Dziadowa Skała Cave in the Cracow-Wieluń Jura. The most recent studies did not confirm the previously reported (Wojtal, Patou-Mathis 2003) presence of the species in the deposits of the Nietoperzowa Cave (Wojtal 2007; Stefaniak *et al.* 2014). The record from the onset of the Weichselian is based on a molar M^3 from the Łokietka Cave (layer 5, MIS 5a-d) in the Cracow-Wieluń Jura. The elk is likely to have been recorded in layer 12 (MIS 5e-a) of the Ciemna Cave, but the material has not been analysed yet (Wojtal, Patou-Mathis 2003; Valde-Nowak *et al.* 2014; Stefaniak *et al.* 2015).

The fossils discovered in the site at Zwoleń are also datable to the onset of the last glaciation (?MIS 5b). A fragment of metatarsal bone, an unidentified fragment of another such bone, a fragment of metacarpal, and a fragment of upper tooth come from the lower cultural level (Gautier 2006, Schild 2006). The elk record from the end of the Świecie stadial (MIS 4) comes from layer 6 of the Raj Cave near Kielce (Kowalski 1972; Wojtal, Patou-Mathis 2003; Patou-Mathis 2004). Lorenc (2008) dated this layer to the cool Schalkholz stadial, but a slightly older age is also conceivable, coinciding with the end of the warmer Odderade interstadial (Kowalski 1972). A metatarsal bone from the Biśnik Cave (Stefaniak *et al.* 2014; Van der Made *et al.* 2014) also comes from the late Świecie stadial, possibly the onset of the Grudziądz interstadial. This proves that the elk occurred in Poland during the cool phases early into the Weichselian.

Some sites date to the middle phase of the last glacial, the period of the Grudziądz interstadial (MIS 3). A fragment of an upper molar, M^3, was found in layer XIX in the Obłazowa Cave, southeast of the town of Nowy Targ, was dated to that period (Valde-Nowak, Nadachowski 2014) which shows that the species penetrated also the mountain region. One of the most extraordinary discoveries was made

inside layer VI in the Borsuka Cave near Cracow (Wilczyński *et al.* 2012). It was a necklace, found next to a child's burial and made of 34 elk incisors and a fragment of digit II. Its age was determined as 25 150 ± 160 (Poz-38236) and 27 350 ± 450 BP (Poz-32394), which after calibration gives 32.5–28.8 cal. ka BP, ie the end of MIS 3 (Wilczyński *et al.* 2012).

There is no evidence of the occurrence of the elk in Poland from the maximum of the Weichselian (MIS 2, LGM) The species re-colonised the territory of our country at the end of the last glacial parallel to the deglaciation and the expansion of boreal forests, and also of wetland habitats which are optimal for elk. The elk was one of the first representatives of woodland fauna to colonise Central Europe. Its expansion probably proceeded from the east and the north. The oldest records from Europe have come from the Allerød and the Younger Dryas (Schmölcke, Zachos 2005). The oldest finds from the site Dudka in north-eastern Poland are likely to date from the same period (Gumiński 2003). In Poland, the oldest elk remains from the Pleistocene - Holocene transition come from a south-eastern part of the country; their age is ca. 12 000 years BP (Nadachowski, pers. comm). The ritual object from Rusinowo, dating from the transition between the Allerød and the Younger Dryas (10 700 ± 60 BP, or 10 780-10 610 BC) is one of the oldest from that period to be recorded in Poland and confirms that the colonisation of the country by the species took place during the closing stages of Pleistocene.

By the beginning of the Holocene, the elk's range in Europe had reached its maximum. In the late Upper Palaeolithic, it encompassed northern Spain in the west, central England and Denmark in the north, extending to northern Italy in the south, as a far as Central and Eastern Europe, and all the way to the Black Sea coast and Russia in the east. There are no elk records from the Preboreal period of northern Spain and western France. The species' occurrence has been recorded in the Baltic states (Latvia and Estonia) and in northern Russia (Willms 1987).

A gradual shrinkage of the elk's range can be observed since the end of the Boreal period, first as a result of the environmental changes involving expansion of deciduous forests and climate warming during the Atlantic period. During the Boreal period, the range extended to western Germany and eastern France, Switzerland and southern Germany and Austria. At that time the elk inhabited southern Sweden and Norway and expanded from northern Russia to Finland (Willms 1987).

In the Atlantic period, the elk became extinct in south-western Europe (Szymczyk 1973 a-c; Willms 1987; Schmölcke, Zachos 2005). There are no elk records south of Austria, in Hungary, although in the east its range extended as far as the Black Sea. The elk did not occur in the British Isles but was established everywhere in Scandinavia and northern Russia. During the Subboreal period, its range remained essentially unchanged, similarly as in the Subatlantic period. Early into the Middle Ages an isolated population existed in the Low Countries (The Netherlands and Belgium); in the present-day Germany the elk's range extends slightly beyond the Elbe, and there exist small populations in the north of Slovenia, Austria and Switzerland (Willms 1987).

Further climatic changes during the Holocene and the expansion of agriculture with its associated environmental changes caused a further shrinkage of the elk's range before the historical times so that at the end of the Middle Ages the species became extinct across most of its earlier territory. Now the eastern boundary of its range runs across the territory of Poland, although in recent years a westward re-expansion has been observed (Szymczyk 1973 a-c; Schmölcke, Zachos 2005).

In the historical region of Lower Silesia, elk remains were discovered in the Radochowska Cave, but there is no information on their age. As these remains have been lost, no further examination is possible (Frenzel 1936; Zotz 1939; Chrzanowska 1985; Bieroński *et al.* 2007, 2009; Wiśniewski *et al.* 2009).

Conclusions

The data presented above show that the elk appeared in the present-day territory of Poland at the Pleistocene-Holocene transition (Allerød/Younger Dryas), and was one of the first large hoofed mammals associated with boreal forests to colonise Poland after the retreat of the last glacier and the extinction or withdrawal of mammals of the Pleistocene steppe-tundra (Schmölcke, Zachos 2005; Płonka *et al.* 2011; Stefaniak *et al.* 2014). As the number of large game animals was reduced, the elk was a very important component of the human diet until the appearance, some time later, of red deer, roe deer and wild pig.

The information on the occurrence, morphology and measurements of fossil elk is rather scanty (Stefaniak *et al.* 2014). Consequently, the morphometric analysis presented here was based on a small body of data and on mostly individual measurements from only a handful of published sites.

However, even based on the limited data set it can be argued that the specimen from Rusinowo was taken from an animal not different in its size from the other elk from the late Pleistocene and the Holocene of Europe Its dimensions were similar also to the other elk found in Poland and originating from the same period. Its age based on the beam circumference was determined as 10–15 years, identifying it as a middle-aged animal.