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# 1 1. Introduction

2 The climatically unstable late Pleniglacial includes the Last Glacial Maximum (thereafter LGM), a  
3 time period during which the palaeoenvironmental and geographical conditions were modified (Clark  
4 et al., 2009; Lambeck et al., 2014) and on which different living beings, including Paleolithic hunters-  
5 gatherers, had to adapt. The aim of this paper is to approach a better understanding of this  
6 phenomenon in the large East European Plain (thereafter EEP), especially concerning the practices of  
7 the nomadic human societies involved. For that purpose, we approach their relationship to the  
8 environments, the landscapes and the territories, and try to define the connections and influences  
9 between social partners, other human groups and other species. In order to bring into light the socio-  
10 ecological systems during this period, we focused our research on the faunal remains in archaeological  
11 context in both quantitative and qualitative terms. We also had a close look to the settlement patterns,  
12 the types of activities, the subsistence economies, the technocultural practices of human societies in  
13 relation to other species and the seasons of occupations in the different areas of the EEP.

## 14 2. Framework

### 16 2.1. Chrono-climatic context of the late Pleniglacial

17 Loess and loess-like deposits are by far the best preserved, complete and therefore relevant late  
18 Pleistocene paleoclimatic archives in the EEP. In all these archives, the end of the Middle Pleniglacial  
19 is characterized by a climatic degradation, reflected by the presence of a tundra gley bound to active  
20 permafrost. In Eastern Europe interpleniglacial paleosols known as Briansk paleosols (Rusakov and  
21 Korkka, 2004) are dated between ca. 33.0 and 31.0 ka cal BP (28.0 and 26.0 ka <sup>14</sup>C BP). They  
22 correspond to Dofinovka paleosols described by Ukrainian researchers (Krotova and Belan, 1993).  
23 Unfortunately, an exact correlation of these paleosols is not always possible.

24  
25 The Extracarpathic area are a model reference for the EEP, from the sites of Molodova V (Ukraine),  
26 Korman IV (Ukraine), Mitoc-Malu Galben (Romania) and Cosăuți (Republic of Moldova).

27  
28 The Upper Pleniglacial or late Pleniglacial corresponds in sedimentary terms with the accumulation of  
29 powderish loessic deposits, observed in the unit 7 at Mitoc-Malu Galben (Haesaerts et al., 2003)  
30 around 31.0 ka cal BP (26.0 ka <sup>14</sup>C BP) (MIS 2; GS-3). Around 27.5 ka cal BP (23.0 ka <sup>14</sup>C BP),  
31 global temperatures decreased and the aridity increased (Clark et al., 2009). According to existing  
32 simulations (Banks et al., 2008) the mean temperatures in the region ranged from 0 to 6°C. The warm  
33 periods would be characterized by temperatures between 16° and 20°C and the coldest periods by  
34 temperatures between -13° and -4°C. Annual precipitation ranged from 80 to 150 mm. Several  
35 interstadial climatic episodes were identified (Velichko, 1961; Noiret, 2009; Haesaerts et al., 2007)  
36 (Table 1).

37  
38 Table 1. Chrono-climatic events during the late Pleniglacial and the beginning of the late Glacial (between 30.0  
39 ka cal BP and 14.7 ka cal BP / 25.5 ka BP-12.5 ka <sup>14</sup>C BP) in the East European Plain.

Events	Marker	Dating	Climate
interstadial of Mitoc-Malu Galben 6/Molodova V subunit 11-2	tundra gley	30.0 ka cal BP (25.5 ka <sup>14</sup> C BP)	aeolian sedimentation in a cold but still contrasted climatic context
cold stage	sandy loess	29.5-28.5 ka cal BP (25.0-24.0 ka <sup>14</sup> C BP)	the wind sedimentation continues increasingly arid and cold
interstadial of Malu Galben 4, Molodova V unit 12-1	greyish brown bioturbated humiferous horizon	27.7 ka cal BP (23.6 ka <sup>14</sup> C BP)	more humid
stadial of Brandenburg, or Brandenburg-Leszno-Bologovo, or Prichernomorski (Molodova V unit 13)	pale yellow sandy loess loess aggradation	27.3-24.0 ka cal BP (23.0-20.0 ka <sup>14</sup> C BP)	cold and arid
oscillation of Cosăuți VI	sandy silt with greyish brown humiferous horizons	23.4 ka cal BP (19.5 ka <sup>14</sup> C BP)	more humid
Frankfurt-Poznan Stage	loess	22.5-21.5 ka cal BP (18.5-18.0 ka <sup>14</sup> C BP)	colder
oscillation of Cosăuți V	light yellowish grey fine silty sand layers with pale greyish brown weak humiferous horizons	21.5 ka cal BP (18.0 ka <sup>14</sup> C BP)	more humid
oscillation of Cosăuți IV	yellowish grey homogenous silty sand alternating with sandy layers	20.7 ka cal BP (17.2 ka <sup>14</sup> C BP)	more humid

Pomeranian, or Vepsovo Stage	sand and sandy loess	20.7-19.2 ka cal BP (17.2-16.0 ka <sup>14</sup> C BP)	cold, arid and relatively moist environment
Dryas I	sandy loess	18.8 ka cal BP (15.5 ka <sup>14</sup> C BP)	arid
oscillation of Cosăuți III (corresponding to the Bølling)	weak brown para-rendzina	14.7 ka cal BP (12.5 ka <sup>14</sup> C BP)	warmer and humid

40  
41 According to Velichko and Kurenkova (1990), Covalenco (1995) and Stepanchuk (1999), the  
42 Ostashkovo phase (maximal extension of the ice sheet) would continue until 19.3 ka cal BP (16.0 ka  
43 <sup>14</sup>C BP), being subsequently followed by the late Glacial. For Haesaerts et al. (2003) and Borziac et al.  
44 (2005) the Upper Pleniglacial interval should be divided into three phases:  
45 -first part of the Upper Pleniglacial, 31.0-24.0 ka cal BP (26.0-20.0 ka <sup>14</sup>C BP)  
46 -second part of the Upper Pleniglacial, 24.0-17.0 ka cal BP (20.0-14.0 ka <sup>14</sup>C BP)  
47 -final phase of the Upper Pleniglacial or late Glacial, transition to the Holocene, 17.0-11.7 ka cal BP  
48 (14.0-10.0 ka <sup>14</sup>C BP)  
49

50 For Hughes and Gibbard (2015) the interval of the LGM is between 23.0 and 19.0 ka <sup>14</sup>C BP (which  
51 would correspond to around 27.5-22.7 ka cal BP) or 24.0 and 18.0 ka <sup>14</sup>C BP (which would correspond  
52 to around 28.2-21.6 ka cal BP), centred on 21.0 ka <sup>14</sup>C BP (around 25.4 ka cal BP). For Clark et al.  
53 (2009), the span time would be between 26.5 and 19.0 ka cal BP and for Mix et al. (2001), between  
54 23.0 and 19.0 ka cal BP (Chronozone level 1) or 24.0 and 18.0 ka cal BP (Chronozone level 2).  
55

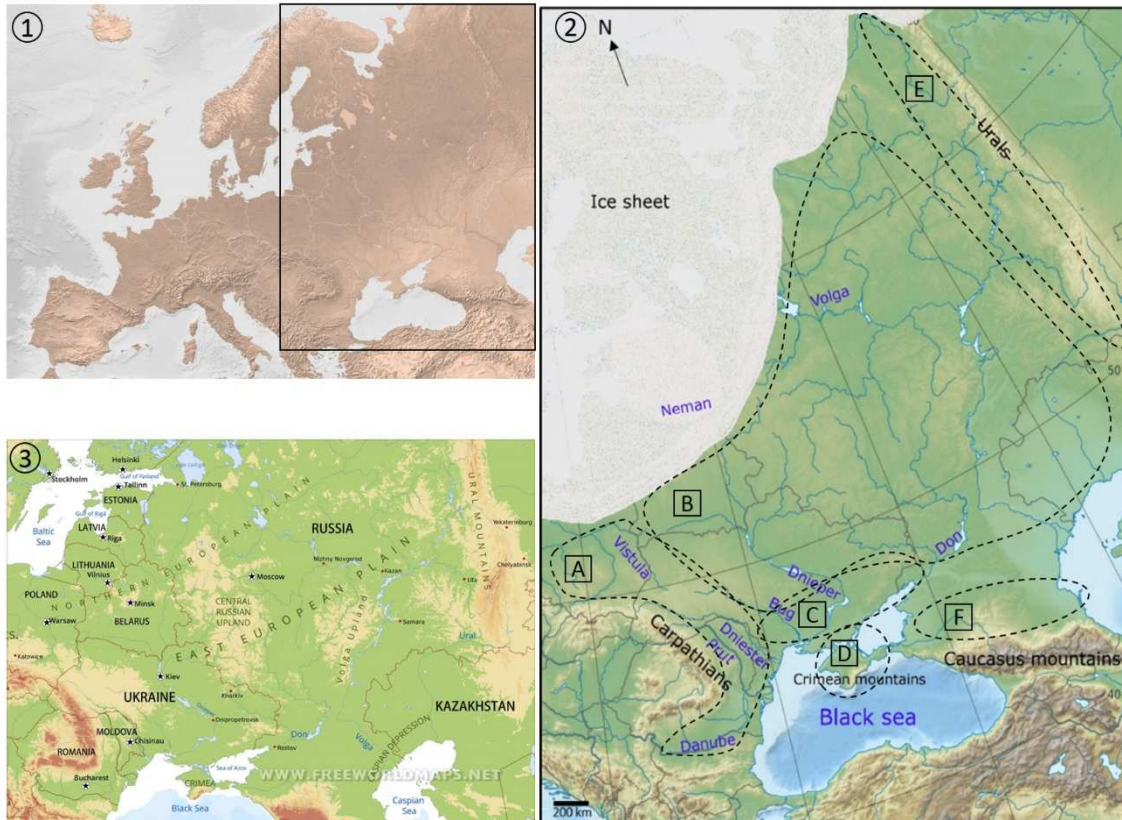
56 Here we took into account, according to the most complete chrono-stratigraphies in the region  
57 (Haesaerts et al., 2003), the period comprised between the sedimentation of unit 7 at Mitoc-Malu  
58 Galben and the unit corresponding to the oscillation of Cosăuți V [31.0-21.5 ka cal BP (26.0-18.0 ka  
59 <sup>14</sup>C BP)]. This interval includes the LGM *sensu stricto* in all the definitions above and can be divided  
60 in subperiods to permit comparisons in relation to events:

- 61 -the beginning of the aeolian sedimentation [31.0-27.5 ka cal BP (26.0-23.0 ka <sup>14</sup>C BP)]
- 62 -the stadial of Brandenburg [27.5-24.0 ka cal BP (23.0-20.0 ka <sup>14</sup>C BP)]
- 63 -the Frankfurt-Poznan Stage [24.0-21.5 ka cal BP (20.0-18.0 ka <sup>14</sup>C BP)]

64  
65 **2.2. Geographic settings of the East European Plain**

66 The EEP is a vast plain, which spans approximately 4,000,000 km<sup>2</sup>. This area is bounded to the north  
67 by Scandinavia and the Barents Sea, to the east by the Urals, to the south by the steppes of Central  
68 Asia, the Caspian Sea and the Black Sea, and to the west by the sea Baltic, the Carpathians and the  
69 plain of Northern Europe. It currently includes several countries: parts of Russia, Kazakhstan,  
70 Ukraine, Republic of Moldova, Romania, Bulgaria, Poland, Belarus, Lithuania, Latvia, Estonia and  
71 Finland (Istituto geographico de Agostini, 1978). Several rivers and their tributaries run through this  
72 territory: the Vistula, the Neman, the Dnieper, the Volga, the Don, the Southern Bug, the Danube and  
73 the Dniester. This area is itself divided into several large regions: the Extracarpatic area, the plain, the  
74 pontic steppe, the Crimean Mountains, the Ciscaucasia, and the Western side of the Ural Mountains  
75 (Figure 1).

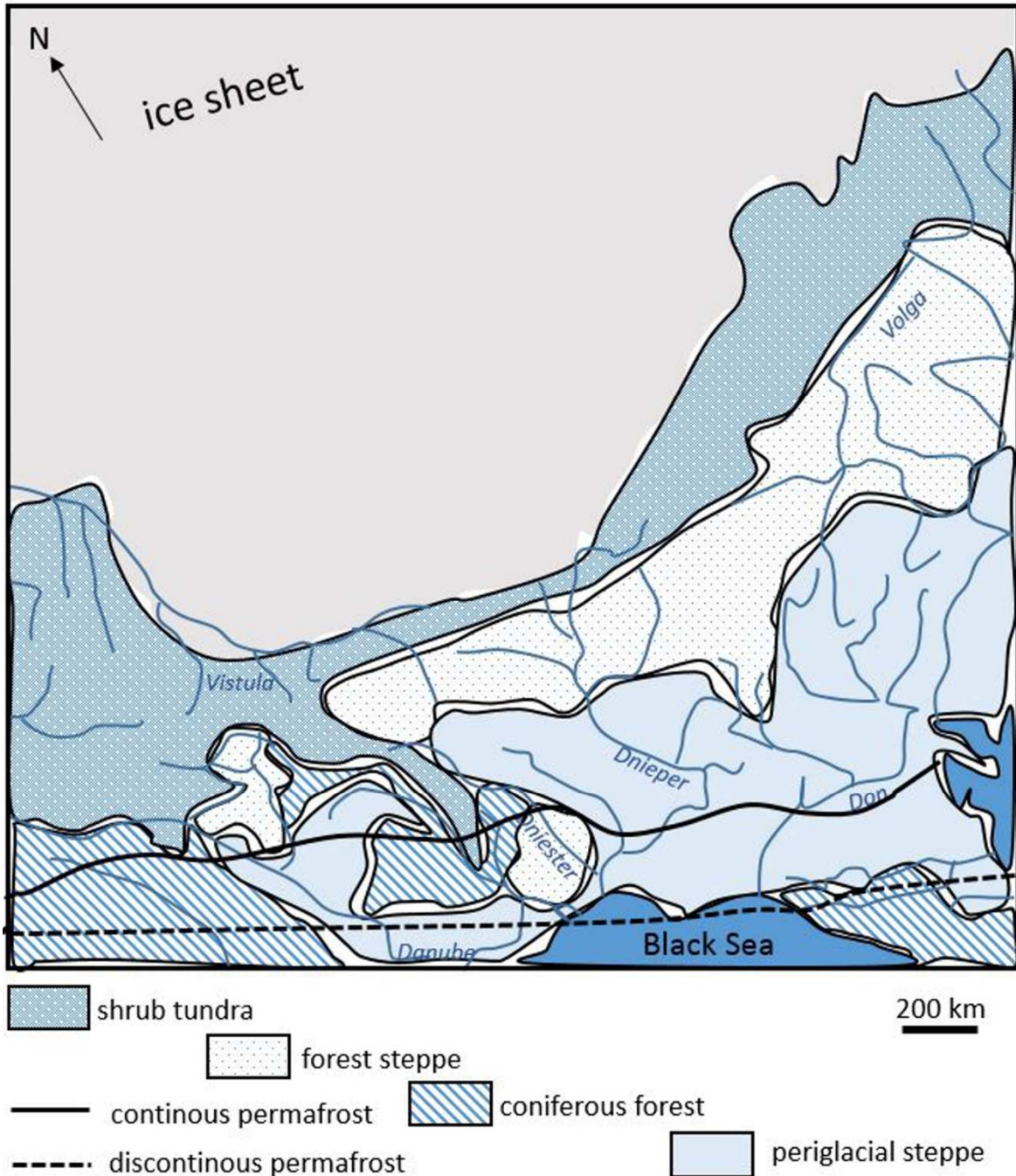
76 During the LGM, changes in sea level have led to the emergence of coastal territories. Indeed the sea  
77 level dropped to 120 meters below current level. The Black Sea was closed, the Sea of Azov was  
78 absent and the northern coast of the Black Sea has widened by 150 km. The Caspian Sea and the Aral  
79 Sea have grown. Then, the extension of the ice sheet led to a recovery of northern European territories.  
80 In the same way, mountain glaciers at more than 1,000 meters of altitude had developed. These last  
81 two phenomena led to changes in direction and flow within the hydrographic network (Pekka Lunkka  
82 et al., 2001; Starkel et al., 2015).  
83



84  
 85 Figure 1. The East European Plain. 1: Location of the studied area; 2: Geographical and topographical setting of  
 86 the studied area, showing the maximum extension of the ice sheet at the LGM (light grey), the LGM extension of  
 87 the Black Sea lake (dark blue) and the different regions considered: A: the Extracarpatic area; B: the plain; C: the  
 88 pontic steppe; D: the Crimean mountains; E: the Western side of the Ural Mountains; F: the Ciscaucasia; 3: the  
 89 current countries. (Maps free to share from [www.freeworldmaps.net](http://www.freeworldmaps.net) and made by Alexrk2 with free to share  
 90 with license Creative Commons Attribution-ShareAlike 3.0 Unported License.  
 91 [https://upload.wikimedia.org/wikipedia/commons/7/79/Europe\\_relief\\_laea\\_location\\_map.jpg](https://upload.wikimedia.org/wikipedia/commons/7/79/Europe_relief_laea_location_map.jpg)  
 92  
 93

### 2.3. Paleoenvironmental context

94 The extension of the continental ice sheet during the late Pleniglacial changed the circulation of the  
 95 winds, which affected the vegetation zones. The territory of cold-adapted plants did expand  
 96 considerably (Novenko, 2006) and the European continent was characterized by a tripartition of plant  
 97 communities: the periglacial tundra, the periglacial steppe -both linked to active permafrost  
 98 environments may have coexisted in some places- and in between, the boreal forest (Starkel, 1977;  
 99 Grichuk, 1973; Velichko et al., 1984). These plant communities may have been present in different  
 100 combinations. In addition, mountainous environments, with steep cliffs, showed also species adapted  
 101 to rocky environments. In general, the periglacial steppe dominated, with halophytic plants (Grichuk,  
 102 1973; Klein, 1973; Starkel, 1977; Grichuk, 1982; Desbrosse and Kozłowski 1988; Gribchenko and  
 103 Kurenkova, 1999; Łanczont and Madeyska 2005; Velichko and Zelikson, 2005; Stepanchuk and  
 104 Sapozhnikov, 2010). This type of shrubby steppe vegetation composed of herbaceous and bunches of  
 105 trees (i.e. pines, birches, juniper), is characteristic to cold and dry climates with strong sunshine. This  
 106 floristic environment favored the existence of large herds of herbivores, especially mammoths.  
 107 Looking more into detail, the plains of the Dnieper Valley and the Dniester Valley (Łanczont,  
 108 Madeyska, 2005) were characterized by sparse woodland spaces along the Periglacial Forest-Steppe  
 109 river (Grichuk 1982; Huntley and Allen 2003). Forest was more present in the Dniester-Prut valleys.  
 110 In Crimea, grassy steppes were dominant (Grichuk, 1982), with the presence of Mediterranean forest  
 111 in the south.  
 112 During the late Pleniglacial, the ice sheet and glaciers extended in the North hemisphere. Moreover a  
 113 continuous permafrost also as an active permafrost (mollisol) were present in a large part (Figure 2).



114 Figure 2. The vegetation during the late Pleniglacial (according to Klein, 1973; Starkel, 1977; Velichko et al.,  
 115 1984; Grichuk, 1982), the maximum extension of the ice sheet and the southern limit of permafrost (according to  
 116 Vandenberghe et al., 2012).  
 117  
 118

119 **2.4. Mammalian fauna during the late Pleniglacial in the East European Plain**

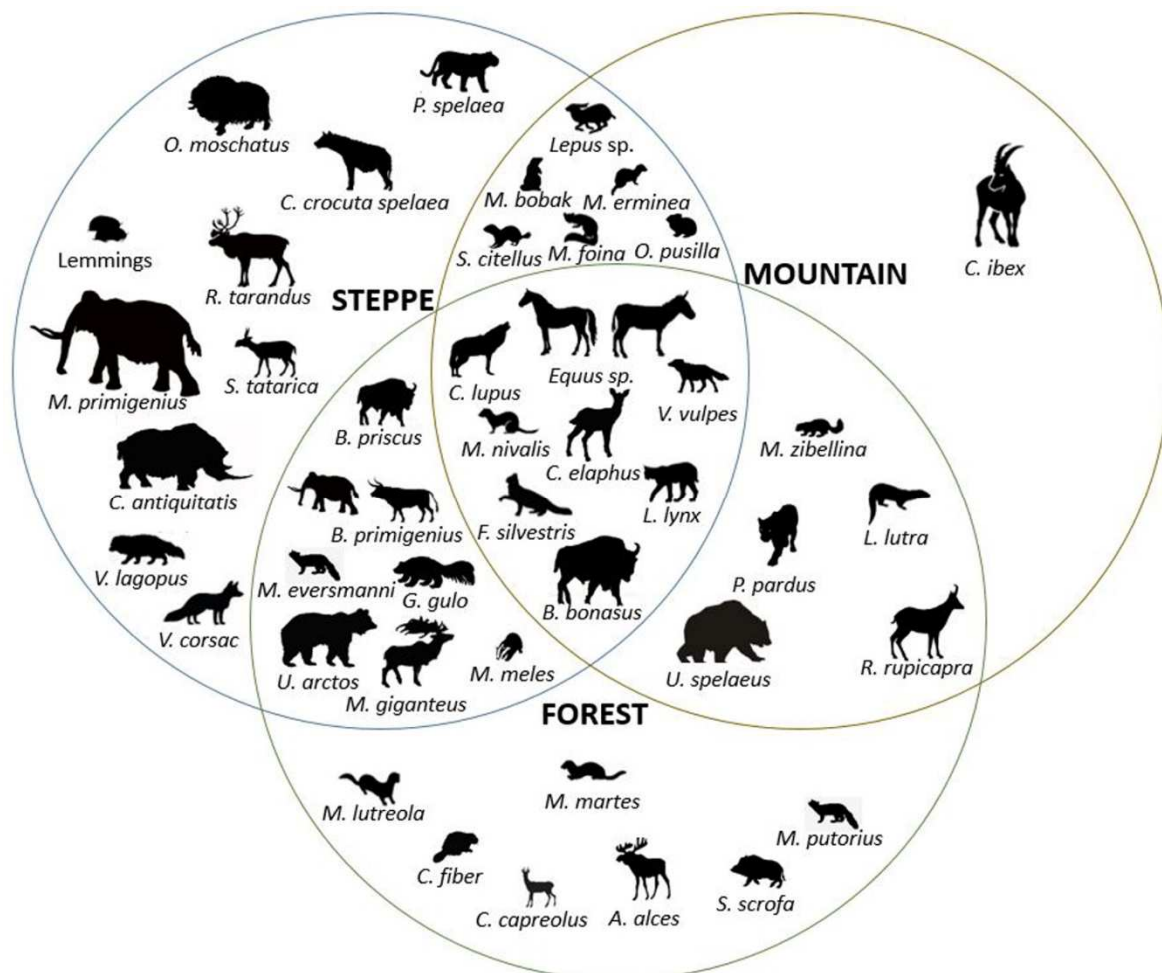
120 The geographic distribution of EEP Last Pleniglacial mammalian fauna greatly depended on local  
 121 conditions, particularly on the altitude, the hydrographic network and the type of available vegetation.  
 122 For each species identified in the different archaeofauna considered, the main eco-ethological trends  
 123 are summarized in Table 2; their ecological preferences are schematized in Figure 3.

Table 2. Ethological trends of species during the late Pleniglacial in the East European Plain (compiled from Bannikov, 1963; Kurtén, 1968; Guérin, 1980; Lent, 1988; Kuzmina, 1997; Geist, 1998; van Vuure, 2002; Pucek et al. (Eds), 2004; Jost and Jost-Tse, 2005; Lister and Bahn, 2007; Pacher and Stuart, 2009; Parrini et al., 2009; Bough, 2012; Julien et al., 2012; Manuel et al., 2020; <https://animaldiversity.org/>).

Species		Vernacular name	Main habitat	Favoured climate	Diet	Longevity	Weight
<i>Mammuthus primigenius</i>		Woolly mammoth	tundra-steppe and possibly steppe-forest	cold and dry	mainly grasses and sedges, with herbaceous plants, flowering plants, shrubs, mosses, and tree matter 150-200 liters of water per day	~60 y.o.	3500-5000 kg
<i>Ceolodonta antiquitatis</i>		Woolly rhinoceros	tundra steppe	cold and dry	grass, shrubby sprouts, forbs, lichens and mosses	~40 y.o.	1500-3000 kg
<i>Equus</i> sp.	<i>Equus ferus</i> cf. <i>latipes</i>	Horse	ubiquitous (favour open environments)	ubiquitous	grasses, sedge, herbs and woody plants 40-60 liters of water per day	~20 y.o.	250-350 kg
	<i>E. asinus</i>	Ass	ubiquitous (favour open environments)	ubiquitous (favour arid climate)	herbs, shrubs, flowers	~15 y.o.	150-250 kg
<i>Bison</i> sp.	<i>B. bonasus</i>	European bison	mosaic-type landscapes of forest and herbaceous, forest, mountainous	temperate	sedges, grasses, herbs, woody plants	~20 y.o.	500-1000 kg
	<i>B. priscus</i>	Steppe bison	steppe-tundra and forests	cold and dry	grasses twigs, barks, leaves, lichen		
<i>Bos primigenius</i>		Aurochs	open areas in marshlands along rivers, forest-steppe	temperate but can adapt to more cold	mainly herbs and grasses, branches of trees or bushes	~15 y.o. (?)	500-900 kg
<i>Ovibos moschatus</i>		Muskox	great steppe plains	cold, extreme cold conditions, with temperatures down to -40 °	willowherb, sedges, grasses	20-25 y.o.	200-400 kg
<i>Capra ibex</i>		Ibex	mountainous regions. a rupicolous species which favors the steep cliffs and the steep walls	ubiquitous	grasses, legumes, juniper, rhododendrons, hazel and green alder shoots, mosses and lichens	~20 y.o.	35-100 kg
<i>Rupicapra rupicapra</i>		Chamois	forest during winter and go up in altitude on the steep slopes from spring	ubiquitous	grasses, vegetables, flowers and shrub foliage	~15 y.o.	20-50 kg
<i>Saiga tatarica</i>		Saiga antelope	steppe	dry climate with very cold winters and hot summers	salt-bearing grasses and sometimes steppe grasses, succulents in summer	~12 y.o.	20-50 kg
<i>Megaloceros giganteus</i>		Giant deer	plains and light forests	cold and dry	grasses and tree buds	~15 y.o. (?)	~700 kg
<i>Alces alces</i>		Elk	cold swampy forests with coppices in boreal and mixed deciduous forests	subarctic climates	grasses, aquatic plants, foliage, branches and bark of bushes and young trees, sometimes lichens, mosses and fungi	15-20 y.o.	400-700 kg
<i>Cervus elephus</i>		Red deer	deciduous and coniferous forests, in the plains as well as in mountainous regions. It can even adapt to a slightly more open environment as steppe	temperate climate that is not very cold and humid, or even to a slightly colder environment with low snow cover	grasses, sedges, fruits, woody and semi-woody plants (bark in winter)	10-15 y.o.	80-250 kg
<i>Rangifer tarandus</i>		Reindeer	holarctic areas (steppe, taiga, tundra)	cold environments		~15 y.o.	80-250 kg
<i>Capreolus capreolus</i>		Roe deer	palaearctic forests	temperate	shoots and leaves of trees, brambles, raspberries, ivy, hazel, herbaceous	7-9 y.o.	~40 kg
<i>Sus scrofa</i>		Wild boar	forest, glade, heath, water point	mild climate	plants, tubers, mushrooms, molluscs, worms, insects, small mammals, birds, sauropsids, fruits. Sometimes scavenger. Rarely attacks herbivores.	8-10 y.o.	30-170 kg
<i>Lepus</i> sp.		Hare	open environments, as steppe or low mountains	cold continental climate	grasses, flowers, buds	~12 y.o.	2-7 kg
<i>Ochotona pusilla</i>		Pika	rocky slopes of mountains, up to 5000 m above sea level, and in the rocky	suitable for cold (up to -20 ° C)	grasses, flowers, buds	~4 y.o.	100-400 gr

		steppes surrounded by vegetation				
<i>Marmota bobak</i>	Marmot	steppe and mountain	temperate, colder and dry	grasses, young shoots, flowers, fruits, worms, bugs	5 y.o.	2-10 kg
<i>Castor fiber</i>	Beaver	amphibious, fresh water (ponds, lakes, rivers) in the forest or at the edge of the forest	temperate, colder	herbs, leaves, twigs	10-15 y.o.	10-30 kg
<i>Spermophilus</i> sp.	<i>S. suslicus</i>	Spotted souslik	temperate, colder and dry	herbs, leaves, roots, insects	6 y.o.	300 gr
	<i>S. citellus</i>	European souslik				
<i>Dicrostonyx</i> sp./ <i>Lagurus</i> sp./ <i>Lemmus</i> sp.	Lemmings	tundra	cold and dry	leaves, shoots, grasses, roots, bulbs, occasionally caterpillars and larvae	1-3 y.o.	50-100 gr
<i>Ursus spelaeus</i>	Cave bear	mixed forests, sometimes with reliefs	cold	omnivorous, largely herbivorous	30 y.o. (?)	500 kg
<i>Ursus arctos</i>	Brown bear	mixed forests and wooded steppes	temperate or moderately cold climate	omnivorous and has a very varied diet	30 y.o.	80-600 kg
<i>Panthera spelaea</i>	Cave lion	great steppes	cold	large mammals	15-20 y.o.	250-400 kg
<i>Panthera pardus</i>	Panther	alpine boreal forest, mountains, forest, more open environments	ubiquitous	medium and small sized mammals	15 y.o.	20-35 kg
<i>Lynx lynx</i>	Lynx	forest, but it can adapt to the steppe	temperate, colder and dry	medium and small-sized mammal, micromammals, birds, frogs, fishes, worms, nuts	20 y.o.	10-35 kg
<i>Felis sylvestris</i>	Wild cat	forest, mountain, steppe	temperate, colder	small-sized mammal, micromammals, frogs, fishes, insects, birds, herb	10-12 y.o.	3-8 kg
<i>Crocuta crocuta spelaea</i>	Cave hyaena	meadows, near water points	cold environment	all types of large herbivores	20 y.o.	80-130 kg
<i>Canis lupus</i>	Wolf	ubiquitous	ubiquitous	wide range of prey	10 y.o.	15-70 kg
<i>Vulpes vulpes</i>	Red fox	ubiquitous	ubiquitous	omnivorous, very varied	10-15 y.o.	5-15 kg
<i>Vulpes corsac</i>	Corsac fox	steppes and semi-deserts	more or less cold, dry	micromammals, birds, insects, berries		
<i>Vulpes lagopus</i>	Polar fox	open environments, arctic regions, steppe	cold environments, up to -70°	micromammals, baby seals, birds, fishes, eggs, berries		
<i>Lutra lutra</i>	Otter	fresh water, swamps, mountains, forest	quite varied temperatures	omnivorous, more piscivorous	10 y.o.	10 kg
<i>Meles meles</i>	Badger	various environments, meadows and forests	humid continental	omnivorous	15 y.o.	10-20 kg
<i>Gulo gulo</i>	Wolverine	taiga, tundra	cold climate	omnivorous with carnivorous tendency	10 y.o.	8-25 kg
<i>Mustela</i> sp.	<i>Mustela putorius</i>	Polecat	forest, swamp	temperate, colder, humid	3-5 y.o.	1-2 kg
	<i>Mustela eversmanni</i>	Steppe polecat	wooded steppes, steppes and semi-steppes	temperate, colder, humid or dry		
<i>Mustela erminea</i>	Stoat	mountains, plains, avoid dense forest	cold	micromammals, frogs, small-sized mammals, birds, fishes, insects, worms	3-5 y.o.	300 gr
<i>Mustela lutreola</i>	European mink	near water, forest, banks, swamps, meadows	temperate, colder, humid	micromammals, frogs, small-sized mammals, birds, eggs, fishes, insects, molluscs	5 y.o.	500 gr-1 kg
<i>Mustela nivalis</i>	Weasel	ubiquitous, avoid wet lands	temperate, colder	micromammals, frogs, small-sized mammals, birds, eggs	3 y.o.	50 gr
<i>Martes foina</i>	Beech marten	plain, mountains, meadows	temperate, colder and warm	micromammals, small-sized mammals, birds, eggs, fruits	10 y.o.	1-2 kg
<i>Martes zibellina</i>	Sable	taiga, mountains, dense forests	temperate, colder	micromammals, small-sized mammals, birds, eggs, fishes, insects, fruits, seeds	10 y.o.	700 gr-2 kg
<i>Martes martes</i>	Pine marten	dense forest, mixt or coniferous forests	temperate, colder and warm	micromammals, small-sized mammals, birds, insects, fruits	10 y.o.	1-2 kg





127

128 Figure 3. Large mammals (lemming included) schematic ecological niches distribution, in the East European  
 129 Plain during the late Pleniglacial.

130 **2.5. Technocultural complexes**

131 Archaeologically, the Mid-Upper Palaeolithic, between 31.0 and 21.5 ka cal BP (26.0-18.0 ka <sup>14</sup>C BP)  
 132 is conventionally subdivided into several technocultural complexes and regional facies  
 133 Gravettian/Molodovian, Kostenkian, Pushkarian, Epigravettian and Epiaurignacian, partially  
 134 overlapping in time and space. To the West (Romania, Moldova, parts of Ukraine), local equivalents  
 135 of Western units (Gravettian, Epigravettian) were usually defined. For the Eastern parts of Ukraine  
 136 and Russia, with settlements clusters separated by huge distances, regional ‘cultures’ were preferred.  
 137 Concerning the archaeological history of features of the different areas, several syntheses were made  
 138 on the EEP (Abramov et al., 1984; Hoffecker, 2002), concerning art (Abramova, 1995) and by areas:  
 139 the plain (Boriskovskyi, 1953; Soffer, 1985; Nuzhnyi, 2015), the Dniester-Prut valleys (Borziac, 1994;  
 140 Chirica and Borziac, 2009; Noiret, 2009), the Pontic steppe (Krotova, 1995; 2003; 2013) Romania  
 141 (Cârciumaru, 1999), Poland (Kozłowski and Kozłowski, 1996; Wilczyński, 2016), the Balkans  
 142 (Tsanova, 2006) and the Baltic region (Gimbutas, 1956).

143  
 144 The Gravettian in Eastern Europe developed from 34.0 to 24.0 ka cal BP (30.0-20.0 ka <sup>14</sup>C BP) (Otte  
 145 and Kozłowski, 1982; Kozłowski, 1986; 1990). Lithic technology is characterized by the importance  
 146 of abrupt retouching and the presence of typical implements: flat-faced points, shouldered points,  
 147 Gravettes and micro-gravettes. Several site clusters made it possible to highlight regional  
 148 particularities: the Lower Danube basin (Temnata, Bacho-Kiro), the Dniester basin (Molodova,  
 149 Korman), the Prut basin (Mitoc), the Desna basin (Pushkari, Klussy, Avdeev, Khotylevo II), the Don  
 150 basin (Kostienki, Gagarino), and the Volga basin (Zaraisk). In the Extracarpatic area, the sequences of  
 151 Molodova V, Korman IV (Chernysh, 1959; Ivanova, 1969; Ivanova and Tzeitlin, 1987), and Mitoc-  
 152 Malu Galben have produced long stratigraphic sequences allowing a better understanding of  
 153 archaeological cultures within their environment (Noiret, 2009). These data were correlated with those

154 from central European sites, which made it possible to identify several major techno-cultural  
155 chronological divisions (Haesaerts et al., 2007), but also with the Bistrița Valley site cluster in the  
156 Eastern Carpathians, clearly connected by raw material transfers to the Prut-Dniestr region (Anghelinu  
157 et al., 2018).

158  
159 The ancient and middle Gravettian is contemporary with the first loessic accumulation of the Upper  
160 Pleniglacial. It is known in an intra-loessic humus soil dated around 30.5 ka cal BP (25.5 ka <sup>14</sup>C BP),  
161 in layer 8 at Molodova V and in the lower part of the Gravettian concentration II at Mitoc-Malu  
162 Galben. The beginning of the Upper Gravettian is contemporary with the deposit of the first loessic  
163 cover of the Upper pleniglacial in a cold but still slightly humid environment, as evidenced by the  
164 tundra gleys associated with it (Haesaerts et al., 2003; Noiret, 2009). In lithic terms, it is characterized  
165 by the development of shouldered points. It is known in levels 8 and 7 at Molodova V, located in  
166 humic silts, corresponding to a temperate episode (Tursac). It was conventionally dated between 30.0  
167 and 27.3 ka cal BP (25.0-23.0 ka <sup>14</sup>C BP). The formal tools are made up of burins (dihedral, on  
168 truncation, on break), of implements with abrupt retouch (gravettes, microgravettes), blades, truncated  
169 elements, endscrapers, shouldered points, retouched and pointed blades.

170 The Mitoc-Malu-Galben site is characterized by a level (Gravettian IV), dated at 28.5-27.7 ka cal BP  
171 (24.0-23.0 ka <sup>14</sup>C BP) with many endscrapers, retouched blades, pointed blades, gravettes,  
172 microgravettes and abruptly retouched pieces (Otte et al., 1996).

173 The second period of the Upper Gravettian is contemporary with the installation of the upper loessic  
174 cover in a cold, but above all very dry context. It was dated at Molodova between 27.7 and 24.0 ka cal  
175 BP (23.0-20.0 ka <sup>14</sup>C BP).

176  
177 It was also during this key period that the Epigravettian techno-complex developed, with the  
178 perpetuation of certain Gravettian traditions, but also with the appearance of new practices, which  
179 expanded during the second part of the Upper Pleniglacial (27.7-17.0 ka cal BP/20.0-14.0 ka <sup>14</sup>C BP),  
180 marked by a progressive deglaciation. The most important features were the microlithisation of lithic  
181 tools, the presence of eyed needles, the greater exploitation of fur-bearing animals, especially  
182 carnivores and hares, and hard materials of animal origin (ivory, antler, bones) to produce tools and  
183 artistic pieces, and the development of more structured habitat spaces (wood or mammoth bones  
184 dwellings, storage pits).

185 The Dniester Gravettian is therefore characterized by the appearance of shouldered points, the  
186 development of burins on truncation and microgravettes. Leaf-points and Pavlovian points are rare and  
187 Kostienki knives are absent. In addition, the shouldered points (narrow with a slightly marked notch)  
188 are different from those of the Kostienki type (wide, with an elongated notch and reverse retouching).  
189 This type of shouldered points and the composition of the lithic material, make this region an original  
190 culture within the Gravettian called Molodovian or Eastern Gravettian of Ukraine (Boriskovskyi,  
191 1953; Grigor'ev, 1970; Chernysh, 1954; 1973; 1985; Otte et al., 1996; Borziac, 1998; Borziac and  
192 Koulakovska, 1998; Djindjian, 2002; Noiret, 2007; Nuzhnyi, 2009; 2015; Koulakovska et al., 2015).

193 In the Lower Danube, the Gravettian and the Epigravettian are relatively poorly represented, due to the  
194 small number of sites uncovered. These are Temnata and Kozarnika in Bulgaria. In Temnata, the  
195 layers Vb, Va, V-VI, delivered in the TD-I survey, massive points with retouched base, carinated  
196 endscrapers and burins, but also many retouched points (Drobiewicz et al., 1992). There are no  
197 retouched and backed tools. This type of tool is well represented in the level IVb industry of the  
198 Kozarnika Cave (Tsanova, 2003). This site also provided numerous bladelets and bilaterally retouched  
199 points. In both sites, composite tools are rare or absent. They therefore stand out from other sites in the  
200 Balkans (Mihailovic and Mihailovic, 2007) or Eastern European sites, without being able to specify  
201 any links with other regions.

202 Very few vestiges of the ancient and middle Gravettian have been discovered in Poland. So far, only a  
203 few flint processing workshops, prior to the sedimentation period of the recent upper loess, have been  
204 discovered in Upper Silesia, linked to the Pavlovian of Central Europe (Kozłowski, 2007). The  
205 presence of the Gravettian was recently recognized up to Lower Silesia in the context of hunting halts  
206 (Plonka and Wiśniewski, 2004). In the south of the Vistula basin, the recent Gravettian is  
207 characterized by notched points, large base camps, linked to the exploitation of flint and the slaughter  
208 and butchery of the woolly mammoth, such as Kraków -Spadzista (Wojtal et al., 2015) and Jaksice II  
209 (Wilczyński (Ed.), 2015). Although these are relatively similar activities between these two sites, the  
210 techno-typological characteristics differ. This finding is interpreted as the possibility of the  
211 contemporary existence of human groups with distinct typo-technological practices.

212  
213 Further to the East, in the Don Valley, the sites of Kostienki provided material enabling regional facies  
214 to be defined. Similarly, the sites of the Dnieper, Neman and Volga basins also allowed for the  
215 identification of several regional archaeological units.

216  
217  
218 The Kostienkovian or Kostienki-Avdeevov facies was described by Efimenko and was further  
219 documented through intensive researches (Sinitsyn, 2007). First of all, the occupations are  
220 characterized by a specific type of organization of space, represented by a large dwelling (36 x 14-15  
221 m) with numerous hearths in line on the longitudinal axis of the dwelling, surrounded by semi-  
222 underground constructions with a depth of one meter and by pits. The characteristic artifacts are the  
223 shouldered points, with specific dimensions, the Kostienki type knives and the realistic female  
224 statuettes.

225  
226 The Kostienki 4 facies (layer II) or Alexandrov type is defined according to other criteria issued by  
227 Rogachev (1955; Praslov and Rogachev, 1982). It is first of all a unique type of long-term housing  
228 structure (35 x 5.5 and 23 x 5.5 m), buried 20-30 cm below the palaeosurface and hearths arranged  
229 along the axis of the constructions. Then, the lithic assemblage is characterized by the striking  
230 importance of the blades and points with a backed edge (41%), splintered pieces of various shapes  
231 (17% or 1,200 pieces). No other Gravettian assembly has delivered these objects in such quantities. A  
232 few rare burins (2%) and scrapers (1%) seem to be another characteristic of this industry. The points  
233 and blades with a backed edge are marked by high variability. They are clearly different from those of  
234 Telmanskaja and the Kostienkovian assemblages and much closer to the points of the "classical"  
235 Western Gravettian. The bone industry and ornaments are rare and uncharacteristic.

236  
237 The Pushkarian (Belyaeva, 2002) is represented by sites Pushkari I, Pogon, Klussy, Mozoliivka and  
238 Novgorod-Severskyi. Most researchers now characterize these sites as a specific version of Gravettian  
239 (Nuzhnyi, 2009). The lithic industries are characterized by points with a curved back and various  
240 processed basal parts, massive rectangles, burins of different types, mainly on blades. In small series  
241 on some sites shouldered points and Kostenki knives are present. The organization of the living space  
242 in Pushkari I presented by different types of dwellings from mammoth bones. Besides of Pushkari I  
243 the hearths are present in Pogon and Klussy.

244  
245 The Kostienki 11/II facies or Anosovka 2 type is defined by the association of simple, circular, light  
246 housing structures, with a diameter close to 6 m, with an original lithic industry and elaborate works of  
247 art, among which we note small animal figurines. These criteria point to a particular variety of  
248 Gravettian. The industry is characterized by a large number of truncated blades, sometimes oblique  
249 and concave, forming the tip of a drill with retouched side edge, a fairly low representation of burins  
250 (15%) and rare scrapers (less than 1%), tools on blades, symmetrical leaf tips with a plano-convex or  
251 bi-convex profile formed by a partial bifacial retouch, points and blades with a backed edge  
252 constituting almost 50% of the tools. The special character of this group is the existence of a series of  
253 objects similar to the federmesser or the Azilian points, associated with various points of Gravettian  
254 type.

255  
256 In Crimea (Chabai, 2001), the sites of Siuren I (upper layer) (Demidenko et al., 2012; Massé and  
257 Patou-Mathis, 2012) and of Buran-Kaya III (layers 5-2, 6-1, 6 -2) (Péan et al., 2013; Yanevich, 2014)  
258 provided material related to the Gravettian techno-complex, for occupations prior to the Upper  
259 Pleniglacial, which is therefore very little known in this region.

260  
261 The Epigravettian succeeds the Gravettian and develops between 25.2 and 16.3 ka cal BP (21.0-13.5  
262 ka <sup>14</sup>C BP). The Epigravettian techno-complex is generally divided into two phases, the ancient  
263 Epigravettian (24.0-20.5 ka cal BP/20.0-17.0 ka <sup>14</sup>C BP) and the recent Epigravettian (19.2-16.3 ka cal  
264 BP/16.0-13.5 ka <sup>14</sup>C BP). The ancient Epigravettian is sometimes called Gravettian stage IV (Noiret,  
265 2009).

266  
267 In the Extracarpatic area, the Gravettian is present up to 28.5-27.5 ka cal BP (20.0-23.0 ka <sup>14</sup>C BP).  
268 Around 24.0 ka cal BP (20.0 ka <sup>14</sup>C BP) we see the development of Epigravettian cultures (Noiret,  
269 2009; Anghelinu et al., 2018).

270  
271 The cultural aspects are fairly homogeneous in the region. Human groups adopted a hunting strategy  
272 focused on the reindeer migrations, by setting up their camps at the crossing points of rivers. The  
273 presence of millstones and grinders also testifies to the exploitation of herbaceous plants. Lithic  
274 industries are characterized by the appearance of a specific type of tool, notably truncated elements,  
275 then large Gravette points, and finally points with convex backs. These cultural particularities are  
276 grouped under the same regional facies, as a late stage of the Molodovian, sometimes labeled as  
277 Molodova-Cosăuți-Cotu Miculinți cultural entity (Borziac et al., 2006). Nevertheless we observe an  
278 intensification of the making of bladelets and boneous industry and the enlargement of the used raw  
279 materials (Anghelinu et al., 2018).  
280  
281 There are also typological changes during the Epigravettian, but the laminar production techniques are  
282 similar to those of the Gravettian. The deposits also provided numerous bone objects, in particular  
283 conical spears points often with lateral grooves. There are also ornaments, in particular in Cosăuți, of  
284 the pendant type, sometimes with geometric decorations. Artistic manifestations are rare (Borziac et  
285 al., 2006; Noiret, 2009).  
286 In Poland, this period is little known (Wilczyński, 2015).  
287 The period between 26.3 and 18.2 ka cal BP (22.0-15.0 ka <sup>14</sup>C BP) is divided into two facies, the  
288 Epigravettian (that is, of Gravettian tradition) and the Epiaurignacian. The Epiaurignacian corresponds  
289 to the resurgence of some of the lithic techniques used in the Aurignacian. This phenomenon has been  
290 observed in several sites (notably in the Dniester Valley and in the Pontic steppe, but also in Central  
291 Europe), without any direct cultural affiliation with previous Aurignacian (Covalenco, 1996; 2003-  
292 2004; Zwyns, 2004; Demidenko et al. 2018).  
293 Further to the East, the Epigravettian of Gravettian tradition developed within the pontic steppe, as  
294 recorded at Amvrosievka, Anetovka II and Yami. Assemblage of Yami (26.3-25.2 ka cal BP/22.0-21.0  
295 <sup>14</sup>C BP) has pronounced Gravettian features: lithic awls and a high index of products with abrupt  
296 retouching, including backed blades. Two atypical shouldered points are presented (Krotova 1986;  
297 2000; 2013). By typological features, the assemblage of Yami finds also analogies in the materials of  
298 the Gagarino site. They are manifested in the prismatic knapping technique, the close correlation of  
299 the main categories of tools and the prevalence of burins over end scrapers. The microinventory -  
300 rectangles, backed bladelets and points- are close to the Gravettian type. Such a similarity suggests the  
301 possibility of linkage between the residents of the Yami site and the population of the Willendorf-  
302 Kostenki community and the Gagarino-Khotylevo group within it (Amirkhanov, 1998; Krotova,  
303 2013).  
304  
305 All these sites preserve short sequences corresponding to seasonal habitats. The lithic industries are  
306 characterized by laminar debitage and backed tools. Burins as well as points and backed bladelets are  
307 abundant. The hunt is geared towards bison - in particular the large slaughter site of Amvrosievka  
308 (Pidoplichko, 1953; Krotova and Belan, 1993; Julien, 2009), sometimes associated with horses and  
309 saiga antelope. Decorated objects are rare but there are some elements of adornment (soft stone and  
310 fossil molluscs).  
311 The Epiaurignacian developed apparently in the same steppes, as shown by sites such as Muralovka,  
312 Zolotovka and Sagaidak I. These are unique levels without any development of the occupation space,  
313 except for Muralovka, which presents a stone pavement. The lithic industries are characterized by  
314 small flake debitage and bladelets. The scrapers are made on large flakes and resemble the thick  
315 nosed type. The bladelets and small chips were transformed into microlithic items by means of  
316 marginal retouch.  
317 A common feature of Sagaydak I, Muralovka, Zolotovka and Anetovka 1 is the high proportion of  
318 microliths - retouched blades and chips of a triangular and segmentoid shape. Some products in the  
319 assemblages of the Sagaydak-Muralovka group can be considered close to the Dufour type - made on  
320 prismatic blades and microblades and have a unilateral retouch on the back (Krotova, 2013). In  
321 addition to these sites in the steppe, the Epiaurignacian is represented by the site Obolonnya in the  
322 Desna region.  
323 In the Don basin, the sites of Kostienki 2, Kostienki 11/1a, Kostienki 19 and Kostienki 3 have cultural  
324 particularities, grouped under the facies of Zamiatnine. The lithic industries are characterized by the  
325 predominance of bipolar or multidirectional knapping. There are many burins and endscrapers. The  
326 question is whether these industries correspond to local adaptations of the Kostienkian. There are few  
327 artifacts related to the bone industry. These are ivory awls and points with a circular section.

328

### 329 **3. Materials and methods**

330 In order to gain a better understanding of the relationship between humans, their environment and  
331 other species, we analyse the mammals present in the archaeological assemblages. We use results  
332 provided by archaeological, zooarchaeological and paleontological investigations, including the  
333 quantification, the taphonomy, the localization of sites, the types of occupations, the seasons, the use  
334 of bones and the representation of animals in art, the status of mammals according to the periods and  
335 regions. The results were compiled from different authors (Table 3).

336 Quantification methods vary according to the authors, especially concerning the number of elements.  
337 So for counting we use the units NR (number of remains) and MNI (minimum number of individuals)  
338 (Lyman, 2008).

339

340 We take into account the archaeological sites between 31.0 and 21.5 ka cal BP (26.0-18.0 ka <sup>14</sup>C BP)  
341 (Figure 4; Table 3; Annex 1).

342

343 Radiocarbon ages were calibrated with the IntCal13 radiocarbon atmospheric calibration curve  
344 (Reimer et al., 2013), using the software OxCal (<https://c14.arch.ox.ac.uk>).

345

346 Concerning statistics, the adjusted residuals are the adjusted values (or the difference between the  
347 observed accounts and the expected accounts) divided by an estimate of the standard error. They allow  
348 variations due to differences in size between samples to be taken into account. Thus, it is possible to  
349 highlight the influence of each species on all of the samples.

350

351 Concerning the pieces made on hard material of animal origins, they were counted by occurrences.  
352 Adornment is here considered together with bone industry.

353

354 This corpus takes into account 62 archaeological sites. Some of them were excavated on several loci  
355 and some others are pluristratified sites, which leads to 115 assemblages in total. The pluristratified  
356 sites are mainly located in the Dniester and Prut basins. The absence of traces of human occupations in  
357 some geographical areas may either reflect that they were emptied of human populations during the  
358 time interval in question, or the lack of systematic archaeological investigations.

359 There are some doubts concerning the chronological and cultural position of some sites, due to the  
360 lack of data concerning the stratigraphic context. For exemple Novgorod-Serverskyi is positioned  
361 around 24.0-23.0 ka cal BP (20.0-19.0 ka <sup>14</sup>C BP), but could be dated between 27.7 and 24.0 ka cal BP  
362 (23.0-20.0 ka <sup>14</sup>C BP). It would be also necessary to make new datings for Climăuți II and Valea  
363 Morilor. These uncertainties about exact position concern also Berdyzh, Brynzeni, Bistricioara-Lutărie  
364 1 and 2, Klussy, Cotu-Miculiți, Crasnaleuca Staniște, Giurgiu-Malu Roșu, Kirillovska, Kostienki 3,  
365 5, 8 and 19, Leski, Oselivka 1, Yami and Radomyshl'.

366 Concerning habitat structures, the sites in the plain settings are generally more elaborately prepared  
367 (dwelling structures, small pits, storage pits) than in other areas. Concerning fauna, bone remains are  
368 more or less preserved, sometimes just few splinters. Only one site (Corpaci) did not yielded faunal  
369 remains. In general, we benefit from a good representation of the presence of faunal remains for the  
370 whole corpus of archaeological sites.

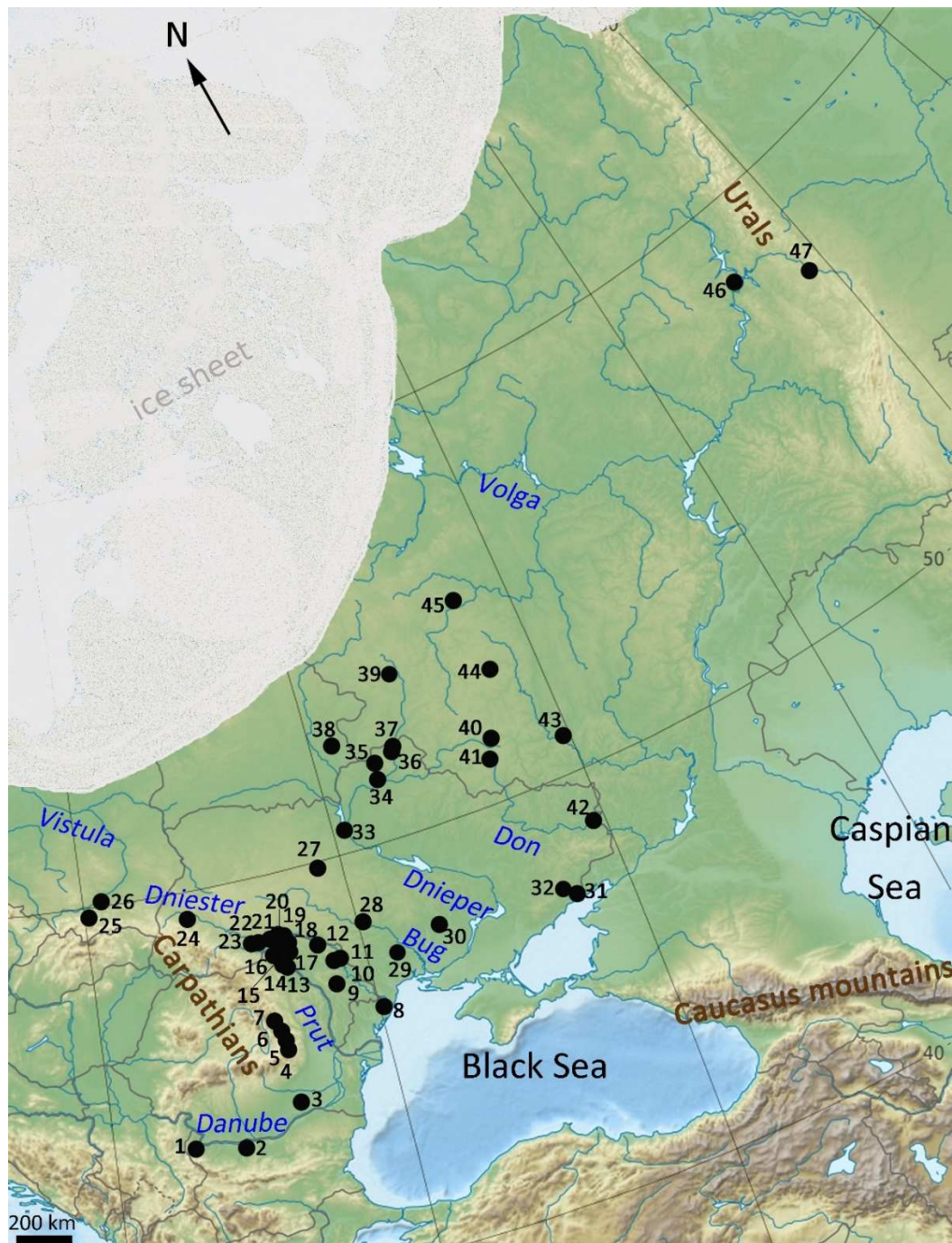


Figure 4. Main archaeological sites between 31.0 and 21.5 ka cal BP (26.0-18.0 ka <sup>14</sup>C BP) in the East European Plain (with the representation of the maximum extension of the ice sheet according to Vandenberghe et al., 2012).

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- 1:** Kozarnika/III, III-IVa; **2:** Temnata/3c-3d; **3:** Giurgiu-Malu Roșu; **4:** Buda-Dealul Viei; **5:** Lespezi- Dealul Viei/IV, V, IV, III; **6:** Piatra Neamt-Poiana Cireșului/Grav III, II, I, Epigrav I; **7:** Bistricioara-Lutărie 1; Bistricioara-Lutărie 2/I,II,III,IV/IV; Bistricioara-Lutărie 3; **8:** Bolshaya Akkarzha/III; **9:** Valea Morilor; **10:** Climăuți II/lower, upper; **11:** Rașkov VIII/V, IV, IIIa, III, II, I; **12:** Cosăuți/10, 9, 8, 7, 6, 5; **13:** Crasnaleuca-Staniște/VII, VI, V, IV; **14:** Cotu-Miculintși/VII, VI, V; **15:** Corpaci; Corpaci-Mas; **16:** Mitoc-Malu Galben/Grav II, III, IV); **17:** Ciuntu; **18:** Brynzeni/III; **19:** Babin I/3 (upper); **20:** Korman IV/7, 6, 5; Korman IX/III, II, I; **21:** Molodova V/8, 7, 6; **22:** Oselivka I/III; **23:** Dorochivtsy III/1, 2, 3, 4, 5, 6, 7; **24:** Galich 1; **25:** Krakow-Spadzista; **26:** Jaksice II; **27:** Radomyshl' 1; **28:** Leski; **29:** Anetovka 2; **30:** Sagaidak; **31:** Muralovka; **32:** Amvrosievska/campment, bone bed; **33:** Kirillovska; **34:** Obollonia/boiling room 2010, excv 2011-2013; **35:** Klussy; **36:** Novgorod-Severskyi; **37:** Pushkari 1 (Paseka)/excv I-II-V-VII; Pushkari 8 = Pogon (Pyatii Metr)/excv I to IV, VII; **38:** Berdyzh (Podluzhe I); **39:** Khotylevo 2; **40:** Avdeevo I; Avdeevo II; **41:** Buki 4 (Pieni 1); **42:** Yami; **43:** Kostienki 1 (Poliakov)/I; Kostienki 3 (Glinitchi); Kostienki 4 (Alexandrova)/II, I; Kostienki 5 (Sviatoi Log)/II; Kostienki 8 (Tel'manskaia)/I; Kostienki 11 (Anosovka 2)/II, Ia; Kostienki 18 (Volkov); Kostienki 19 (Valukinskii); Kostienki 21 (Gmelin)/III; Borshevo 5/1/1b, 1/1a; **44:** Gagarino; **45:** Zaraïsk; **46:** Ostrovskaya = Talitskyi; **47:** Bezymyanni.

392 Table 3. Details of the different archaeological localities taken in account in the present study (OA = open air;  
 393 CV = cave; RS = rockshelter).

Sites	N°	Country	Year of first works	Type	Technocomplex	Main references	References for fauna	
Amvrosievska	32	Ukraine	1935	OA	Epigravettian	Krotova and Belan, 1993	Julien and Krotova, 2008; Julien, 2009	
Anetovka 2	29	Ukraine	1978	OA	Gravettoid/Anetovka facies	Stanko, 1999	Starkin, 2006	
Avdeevo I	40	Russia	1941	OA	Gravettian/Kostienki-Avdeevo type	Gvozdover, 1995		
Avdeevo II		Russia	1970's	OA	Gravettian/Kostienki-Avdeevo type			
Babin I	19	Ukraine	1928	OA	Gravettian	Chernysh, 1959 Noiret, 2009	Chernysh, 1959	
Berdyzh	38	Bielorussia	1926	OA	Gravettian	Boriskovskiy (Ed.), 1984 Nuzhnyi, 2009	Polikarpovich, 1968	
Bezmyanni	47	Russia	1974	CV	/	Bader and Petrin, 1978		
Bistricioara-Lutărie 1/2	7	Romania	1955	OA	Gravettian Final Gravettian/Early Epigravettian Epigravettian	Chirica and Borziac, 2009		
Bistricioara-Lutărie 3		Romania	2007	OA	Gravettian Final Gravettian/Early Epigravettian Epigravettian	Anghelino et al., 2019		
Bolshaya Akkarzha	8	Ukraine	1955	OA	Epiaurignacian	Medeanic and Sapozhnikov, 2006	Sapozhnikov, 2014	
Borshevo 5	43	Russia	1998	OA	Final Gravettian/Early Epigravettian	Lisitsyn, 2015		
Brynzeni/III	18	Moldova	1960	CV	Brynzenian	Chirica et al., 1996	David and Pascaru, 2005	
Buda-Dealul Viei	4	Romania	1958	OA	Gravettian	Dumitraşcu and Vasile, 2019	Bolomey, 1961 Necrasov and Bulai-Ştirbu 1971 Dumitraşcu and Vasile, 2019	
Byki 4 (Pieny 1)	41	Russia	1975	OA	?	Ahmetgaleeva, 2009		
Ciuntu	17	Moldova	1975	RS	Gravettian	Borziac et al., 1997	David, 1980	
Climăuţi II	10	Moldova	1989	OA	Epiaurignacian	Borziac et al., 1992	David et al., 1995 Demay et al., in press <sup>a</sup>	
Corpaci	15	Moldova	1970's	OA	Gravettian	Borziac and Chetaru, 1996		
Corpaci-Mas		Moldova	1966	OA	Aurignacoid Gravettian			
Cosăuţi	12	Moldova	1978	OA	Epigravettian	Borziac, 1996	David et al., 2003	
Cotu-Miculiţi	14	Romania	1977	OA	Epigravettian	Chirica and Bodi, 2014		
Crasnaleuca Stanişte	13	Romania	1970's	OA	Early Epigravettian	Cărciumaru et al., 2004-2005	Paulescu, 1999	
Dorochivtsy III	23	Ukraine	1968	OA	Gravettian with epigravettian features Gravettian	Koulakovska et al, 2012; 2015	Demay et al., 2015	
Gagarino	44	Russia	1926	OA	Gravettian	Zamiatnine, 1935 Tarassov, 1979	Freeman, 1978	
Galich 1	24	Ukraine	1988	OA	Gravettian	Wojtal et al., 2001		
Giurgiu-Malu Roşu	3	Romania	1952	OA	?	Alexandrescu et al., 2004		
Jaksice II	26	Poland	1912	OA	Gravettian	Wilczyński (Ed.), 2015		
Khotylevo 2	39	Russia	1967	OA	Gravettian	Zavernaev, 2000 Gavrilov et al., 2015	Soffer, 1985 ; Chubur, 1995	
Kirilovska	33	Ukraine	1893	OA	Gravettian	Khvoika, 1913 Pidplichko, 1998 Shydlovskiy and Stupak, 2015	Pidplichko, 1969 Soffer, 1985 Shydlovskiy and Stupak, 2015	
Klussy	35	Ukraine	1964	OA	Gravettian/ Pushkarian facies	Shovkoplias, 1967 Stupak, 2008	Stupak, 2008	
Korman IV	20	Ukraine	1930	OA	Gravettian Epigravettian	Chernysh, 1977	Tatarinov, 1977	
Korman 9		Ukraine	2012	OA	Epigravettian	Kulakovska et al., 2019		
Kostienki 1	43	Russia	1930's	OA	Kostienkian	Sinitsyn, 2007	Lazukov, 1957	
Kostienki 3		Russia	1923	OA	Epigravettian/ Zamiatnine culture	Klein, 1969	Lazukov, 1957	
Kostienki 4		Russia	1927	OA	Kostienkian	Zheltova, 2015	Sinitsyn and Praslov, 1997 Dolukhanov et al., 2001	
Kostienki 5		Russia	1928	OA	/	Rogachev, 1957	Rogachev, 1957	
Kostienki 8		Russia	1936	OA	specific Gravettian	Efimenko and Borikovski, 1957	Lazukov, 1957	
Kostienki 11		Russia	1951	OA	Kostienkian	Popov et al., 2004 Sinitsyn, 2007	Vereshchagin and Kuzmina, 1977	
Kostienki 18		Russia	1953	OA	Gravettian/Kostienki-Avdeevo type	Sinitsyn, 2007 Reynolds et al., 2017	Klein, 1969	
Kostienki 19		Russia	1956	OA	Epigravettian/ Zamiatnine culture	Klein, 1969	Boriskovskiy, 1963	
Kostienki 21		Russia	1956	OA	Gravettian/Kostienki-Avdeevo type	Praslov and Rogachev, 1982 Reynolds et al., 2019	Praslov, 1964 Reynolds et al., 2019	
Kozarnika		1	Bulgaria	1931	CV	Gravettian/Epigravettian ? Balkan Gravettian	Guadelli et al., 1999	
Kraków Spadzista		25	Poland	1967	OA	Gravettian	Wojtal and Sobczyk, 2005; Wilczyński et al., 2012	
Leski	28	Ukraine	1985	OA	Epiaurignacian	Demidenko, 2004	Smolyaninova and Mukha, 1989	
Lespezi-Dealul Viei	5	Romania	1960's	OA	Gravettian/Epigravettian	Bitiri-Ciortescu et al., 1989 Tuffreau et al., 2018	Bolomey, 1991	
Mitoc-Malu Galben	16	Romania	1885	OA	Gravettian	Chirica, 2001 Noiret, 2009	López Bayón and Gautier, 2007	
Molodova V	21	Ukraine	1948	OA	Gravettian Epigravettian	Chernysh, 1959	Alekseeva, 1987	
Muralovka	31	Ukraine	1963	OA	Epiaurignacian	Praslov and Filippov, 1967	Leonova, 1994; Krotova, 2013	
Novgorod-Severskyi	36	Ukraine	1933	OA	Final Gravettian/Early Epigravettian Pushkarian facies	Pidplichko, 1947	Pidplichko, 1947 Demay, 2017	
Obolonnya	34	Ukraine	2010	OA	Epiaurignacian	Stupak et al., 2014	Demay et al., 2016	
Oselivka 1	22	Ukraine	1920's	OA	Gravettian	Borziac et al., 2006		
Ostrovskaya	46	Russia	1930's	OA	Gravettian ?/Kostienki-Borshevo type	Scherbakova, 1994	Talitzky, 1940 Bader, 1960	
Piatra Neamt-Poiana Ciresului	6	Romania	1963	OA	Gravettian Epigravettian	Cărciumaru et al., 2007	Cărciumaru et al., 2003	
Pushkari 1	37	Ukraine	1932	OA	Gravettian/ Pushkarian facies	Boriskovskiy, 1953 Belyaeva, 2000	Rudinski, 1947 Boriskovskiy, 1953 Sablin, 1997 Demay et al., in press <sup>b</sup>	
Pushkari 8 (Pogon)		Ukraine	1940	OA	Gravettian/ Pushkarian facies	Voievodskiy, 1950 Vasil'ev, 2014	Boriskovskiy, 1953 Demay et al., in press <sup>b</sup>	
Radomyshl' 1	27	Ukraine	1956	OA	Gravettian	Shovkoplias, 1964 Kononenko, 2015	Kornietz, 1962 Péan and Kononenko, 2004; Kononenko et al., 2006	
Raşkov VIII	11	Moldova	1958	OA	Epiaurignacian	Chetaru et al., 1986 Covalenco, Chetaru, 2005	Croitor and Covalenco, 2011	
Sagaidak	30	Ukraine	1950's	OA	Epiaurignacian	Sinitsyn and Praslov, 1997	Starkin, 2006	
Temnata	2	Bulgaria	1924	CV	Gravettian	Kozłowski et al., 1992; 1994	Delpech and Guadelli, 1992 Guadelli and Delpech, 2000	

Valea Morilor	9	Moldova	2009	OA	Upper Pal., Epiaurignacian features	Obadă et al., 2012	Demay et al., 2019
Yami	42	Ukraine	1980's	OA	Upper Pal., Gravettian, Epiaurignacian features	Grigoriev, 1993	Krotova, 1986; 2013
Zaraïsk	45	Russia	1980	OA	Gravettian/Kostienki-Avdevo type	Amirkhanov, 2009	

394

395 We took also into account the taphonomy (Efremov, 1940), when possible, to better estimate the  
396 structure of preserved archaeological materials, including faunal.

397 Indeed, the range of post-depositional factors that affected pan-LGM sites in the EEP, many located  
398 beyond the permanent permafrost line, is unfortunately large and diverse. Most archaeological  
399 deposits were impacted by the soil activity of alternate freezing and thawing (cryoturbation,  
400 solifluction etc.). Some sites were particularly affected. Bioturbation, low accumulation rates, slope  
401 movement, soil acidity and more recent anthropic intervention further affected the preservation or  
402 some sites. For instance, the layer 6 of Dorochivtsy III was affected by leaching phenomena and the  
403 layers 1, 2 and 7 were quasi totally destroyed. Bone surfaces were strongly altered in several sites as in  
404 Pushkari sites due to the acidity of the soil. Considering the site of Novgorod-Severskyi, the material  
405 is really rich, representing quasi all the existent faunal spectrum. However, a part of the material was  
406 blunt by rolling due to the flooding-deflooding of the Desna. In this site a part of material looks like  
407 natural deposits, another part was redeposited and a third part seems related to human activities. The  
408 site of Kirillovska raises question about potential redeposition of cultural layer(s) and/or disturbances.  
409 At Kozarnika a part of bones, such as ibex, were probably carried by bears, whose bones are also  
410 numerous at the site. In Avdevo, a part of the site was destroyed by the river. In Berdyzh a part of the  
411 site was altered by a recent ravine formation and some deposits were reworked. The site of Brynzeni  
412 raises particular questions. Indeed, as the lithic tools are characterized by Upper Palaeolithic pieces  
413 and Mousterian pieces, it was interpreted as a Middle to Upper Paleolithic transition site. However, it  
414 is equally possible to suggest a disturbed site with mechanically mixed different levels. At Buda, in the  
415 Eastern Carpathians, some remains were in a vertical position, between 0.50 and 0.60 m, following  
416 slides from the upper level due to periglacial phenomena. Gagarino was in part destroyed by  
417 agricultural work. At Korman IV, the deposits are inclined towards the river, having caused rupture  
418 zones in the stratigraphy. In Kostienki 1/1, disturbances from burrowing animals have been reported.  
419 The cultural layer of Leski was partly disturbed by erosion phenomena. In Khotylevo, periglacial  
420 phenomenon were observed but the archaeological layer is *in situ*. In Obollonia, the archaeological  
421 remains were affected by effect of flooding and deflooding but are relatively *in situ*. In Valea Morilor,  
422 the bones were impregnated with iron and manganese oxides by postdepositional hydromorphy and  
423 percolation effects. They have also been subject to the effects of hydraulic alteration phenomena  
424 related to the variations of the river bed, but with slow current. At Kraków Spadzista huge  
425 accumulation of mammoth bones was affected of solifluction and mammoth trampling. In Climăuți II,  
426 the material is well preserved, as in Molodova V, Dorochivtsy III/5-4-3 and Jaksice II. Cosăuți is  
427 really well preserved with an exceptionnal resolution of individual occupations. In sum, it is clear that  
428 some data could be biased and that some sites would need extensive taphonomic studies. However,  
429 although plagued by an unequal resolution, the existing corpus may still be used for discerning general  
430 trends over the selected chronological interval.

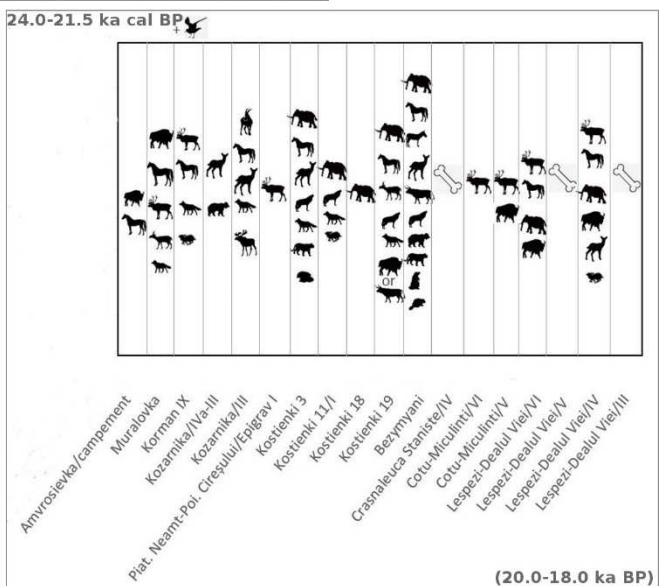
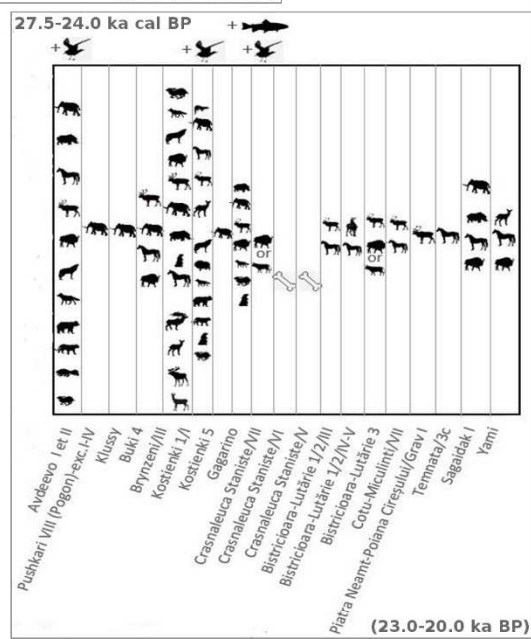
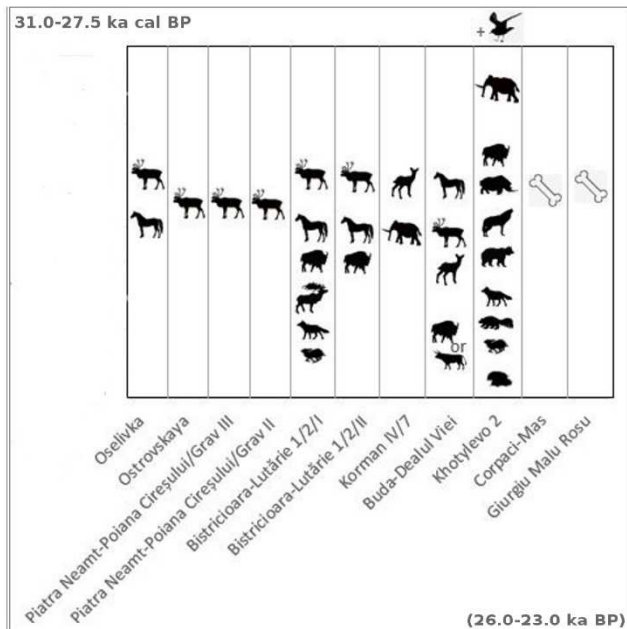
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## 432 4. Results

### 433 4.1. Faunal spectrum from archaeological sites

434 Concerning the faunal remains at archaeological sites (Figure 5; 6; 7; 8) they belong mainly to  
435 mammoth, horse, reindeer between 31.0-27.5 ka cal BP (26.0-23.0 ka <sup>14</sup>C BP), mammoth, horse,  
436 reindeer, fox and hare between 27.5-24.0 ka cal BP (23.0-20.0 ka <sup>14</sup>C BP) and mammoth, horse,  
437 reindeer and bison between 24.0-21.5 ka cal BP (20.0-18.0 ka <sup>14</sup>C BP). As a general feature then,  
438 mammoth, horse and reindeer are increasingly present, while fox and hare are more present from 27.5  
439 ka cal BP (23.0 ka <sup>14</sup>C BP) and bison is more common after 24.0 ka cal BP (20.0 ka <sup>14</sup>C BP).

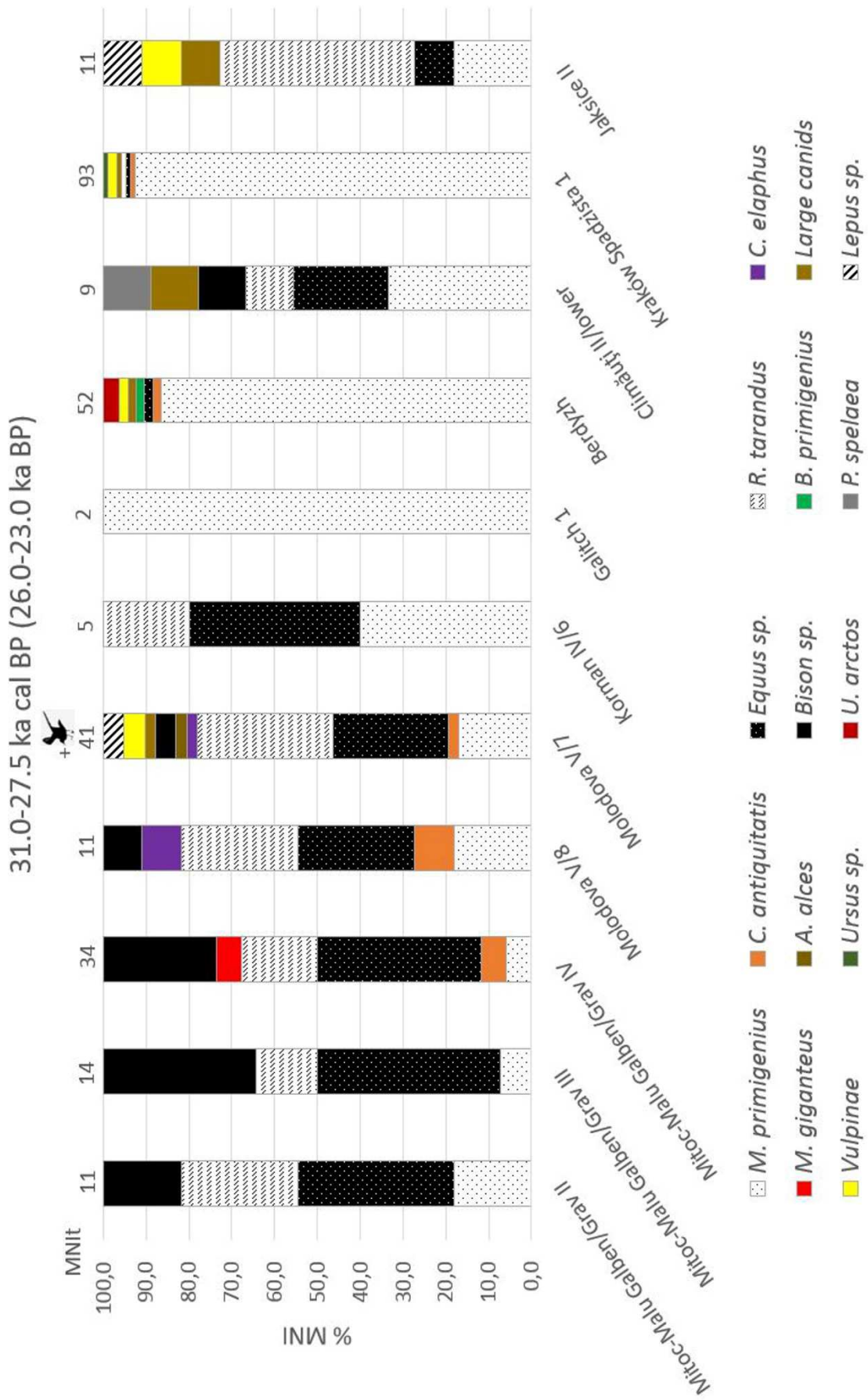




- M. primigenius*
- C. antiquitatis*
- Equus sp.*
- E. asinus*
- Bison sp.*
- B. primigenius*
- R. tarandus*
- C. elaphus*
- A. alces*
- M. giganteus*
- C. capreolus*
- S. tatarica*
- O. moschatus*
- C. ibex*
- Lepus sp.*
- M. bobak*
- C. fiber*
- Lemmings
- L. lutra*
- Large canid
- Fox
- G. gulo*
- Ursus sp.*
- P. spelaea*
- Aves sp.*
- Pisces sp.*
- undetermined

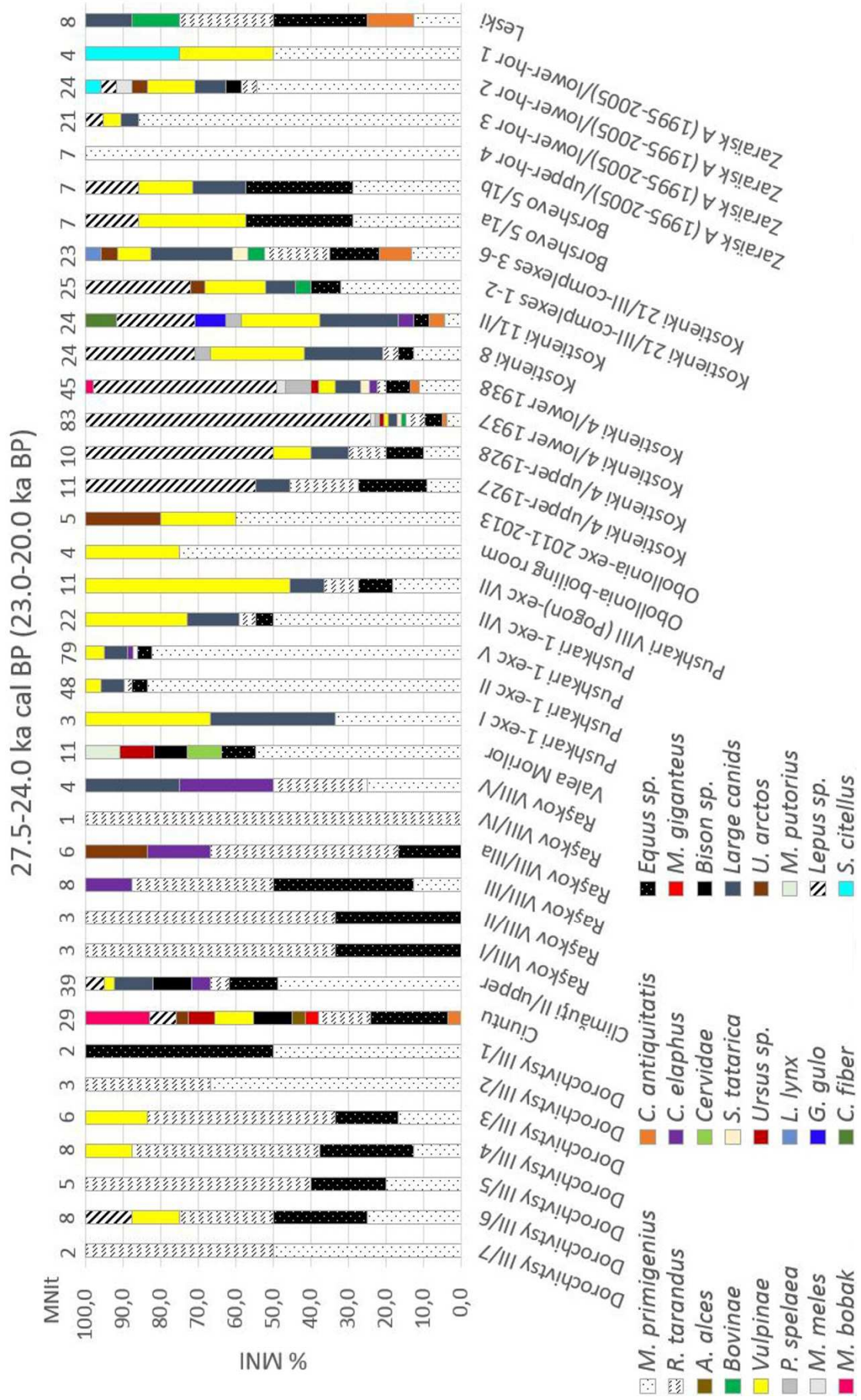
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Figure 5. Presence of species in the main archaeological sites from the East European Plain, between 31.0 and 21.5 ka cal BP (26.0-18.0 ka <sup>14</sup>C BP).



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Figure 6. Faunal composition in percentage of the minimum number of individuals of the main archaeological sites from the East European Plain, between 31.0-27.5 ka cal BP (26.0-23.0 ka <sup>14</sup>C BP).

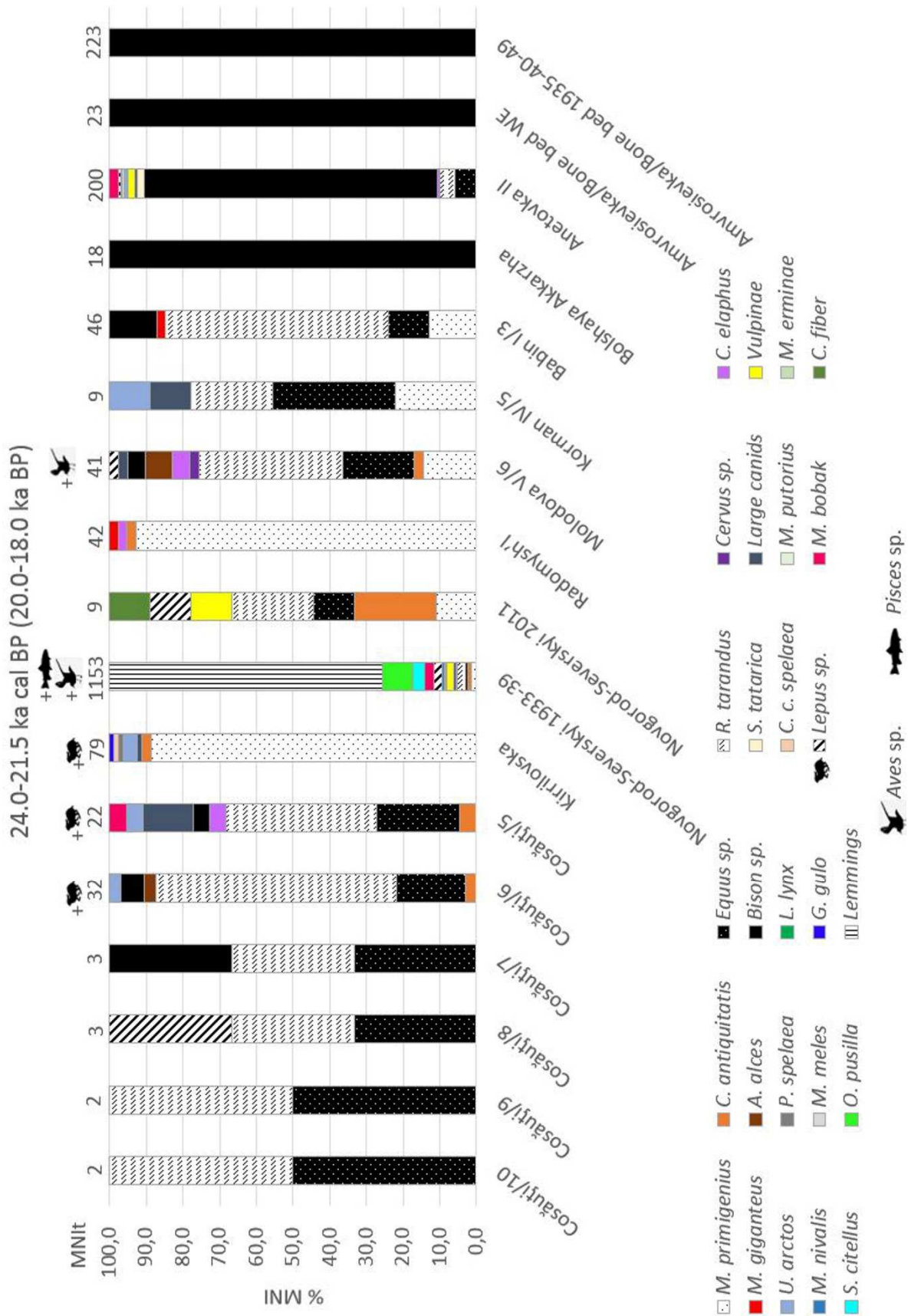


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Figure 7. Faunal composition in percentage of the minimum number of individuals of the main archaeological sites from the East European Plain, between 27.5-24.0 ka cal BP (23.0-20.0 ka <sup>14</sup>C BP).



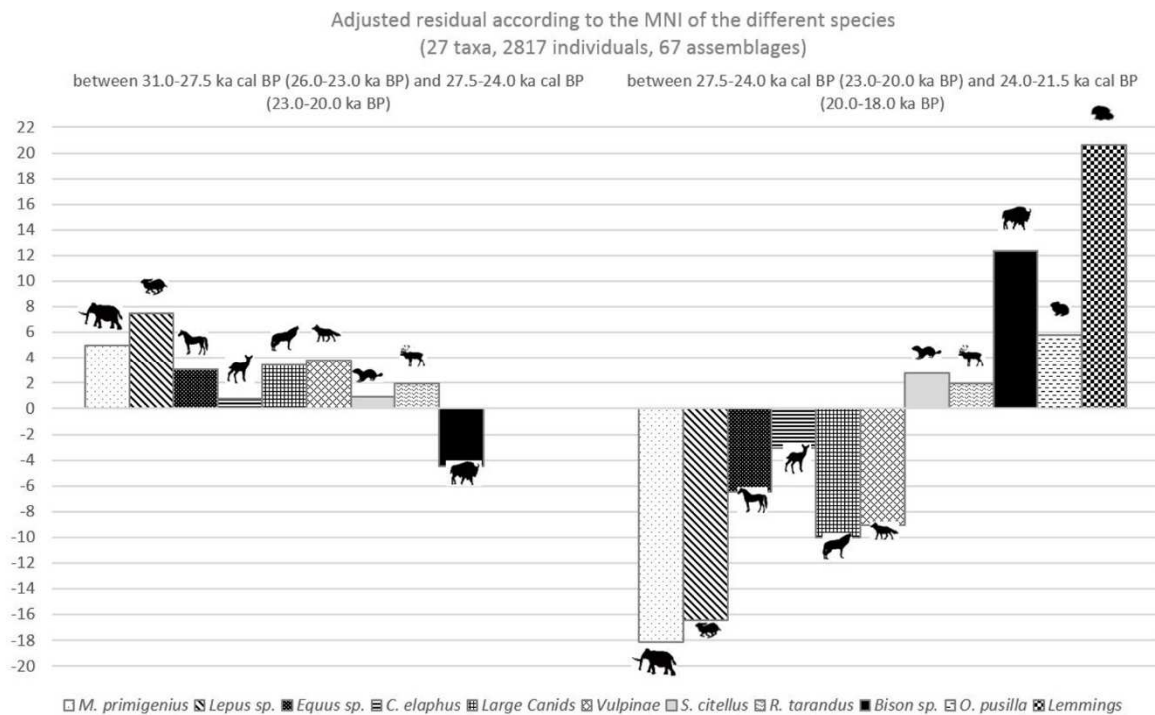
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451 Figure 8. Faunal composition in percentage of the minimum number of individuals of the main archaeological  
 452 sites from the East European Plain, between 24.0-21.5 ka cal BP (20.0-18.0 ka <sup>14</sup>C BP).  
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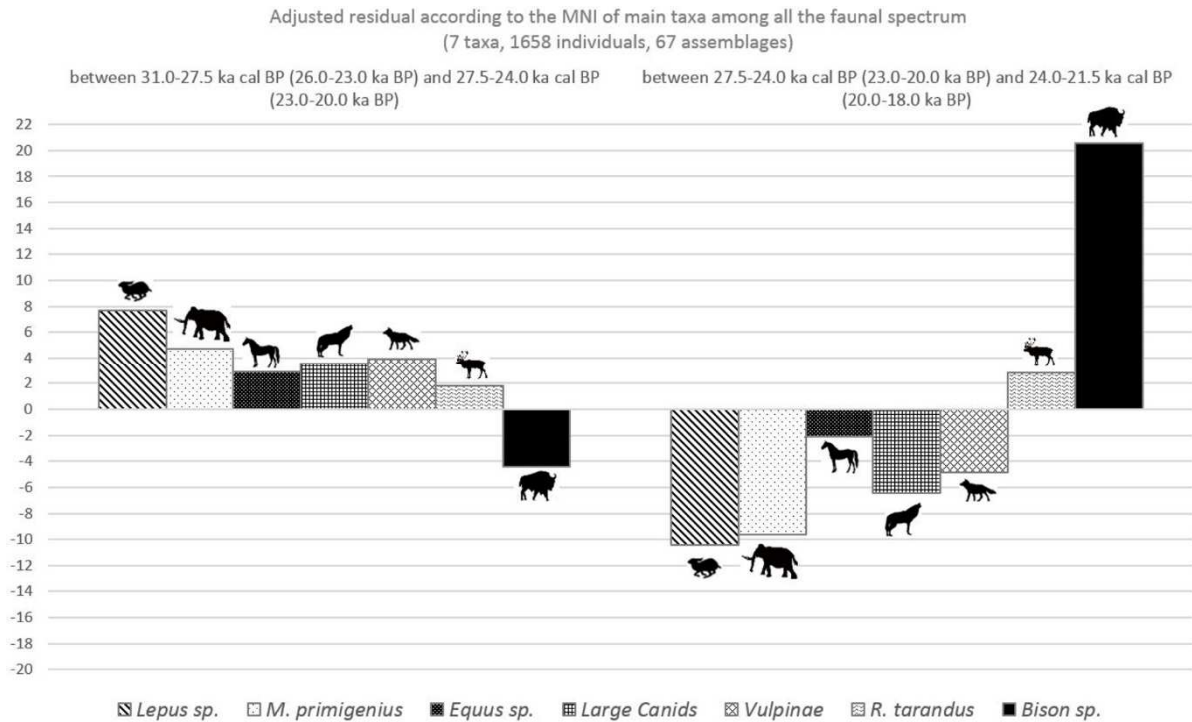
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456 To better evaluate the status of different species in archaeological sites by periods we proceeded to the  
 457 adjusted residuals analyses (Annex 2).  
 458 The dominant species in terms of presence are mammoth, reindeer, horse, red deer, large canid, fox,  
 459 hare, souslik, pika and lemmings (Figure 9). While we do not observe many differences, except a  
 460 slight global increase for these species between 31.0-27.5 ka cal BP (26.0-23.0 ka <sup>14</sup>C BP) and 25.7-  
 461 24.0 ka cal BP (23.0-20.0 ka <sup>14</sup>C BP), the differences are more pronounced after 24.0 ka cal BP (20.0  
 462 ka <sup>14</sup>C BP), when we note a decrease of large and medium-sized mammals, canids and hare. However  
 463 the bison increase and so do other species such as souslik, pika and lemmings. We have to be careful  
 464 concerning the latter small species. It is indeed possible that their bones were not systematically  
 465 preserved and/or collected during the excavations.  
 466  
 467



468  
 469 Figure 9. Adjusted residuals according to the number of individuals per species between the main range periods  
 470 between 31.0 and 21.5 ka cal BP (26.0-18.0 ka <sup>14</sup>C BP).  
 471

472 When removing these species and doing the same statistical test only between the main species, we  
 473 observe the same trend but with a high increase of reindeer and bison after 20.0 ka <sup>14</sup>C BP (Annex 3;  
 474 Figure 10).  
 475

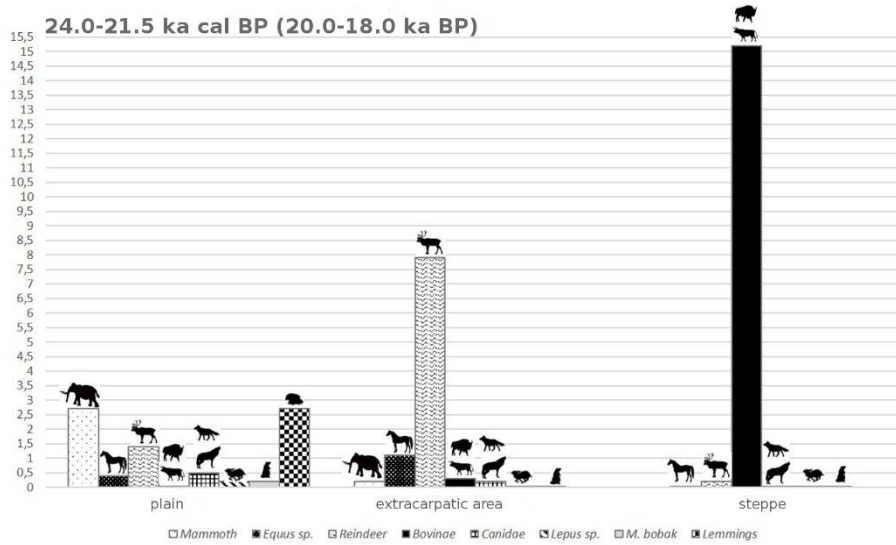
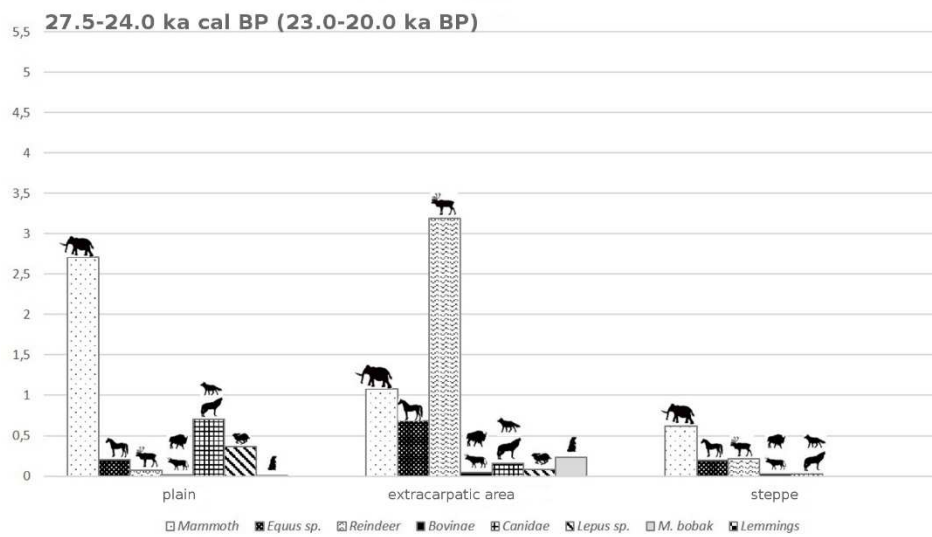
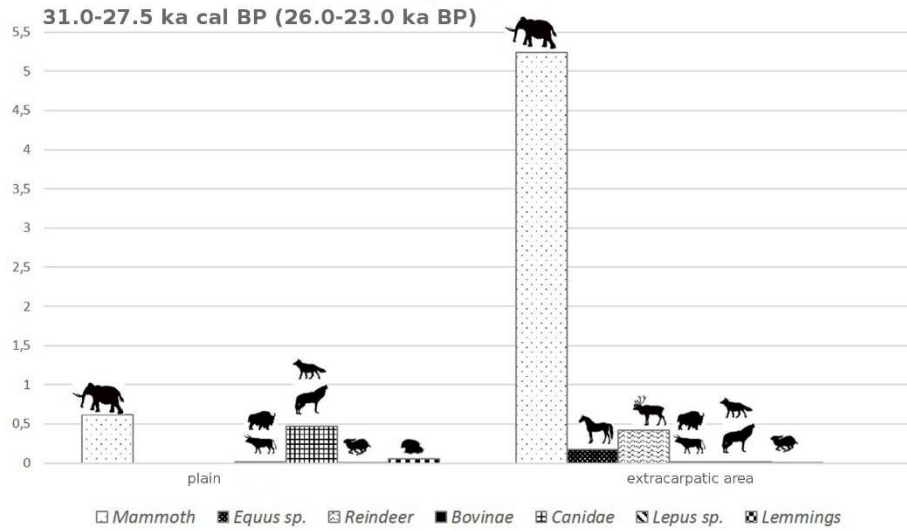


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Figure 10. Adjusted residuals according to the number of individuals per species of the main species between the different periods between 31.0 and 21.5 ka cal BP (26.0-18.0 ka <sup>14</sup>C BP).

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According to the distribution of species by regions (Figure 11) between 31.0-27.5 ka cal BP (26.0-23.0 ka <sup>14</sup>C BP) we observe a quite equal representation in all regions, with a higher density of canids in the plain and mammoth in the Extracarpatic area. However, this high density of mammoth is mainly due to the Kraków Spadzista site which preserves 86 mammoths. Between 27.5-24.0 ka cal BP (23.0-20.0 ka <sup>14</sup>C BP) mammoth is more present in the plain, with canids and hare, whereas in the Extracarpatic area reindeer is very common. We have few data about the steppe for this interval. Between 24.0-24.5 ka cal BP (20.0-18.0 ka <sup>14</sup>C BP) mammoth is still more present in the plain, with canids and lagomorphs, whereas in the Extracarpatic area reindeer is very common. In the steppe the bison is highly represented.

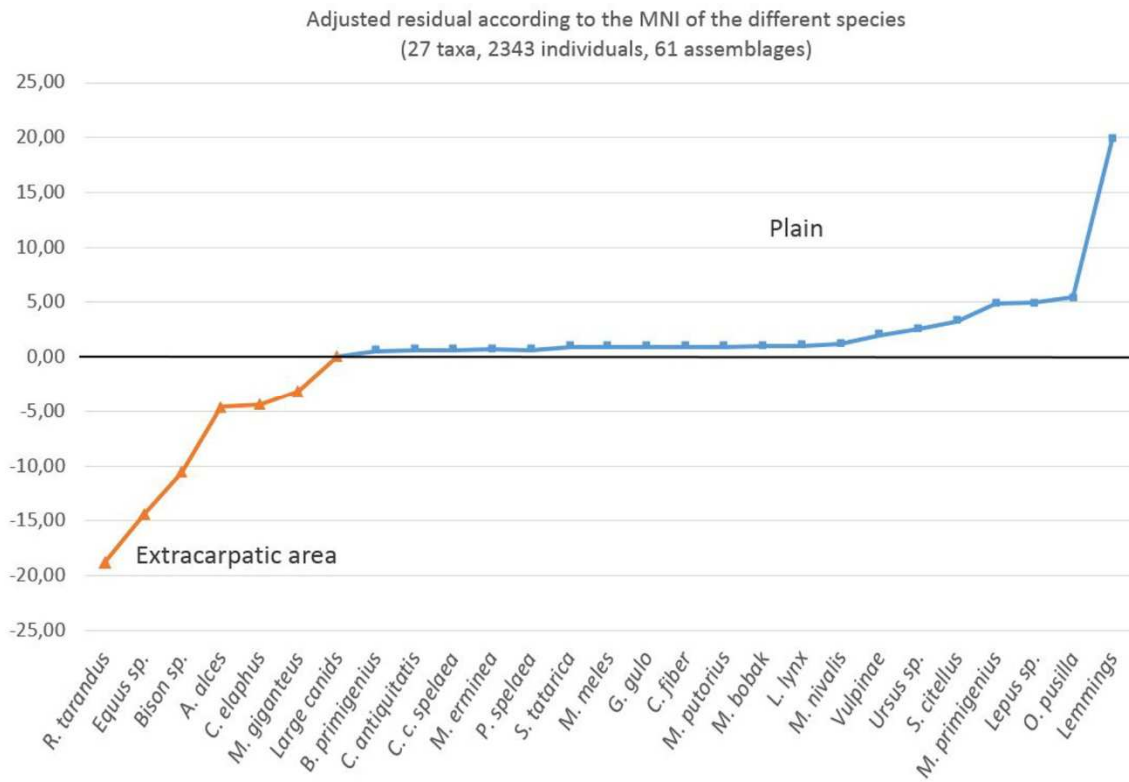


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Figure 11. Repartition of main species by regions from the East European Plain between 31.0 and 21.5 ka cal BP (26.0-18.0 ka <sup>14</sup>C BP), according to the density = [summation (number of remains/excavation surfaces in m<sup>2</sup>) of a species]/total number of assemblages from a region.

497 To better evaluate the repartition of species according to both regions which furnished enough data,  
 498 we proceeded to the adusted residuals analyses for all the periods (Annex 4; Figure 12).

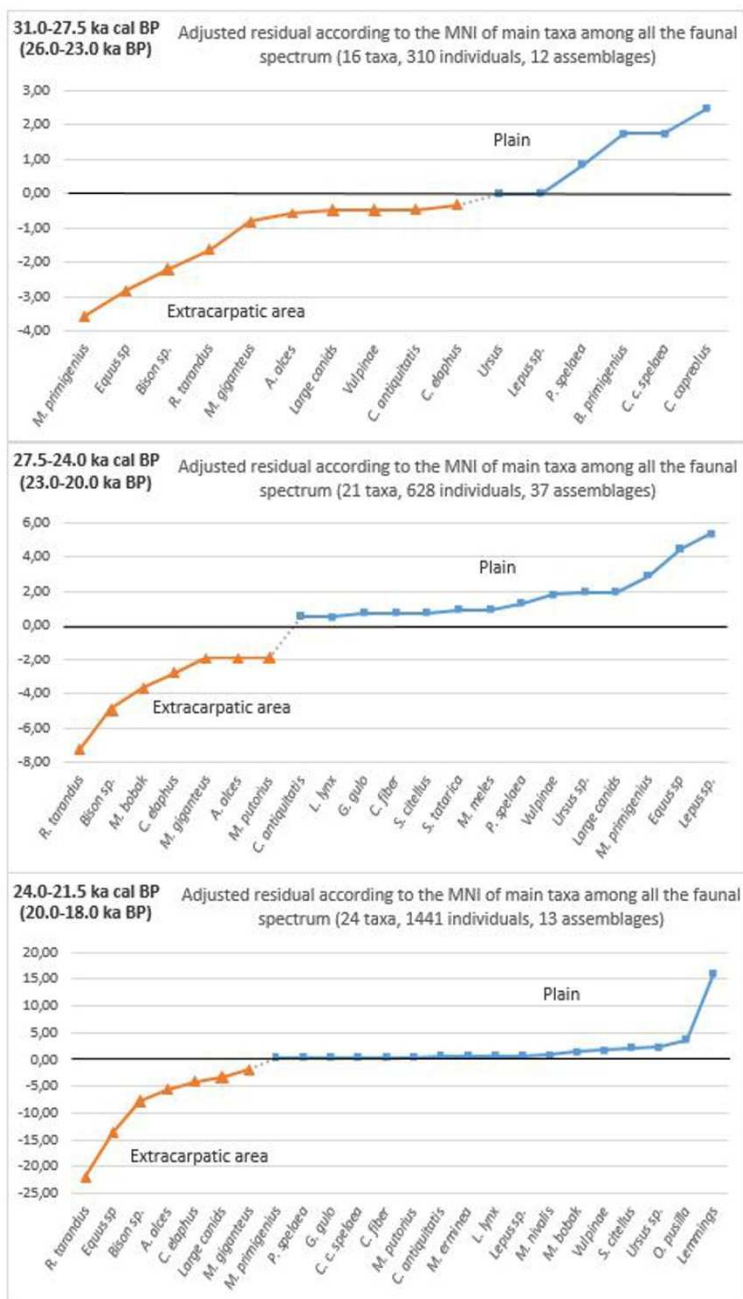
499 Generally the faunal spectrum is more diversified in the plain and much more restricted in the  
 500 Extracarpatic area. The most frequently recorded species in the Extracarpatic area are reindeer, horse  
 501 and bison, then moose, red deer and megaloceros. In the plain, rodents, lagomorphs, mammoth and  
 502 small and large-sized carnivores are most often recorded.



503  
 504 Figure 12. Adjusted residuals according to the number of individuals per species between the different regions  
 505 between 31.0 and 21.5 ka cal BP (26.0-18.0 ka <sup>14</sup>C BP).

506  
 507 On a closer look, between 31.0-27.5 ka cal BP (26.0-23.0 ka <sup>14</sup>C BP) the faunal spectrum is more  
 508 diversified in the Extracarpatic area than in the plain, while in the ensuing interval the tendency is  
 509 totally reversed, with an orientation on cervids, horse and bison in the Extracarpatic area. The  
 510 predominance of mammoth during the first period is mostly related to the peculiarity of Kraków  
 511 Spadzista, which distances itself from the other sites of the Extracarpatic area and appears more  
 512 typical for the tendencies of the plain (Figure 13).

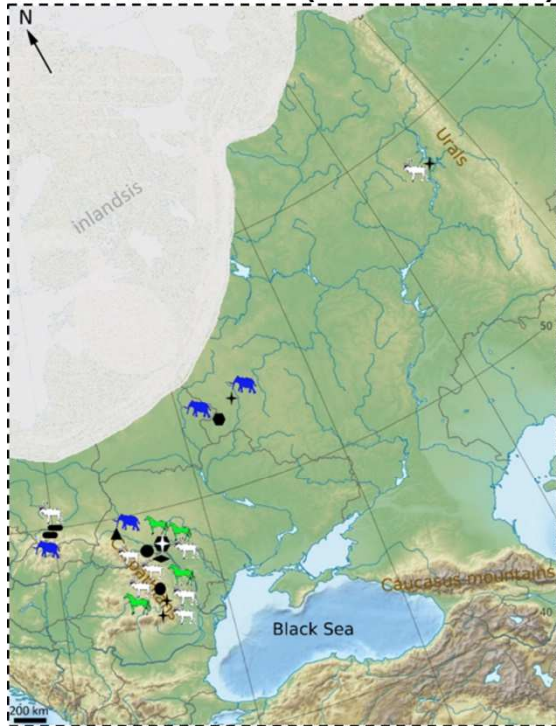




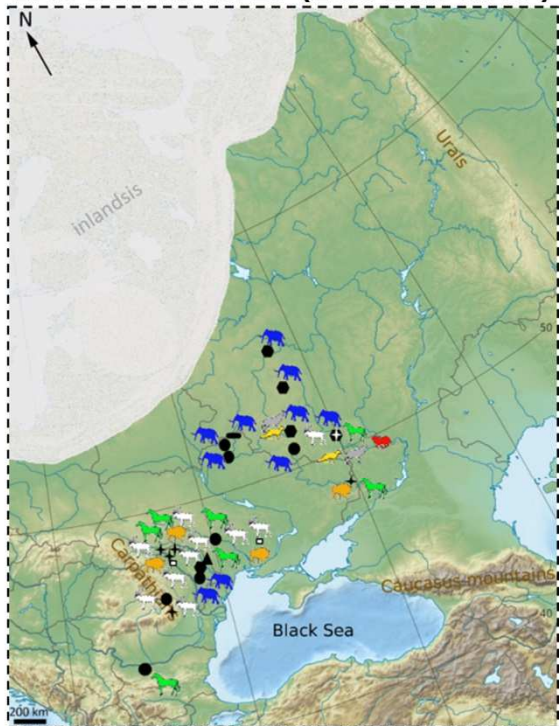
514 Figure 13. Adjusted residuals according to the number of individuals per species by the different regions  
 515 and periods, between 31.0 and 21.5 ka cal BP (26.0-18.0 ka <sup>14</sup>C BP).  
 516

517 When viewing the main species according to the geographical repartition and the presumed functions  
 518 of the sites, one may note either monospecific sites or more varied spectrum, especially in Kostienki-  
 519 Borshevo sites. Horse and reindeer are common in the Extracarpatic area and in the Ural sites. Bison is  
 520 more present in the South, mainly in the steppe, with specialized sites, but also in the Eastern  
 521 Carpathians, e.g. Buda (Dumitraşcu, Vasile, 2018). Mammoth is more present in the North, with the  
 522 exception of Valea Morilor and Climăuți II in the South. Camp bases are more present in the plain, in  
 523 Dnieper, Don and Volga valleys. The main hunted species seem to vary independently from the type  
 524 of occupations (Figure 14).  
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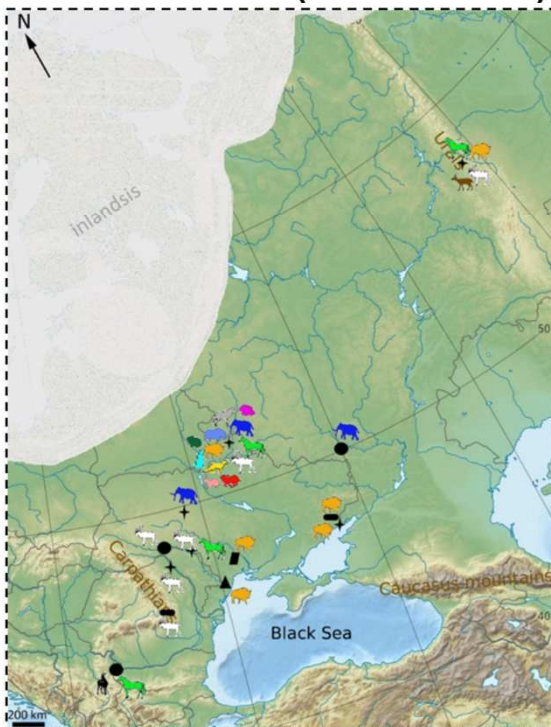
31.0-27.5 ka cal BP (26.0-23.0 ka BP)



27.5-24.0 ka cal BP (23.0-20.0 ka BP)



24.0-21.5 ka cal BP (20.0-18.0 ka BP)



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Figure 14. Main species in archaeological sites according to the type of occupations in the East European Plain, between 31.0 and 21.5 ka cal BP (26.0-18.0 ka <sup>14</sup>C BP).

## 4.2. Hunting and game

531 Focusing on the data concerning mortality profiles, in the steppe all age categories and both sex of  
532 bison were hunted, except in Muralovka were juveniles where present. At mammoth sites there are  
533 mainly adults with few calves, matriarchal herds and more punctually male groups, at the exception of  
534 Kostienki 21 were juveniles are dominant. At Raşkov VIII and Ciuntu, old horses were hunted,  
535 whereas in Dorochivtsy adults with foals were killed, corresponding to family bands. Concerning  
536 reindeers there are mainly adults, males and females, with young that which could correspond to  
537 herding (Table 4).

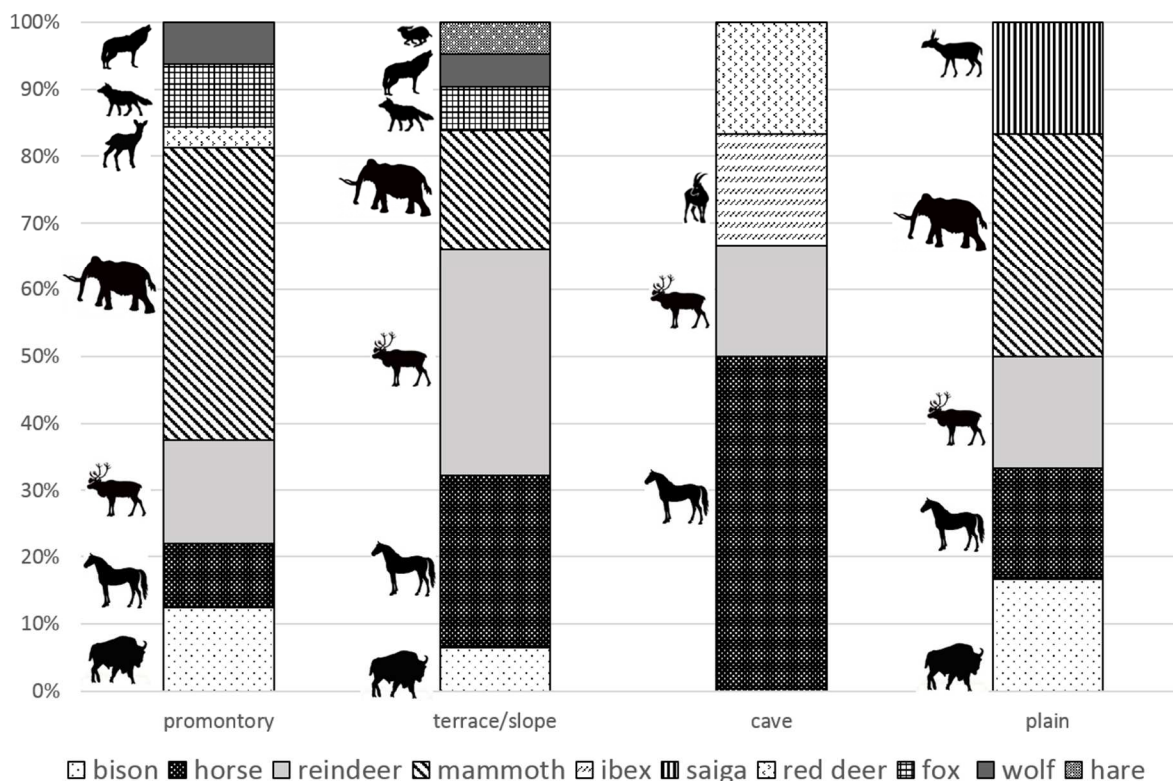
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Table 4. Profiles of game populations in the main archaeological sites from the East European Plain between 31.0 and 21.5 ka cal BP (26.0-18.0 ka <sup>14</sup>C BP).

Sites	Species	Age classes						Sex	
		foetal	juvenile	adult s.l.	young adult	adult	old	female	male
Amvrosievka/bone bed	bison		x		x	xx		x	x
Anetovka 2	bison	x	x		x	x	x	/	/
Ciuntu	horse						x		
Climăuți II/upper	mammoth		x	xx				x	x
Dorochivtsy III/6	horse		x			x			
	reindeer		x			x			
Dorochivtsy III/5	reindeer				xx	x		x	x
Dorochivtsy III/4	horse		x		x				
	reindeer		x		xx	x			
Dorochivtsy III/3	reindeer		x		x	x			
Kostënki 21/III	mammoth	x	xx		x	x			
	hare			x					
Obollonnya	mammoth	x			x	x		x?	/
Pushkari 1	mammoth		x		x	xx		x	x
Pushkari 8 (Pogon)	mammoth			x	x			/	/
Muralovka	bison		x						
	saiga		x					/	/
	antelope								
Rașkov VIII	reindeer		x		x	x		x	x
	horse						x	/	/
Zaraïsk	mammoth			xx				/	/

541

542 Looking on the topographic localization, the ibex is present in caves, together with red deer.  
543 Mammoth was more hunted on promontories and in the plain and reindeer on terrace/slope. We  
544 observe no topographic specificity for bison (Figure 15).  
545



546

547 Figure 15. Presence of species, by occurrences, according to the types of the site localization, of the main  
548 archaeological sites in the East European Plain, between 31.0 and 21.5 ka cal BP (26.0-18.0 ka <sup>14</sup>C BP).  
549

550 As a general feature, the typological spectrum reported seems to vary independently from the types of  
551 prey. Also, the mammoth hunting sites seem to correspond to high numbers of microliths (Table 5).

552  
553

Table 5. Tool kits linked to dominant species in the main archaeological of the EEP between 31.0-21.5 ka cal BP (26.0-18.0 ka BP) (PS: Pontic steppe; EC: Extracarpatic area; PL: plain; UR: Ural; 1: 31.0-27.5 ka cal BP (26.0-23.0 ka <sup>14</sup>C BP); 2: 27.5-24.0 ka cal BP (23.0-20.0 ka <sup>14</sup>C BP); 3: 24.0-21.5 ka cal BP (20.0-18.0 ka <sup>14</sup>C BP).

Sites	Area	Period	Dominant tools	Raw material origin	Dominant species
Amvrosievka/camp	PS	3	burins, backed bladelets, endscrapers	local	Bison
Amvrosievka/bone-bed	PS	3	blades, retouched flakes	local	Bison
Anetovka 2	PS	3	burins, micropoints	local+exogenous	Bison
Babin I/3	EC	3	burins, endscrapers	local	Reindeer
Bistricioara-Lutărie 1-2/I	EC	1	endscrapers, retouched blades	/	Reindeer, Horse
Bistricioara-Lutărie 1-2/II	EC	1	retouched blades	/	Reindeer, Horse
Bolshaya Akkarzha/III	PS	3	microblades, endscrapers, burins	/	Bison
Borshevo 5/1-1b-1a	PL	2	backed bladelets, retouched flakes, burins, points	/	Mammoth, Horse
Brynzeni/III	EC	2	blades, denticulates, retouched flakes, burins, endscrapers	local+exogenous	Horse, Reindeer, Marmot, Bison
Buda-Dealul Viei	EC	1	endscrapers, burins, retouched blades, bladelets	exogenous	Reindeer
Buki 4 (Pieny 1)	PL	2	points, blades, burins, endscrapers	/	Mammoth
Ciuntu	EC	2	retouched blades	local	Horse, Reindeer, Marmot, Bison
Climauti II/upper	EC	2	endscrapers, burins, retouched blades	exogenous	Mammoth
Cosăuți/6-5	EC	3	burins, endscrapers, backed pieces	local	Reindeer, Horse
Cotu-Miculinti/V	EC	3	burins, endscrapers, points	local	Reindeer
Dorochivtsy III/6	EC	2	microliths, endscrapers, blades, bladelets	local	Reindeer, Horse, Mammoth
Dorochivtsy III/5	EC	2	burins	local	Reindeer
Dorochivtsy III/4	EC	2	endscrapers, blades, bladelets	local	Reindeer
Dorochivtsy III/3	EC	2	endscrapers, blades, bladelets	local	Reindeer
Gagarino	PL	2	backed blades, endscrapers	local+Kostienki flint	Mammoth
Galich 1/3	EC	1	endscrapers, burins	local	Mammoth
Jaksice II	EC	1	burins, backed pieces	local+exogenous	Reindeer
Khotylevo 2	PL	1	burins, backed microliths	local+exogenous	Mammoth
Kostienki 1/1	PL	2	Kostienki knives, burins	local	Mammoth, Horse, Wolf, Hare
Kostienki 3	PL	3	burins, nucleiform tools	/	Mammoth
Kostienki 4/II	PL	2	blades, backed edge points	local+exogenous	Hare, Mammoth, Reindeer, Horse
Kostienki 8/I	PL	2	points, burins, endscrapers	/	Mammoth, Hare, Wolf, Fox
Kostienki 11/II	PL	3	blades, bladelets, burins	/	Hare, Wolf, Fox
Kostienki 21/III	PL	2	endscrapers, burins, retouched blades	exogenous	Reindeer, Horse, Mammoth, Wolf, Hare
Kraków-Spadzista	EC	1	burins, backed pieces, shouldered points	local	Mammoth
Leski	SP	2	burins	/	Horse, Reindeer
Lespezi-Dealul Viei/IV	EC	3	burins, endscrapers, microgravettes	local	Reindeer
Mitoc-Malu Galben/Grav II-III-IV	EC	1	endscrapers, burins, retouched blades	local+Volhyn flint	Horse, Reindeer
Molodova V/8	EC	1	burins, endscrapers, retouched blades	local+Volhyn flint	Reindeer, Horse, then Mammoth
Molodova V/7	EC	1	burins, endscrapers, retouched blades	local	Reindeer, Horse, Mammoth
Molodova V/6	EC	3	burins, retouched blades, endscrapers	local	Reindeer, Horse, then Mammoth
Muralovka	PS	3	microliths	/	Bison
Obollonnya/exc. 2011-2013	PL	2	endscrapers, burins, bladelets, microliths	local+exogenous	Mammoth
Oselivka 1/III	EC	1	points, burins, endscrapers	/	Reindeer, Horse
Ostrovskaya	UR	1	blades, backed bladelets	local+exogenous	Reindeer
Piatra Neamt-Poiana Cireșului/Grav III-II	EC	1	endscrapers, burins, retouched bladelets	/	Reindeer
Piatra Neamt-Poiana Cireșului/Grav I	EC	2	burins, blades, retouched bladelets	/	Reindeer

Piatra Neamt-Poiana Cireşului/Epigrav I	EC	3	backed bladelets	/	Reindeer
Pushkari 1/exc. I-II-V	PL	2	retouched blades, points	local	Mammoth
Pushkari 1/exc. VII	PL	2	retouched blades, microlithes	local	Mammoth
Pushkari 8 (Pogon)/exc. I-IV	PL	2	retouched blades, points	local	Mammoth
Pushkari 8 (Pogon)/ exc. VII	PL	2	points, retouched blades, bladelets, microlithes	local	Mammoth
Radomyshl' 1	PL	3	burins, endscrapers, retouched bladelets	local	Mammoth
Raskov VIII/IV	EC	2	micropoints, burins	local	Reindeer, Horse
Raskov VIII/IIIa	EC	2	bladelets, endscrapers, burins		Reindeer, Horse
Raskov VIII/III	EC	2	bladelets, endscrapers, burins		Reindeer, Horse
Raskov VIII/II	EC	2	backed bladelets, micropoints, endscrapers, burins		Reindeer, Horse
Raskov VIII/I	EC	2	backed bladelets, micropoints, endscrapers, burins		Reindeer, Horse
Valea Morilor	EC	2	endscraper, blades	local	Mammoth
Yami	PS	2	micropoints, backed bladelets	local	Horse, Red deer, Bison
Zaraïsk	PL	2	retouched blades, burins, microlithes	local	Mammoth

554 **4.3. Bone working and bestiary**

555 Among the 115 assemblages considered in this study, 50 (43.5%) yielded objects made on animal hard  
 556 tissues. The inventory was mainly composed of bone tools and adornments (96%), followed by  
 557 portable art (56%). Half of the sites (52%) display the presence of both bone industry/adornment and  
 558 artistic pieces.

559  
 560 Raw materials are composed mainly of bone (70.6%) and ivory (52.9%), followed by antler (27.7%)  
 561 and teeth (25.5%), and then shells (15.7%) and fossils (5.9%). Mammoth remains are the most used  
 562 raw material (52.9%), followed in order of importance by reindeer antler (29.4%), shell (17.6%), fox  
 563 (15.7%), wolf/large canid (7.8%), red deer (5.9%), hare (3.9%), fossils (3.9%) and horse (2%)  
 564 remains. It should be noticed however that a large part of the bones used are taxonomically and/or  
 565 anatomically undetermined (49%).

566  
 567  
 568 The most dominant species also provided most of the raw material, with an occurrence of 72% of the  
 569 total number of sites considered.

570 Bones were also used in different manners.  
 571 In Anetovka 2, several clusters of ochre-covered bison skulls and hemi-mandibles were located near a  
 572 human skull. In Buky 4, tusks were stored. In Climăuți II mammoth bones were sorted by types of  
 573 elements and put circularly. In Gagarino, an excavated space around mammoth and rhinoceros bones  
 574 was reported. In Khotylevo 2, mammoth ribs were put vertically in small pits.  
 575 In Kostienki 1/1, a habitat structure with mammoth tusks was found. In Kostienki 11/II a dwelling  
 576 structure made of mammoth bones was present. In Kostienki 18, a child skeleton placed on its side in a  
 577 position with knees flexed was covered with mammoth bones (notably a scapula). In Pushkari 1/  
 578 sectors II and V, a habitat structure with mammoth tusks was found in the first one and with mammoth  
 579 skulls, in the second one. In Pushkari 1/sector VII, mammoth tusks were stored and small pits  
 580 contained bone extremities of fox and wolf in anatomical connexion. In Pogon, mammoth bones were  
 581 put vertically in small pits around a hearth, that which could correspond to a wedging structure. In  
 582 Valea Morilor a small structure with mammoth bones was also mentioned.

583  
 584 Bones (e.g. mammoth ribs) were used as fire fuel in at least 26 archaeological sites.

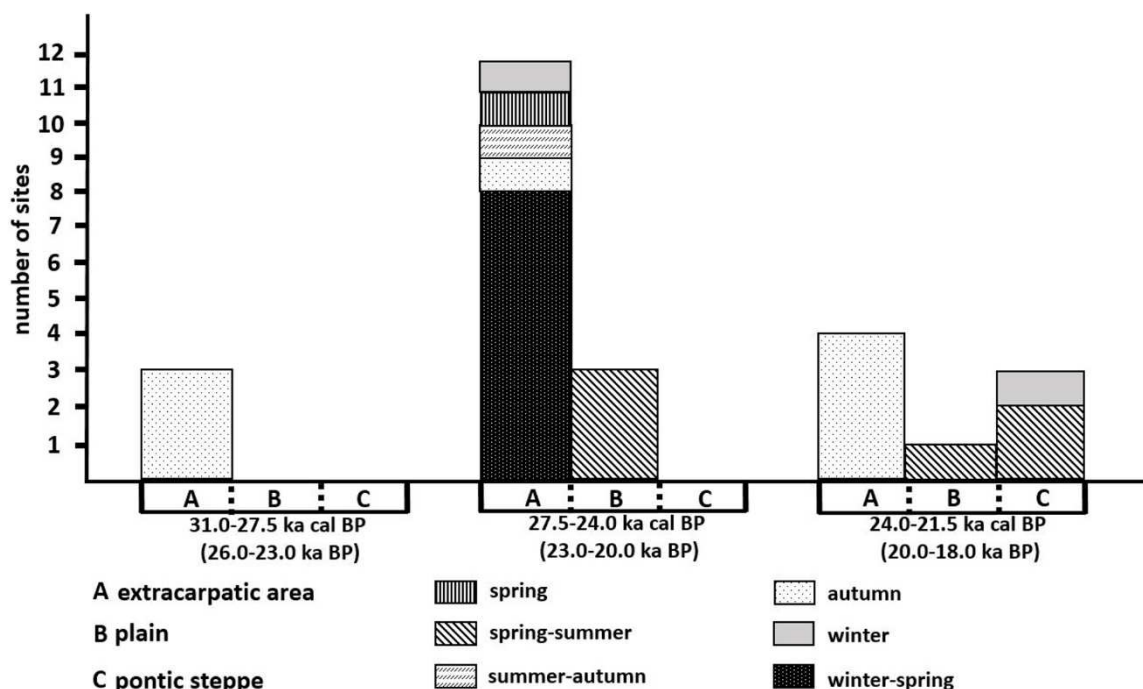
585  
 586 Eight sites mainly located in the plain yielded representations of animals. The species represented by  
 587 humans during this period are mammoth, rhinoceros, lion and bison, mainly by sculpture, then  
 588 engraving, on different osseous and mineral matters: bone, ivory, antler, sandstone, marl and schist  
 589 (Table 6).

590  
 591 Table 6. Representation of animals from the East European Plain archaeological sites, between 31.0-21.5 ka cal  
 592 BP (26.0-18.0 ka <sup>14</sup>C BP) (unid.=unidentified).

Sites	Raw material	Technic	Species
Avdeevo	sandstone	sculpture	mammoth
	bone		
Bezmyanni	ivory	sculpture	unid.
Dorochivtsy III/6	ivory	engraving	unid.
Kostienki 1/I	marl	sculpture	mammoth
			lion
Kostienki 4/II	ivory	sculpture	unid.
	antler		
Kostienki 11/II	marl	sculpture	mammoth
			rhinoceros
Kostienki 21/III	sandstone	engraving	unid.
	schist		
Zaraïsk	ivory	sculpture	bison

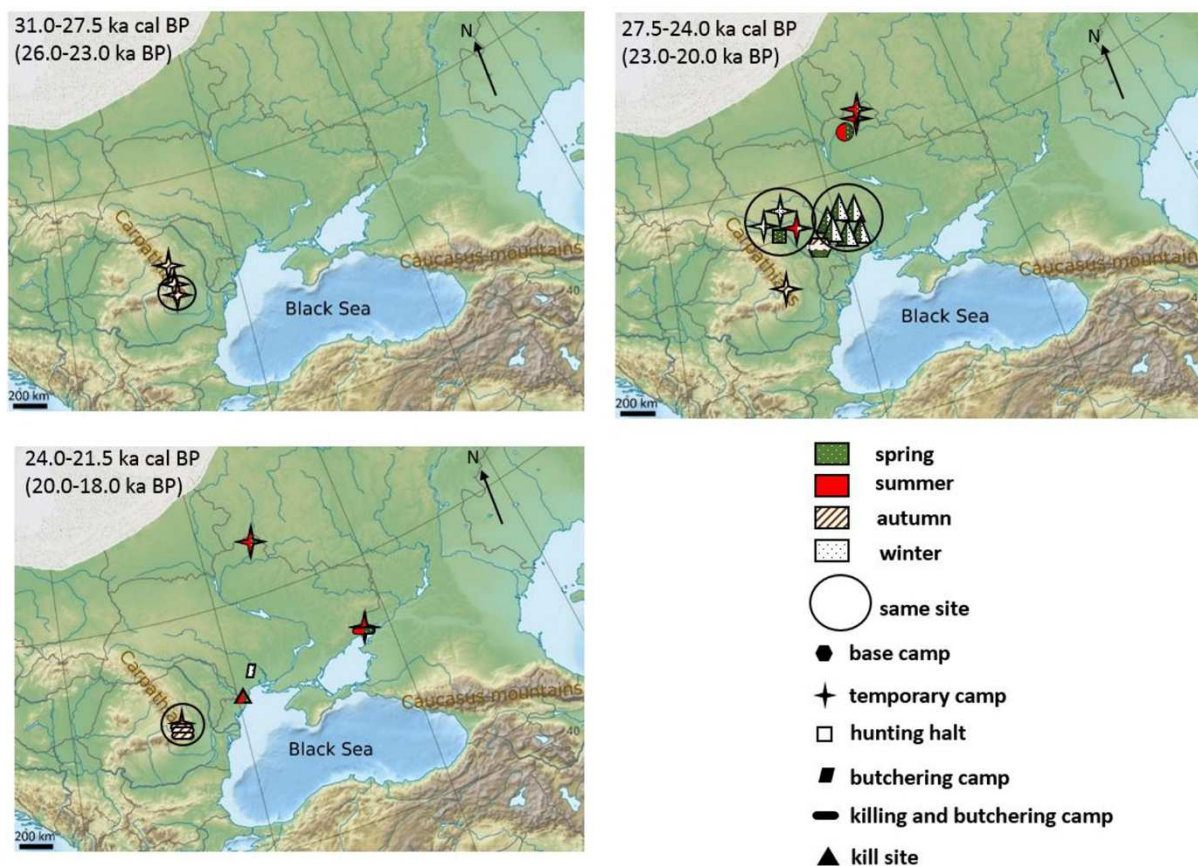
593  
 594 **4.4. Seasonality**

595 Data about seasonality are more numerous from assemblages from the Dniester valley linked to  
 596 multilayered occupations. In this region all seasons are represented, particularly the fall. In the plain,  
 597 for Pushkari 1, Pogon and Obollonnya seasonality was estimated based on calve birth estimated to  
 598 spring-summer (Rountrey et al., 2012) (Figure 16).



599 Figure 16. Seasons of occupations of the archaeological sites from the East European Plain, according to the  
 600 areas and periods, between 31.0 and 21.5 ka cal BP (26.0-18.0 ka <sup>14</sup>C BP).  
 601  
 602

603 The same preys are present in all types of occupations. Some sites as in the Desna and in the Prut  
 604 valley are occupied each time at the same season. Some others, as Dorochivtsy III are occupied during  
 605 all or circum-annually seasons (Figure 17; 18).  
 606

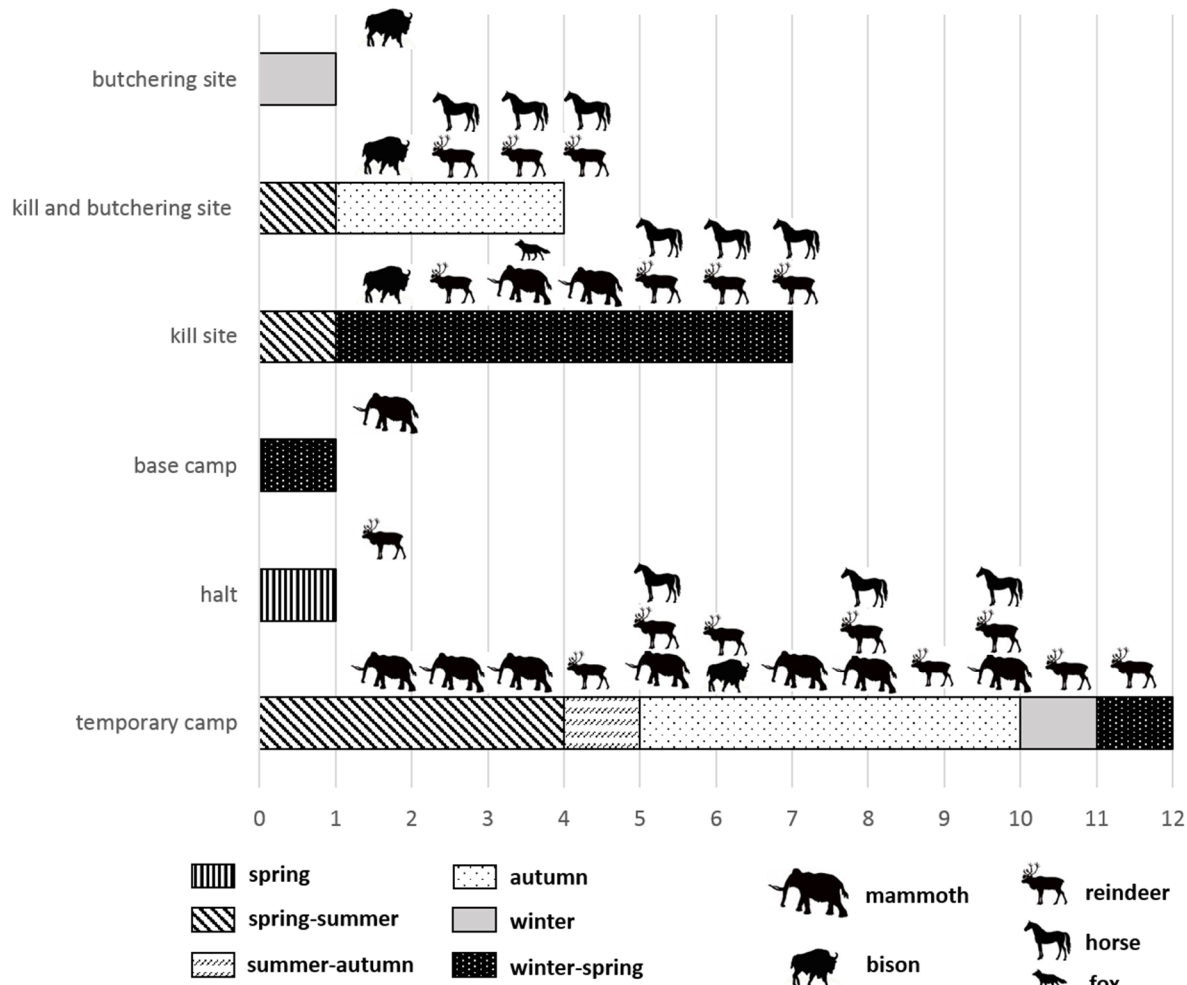


607



608  
609

Figure 17. Seasons of occupations of the archaeological sites from the East European Plain, according to the types of occupations and periods, between 31.0 and 21.5 ka cal BP (26.0-18.0 ka <sup>14</sup>C BP).



610  
611  
612  
613  
614

Figure 18. Seasons of occupations of the archaeological sites from the East European Plain, according to the types of occupations and main species, per sites, between 31.0 and 21.5 ka cal BP (26.0-18.0 ka <sup>14</sup>C BP).

## 5. Discussion

615 The number of sites varies according to the periods, which can skew the representativity of mammals  
 616 within human occupations. Similarly, it is possible that the bones of small species - mustelids,  
 617 lagomorphs and rodents - have not been systematically collected and/or identified by archaeologists.  
 618 Despite this, it is quite obvious that the different mammalian species notably contributed to the human  
 619 diet and their bones were also exploited as fuel, construction material or raw material for tool making.  
 620 It is important to take into consideration a potentially significant amount of plant part that contributed  
 621 to the diet, as many sites preserve flat pebbles that might have been used as grinders and pestles, as  
 622 well as potentially fish and birds. In addition, some large-sized species, such as mammoths, could  
 623 have been consumed without being represented in faunal remains of the human occupations. However,  
 624 several major trends can be identified with regard to the faunas present in Paleolithic sites allowing us  
 625 to highlight the exploitation of animal resources by human groups and their relation to the territory,  
 626 toolkits and some specific cultural features.

627  
628  
629

### 5.1. Technical systems

630 Human groups used local and regional raw material for their lithic industries. In relation to game  
 631 acquisition, lithic tool kits do not seem to display specific typologies in what horse and reindeer are  
 632 concerned. However, mammoth hunting sites are often associated with microliths in larger number. It  
 633 could correspond to composite tools or/and be specific to such a large game killing and/or butchering,  
 634 or only linked to human mobility reasons.

635 At the Epiaurignacian sites games are bison, horse and reindeer and tool kits particularly include  
636 micropoints, microliths and microblades, linked to regional traditions.  
637 Concerning the raw materials of animal origin, bone is mainly used to make tools and particularly as  
638 fuel for fire. Ivory and antler were widely used for tools, while teeth -especially canid tooth- and  
639 shells, for pendants. Ivory was also used for ornaments and portable art items.  
640 Mammoth bones received particular treatments, such as tusk storage, and use of bones as wedging  
641 elements or building materials for dwelling structures.

642  
643

## 5.2. Territories, human strategies and ecological patterns

644 The topographic conditions seem to have played a role in hunting strategies. Indeed mammoths were  
645 more commonly killed on promontories and reindeers on terraces/slopes. The high number of  
646 mammoths on promontories could be explained by the fact that at the end of the winter season,  
647 mammoths were stressed from lack of food and came to find the necessary nutriment (specific  
648 vegetation, mineral salts). Moreover, due to their morphology, it is quite difficult for elephantids to  
649 quickly down slopes, which represented a major advantage for hunters. Concerning reindeers it is  
650 quite difficult to approach them on flat land because of their acute senses of smell and hearing.

651 The main species selected by humans seem to vary independently of the type of human occupations.  
652 Some species acquisitions are totally linked to the expected ecological niche, like ibex. Furthermore,  
653 horse and reindeer are common in the Extracarpatic area occupations and in the Ural. Bison is more  
654 present in the South and mammoth is more present in the North. The Extracarpatic area were  
655 characterized by the partial presence of coniferous forest which could, on the one hand be an  
656 environment not conducive for mammoth and, on the other hand could have been richest in food such  
657 as berries and nuts for humans. In this case human behavior could have been therefore more dependant  
658 on the ecological system. In other cases, in the plain, both mammoth and reindeer or the trio  
659 mammoth-reindeer-bison was reported, although hunted reindeers were few in the steppe. Moreover, a  
660 specialisation of mammoth and bison hunting was noted at some sites.

661 The killing selection strategies are very different from site to site. Different strategies were used by  
662 humans for procuring large mammals within each species and between species. However, more data  
663 about skeletal preservation will be necessary in order to identify possible local hunting traditions.  
664 Concerning the butchering strategies, whole carcasses are present on the site, particularly mammoths  
665 for which the killing site is also the camp site, such as Pushkari 1. For some sites, killing sites of bison  
666 are near the camps. For reindeers, we often see the transport of specific quarters in the camps with a  
667 more important independancy of humans from the kill site. These observations are logically linked to  
668 the differences of weight between mammals. They also show that some species specificities,  
669 particularly bisons and mammoth, patterned the human behaviour. Foxes, wolves, and hares were  
670 more present in the Northern sites. They could be linked to the drier and more open environment  
671 which required more thermal protections for humans than in the southern and forested areas and  
672 consequently with the use of furs with high isothermal capacities from these three types of species.

673 In the Extracarpatic area some sites are seasonally occupied as hunting campements in connection  
674 with migration cycles, particularly in autumn which could be linked to meat storage before winter  
675 especially because in autumn, reindeers acquired their maximum weight and fat reserves. Some sites,  
676 such as Dorochivtsy III were occupied during all the seasons, probably because it acted as a relay in  
677 the area. In the plain, there are camp bases and more specialized sites, notably for mammoth hunting.

678 This also shows different mobility strategies of humans. In the Extracarpatic area, it seems that small  
679 groups moved to perform punctual tasks, whereas in the plain it corresponds to the displacement of  
680 larger human groups for specialized activities. Only Kraków-Spadzista and Climăuți II sites in the  
681 Extracarpatic area indicate very different human behaviors compared to the other regions.

682  
683

## 5.3. Cultural aspects

684 Through human behaviors we also understand cultural specificities, especially the way to deal  
685 symbolically with the world. Indeed the mammoth hunting specialized sites could correspond to  
686 particular needs, but also to cultural traditions oriented toward this species. Moreover, mammoth ivory  
687 seems to have been both a practical and a symbolical material. Whereas reindeer and horse are rarely  
688 if at all represented *via* sculptures or engravings, and no particular disposition nor use of their bones  
689 was recorded, it is the case for bison and mammoth. Some other species also enjoyed a special, likely

690 symbolic consideration. Highly dangerous species, like rhinoceros and large felids, provide such  
691 examples.

692

#### 693 **5.4. Human evolution of behaviors**

694 During all the considered period (between 31.0-21.5 ka cal BP and 26.0-18.0 ka <sup>14</sup>C BP) the main  
695 species present in archaeological sites are mammoth, reindeer, horse, bison, hare, fox and wolf. Data  
696 collected at all sites indicate a continuous occupation of territories, across all seasons, with the  
697 persistence of organized activities, innovations and various behaviors until around 23.0 ka cal BP  
698 (19.0 ka <sup>14</sup>C BP). The environmental conditions of the LGM do not seem to have had any influence on  
699 the games selected by human groups, which remain mobile throughout the territory. However, changes  
700 in the lithic industries were recorded between the middle Gravettian, late Gravettian and Epigravettian  
701 assemblages during the LGM. At the end of the LGM peak, between 23.0 and 19.2 ka cal BP (19.0-  
702 16.0 ka <sup>14</sup>C BP), human populations apparently disappeared from the EEP, particularly from the  
703 northern area. This absence may be related to a differential site preservation, or, more likely to an  
704 ecological system forbidding full human resilience in the area.

705

#### 706 **6. Conclusions and perspectives**

707 The late Pleniglacial was an important period for the ecological systems of the human populations  
708 who had to adapt to major ecological changes. Recent archaeological and particularly  
709 zooarchaeological investigations allow for substantial fresh insights regarding both ecological and  
710 technocultural systems of humans through their relation to other species. Generally, the main species  
711 present in East European Palaeolithic occupations during the late Pleniglacial are reindeer, horse,  
712 mammoth and bison, then canids, lagomorphs and rodents. They were a source of food and fur.  
713 Mammoth ivory and reindeer antler were also used as tools, ornaments and for artistic purposes.  
714 Whereas bones of cave lions and woolly rhinoceros are generally absent in archaeological sites, these  
715 species were represented in mobile art. Bison and mammoth were also represented, which is not the  
716 case for horse and reindeer. This peculiarity seems to highlight different considerations of subsistence  
717 and symbolism according to the species. Although there is a decrease in ungulate populations in  
718 archaeological sites between 27.5-24.0 ka cal BP (23.0-20.0 ka <sup>14</sup>C BP), the same species are exploited  
719 on a continuous basis. Even if we often found the trio mammoth-reindeer-horse, there are differences  
720 between the faunas of the Dniester valley -reindeer, horse- and those of the Dnieper and Don valleys -  
721 mammoth. We also observed different strategies of mobility to develop between the extracarpatic area,  
722 where small human groups performed punctual tasks and the plain, which corresponds to the  
723 displacement of larger human groups engaged in specialized activities. We observed the continuous  
724 occupation of the territories, at different seasons, with the persistence of organized activities,  
725 innovations and various behaviors. While there is a broad connection between the spread of major  
726 industries, middle Gravettian, late Gravettian and Epigravettian assemblages and the climatic events  
727 around the Last Glacial Maximum, some cultural features such as mammoth hunting proved more  
728 persistent. The end of Last Glacial Maximum brought a certain demographic decline between 23.0 and  
729 19.2 ka cal BP (19.0-16.0 ka <sup>14</sup>C BP), particularly in the plain. It is therefore imperative to ask why the  
730 different adaptative systems in the East European Plain failed on the long run. To better understand  
731 this transition in the socio-ecological systems of the nomadic populations, these systems should be  
732 better analyzed regionally and compared with those of the Epigravettian groups from the second part  
733 of Upper Pleniglacial after 19.2 ka cal BP (16.0 ka <sup>14</sup>C BP).

734

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741

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1503 Annex 1. Datings of the main archaeological sites of the East European Plain between 31.0-21.5 ka cal BP (26.0-  
1504 18.0 ka <sup>14</sup>C BP) (references in Table 3).

Site	Details	Method	Dating (BP)	Reference	Dating (cal BP)	Material
Amvrosievka		14C	18,240±200	Ki-9706	22,496-21,602	bone
		AMS	18,700±240	OxA-4890	23,154-21,980	bone
		AMS	18,860±220	OxA-4891	23,348-22,336	bone
		AMS	18,220±200	OxA-4894	22,481-21,582	bone
		AMS	18,700±220	OxA4892	23,110-22,039	bone
		AMS	18,620±220	OxA-4893	23,000-21,954	bone
		AMS	18,660±220	OxA-4895	23,050-21,989	bone
		14C	15,900±200	Ki-10307	19,676-18,762	bone
		14C	18,040±200	Ki-9704	22,375-21,350	bone
		14C	18,350±200	Ki-9705	22,630-21,731	bone
		14C	17,800±200	Ki-9709	22,085-20,968	bone
		14C	15,250±150	LE-1637	18,819-18,139	bison bone
		14C	20,620±150	LE-1805	25,277-24,399	bison bone
		14C	21,500±340	LE-3403	26,553-25,085	bone
Anetovka II		14C	18,040±150	LE-2424	22,293-21,461	bison bone
		14C	24,600±150	LE-2624	28,976-28,285	mammoth checktooth
		14C	19,710±120	LE-2947	24,060-23,415	bison bone
		14C	18,265±1,650	LE-4066	26,882-18,762	burned bone
		14C	19,090±980	LE-4610	25,643-20,944	burned bone
Avdeevo		14C	11,950±310	IGAN-151	14,996-13,211	mammoth bone
		14C	13,900±200	IGAN-78	17,441-16,270	mammoth bone
		14C	16,950±420	QC-621	21,637-19,500	mammoth bone
		14C	16,565±270	QC-886	20,670-19,330	mammoth bone
		14C	18,500±2100	QC-887	29,318-18,078	bone
		14C	17,200±1,800	GIN-1571b	26,518-17,146	burned bone
		14C	22,700±700	GIN-1571a	28,337-25,728	burned bone
		14C	23,400±700	GIN-7729	29,036-26,191	mammoth bone
		14C	19,500±500	GIN-7727	24,807-22,419	mammoth bone
		14C	22,400±500	GIN-1969	27,604-25,829	burned bone
		14C	22,200±700	GIN-1970	27,844-25,190	burned bone
		14C	21,600±400	GIN-4693	26,922-25,091	burned bone
		14C	21,200±200	GIN-1569	25,914-25,109	burned bone
		14C	19,800±1,200	GIN-1570(a)	27,032-21,451	burned bone
		14C	20,100±500	GIN-1746	25,494-23,076	burned bone
		14C	20,800±200	GIN-1747	25,571-24,490	burned bone
		14C	21,000±200	GIN-1748	25,781-24,724	burned bone
		14C	21,000±800	GIN-2535	26,505-25,703	burned bone
		14C	20,100±300	GIN-6592	25,072-23,499	burned bone
		14C	20,100±200	GIN-6593	24,750-23,654	burned bone
	14C	20,100±400	GIN-6594	25,304-23,279	burned bone	
Babin I		no dating				
Berdyzh		AMS	15,100±250	OxA-716	18,874-17,801	mammoth bone
		14C	22,500±200	GIN-2695	27,292-26,285	bone
	14C	24,430±180	LU-104	28,840-28,021	mammoth bone	
Bezmyannyi		14C	22,500±200	GIN-2695	27,292-26,285	mammoth bone
		14C	19,240±265	SOAN-2212	23,821-22,546	bone
Bistricioara-Lutărie 1		14C	19,055±925	Gx-8730	25,485-21,005	charcoal
		AMS	21,541±155	Erl-11854	26,095-25,554	/
		AMS	24,396±192	Erl-11855	28,822-27,971	charcoal
		AMS	22,181±112	Erl-12164	26,755-26,070	/
		AMS	24,370±300	Erl-9967	29,009-27,800	charcoal
		AMS	24,213±299	Erl-9968	28,829-27,729	charcoal
		AMS	28,068±452	Erl-9969	33,203-31,161	charcoal
		AMS	26,869±447	Erl-9970	31,701-30,030	charcoal
		14C	16,150±350	GrN-10528	20,364-18,754	charcoal
Bistricioara-Lutărie 2		14C	18,330±300	GrN-12670	22,885-21,455	/
		14C	20,300±1,300	Gx-8726	27,649-21,851	charcoal
		14C	23,450±2,000	Gx-8727G	33,966-23,975	bone
		14C	20,310±150	Gx-87GrN-16982	24,942-24,022	/
		14C	18,800±1,200	Gx-8728	25,900-20,140	charcoal
		14C	20,995±875	Gx-8729	27,289-23,450	charcoal
		14C	23,560±1,150	Gx-8845G	30,580-25,870	burned bone
		14C	24,100±1,300	GrN-10529b	31,211-26,011	charcoal
		14C	24,760±170	GrN-11586b	29,236-28,420	bone
		14C	27,350±1,300	GrN-10529	34,582-29,041	/
Bistricioara-Lutărie 3		AMS	19,749±149	Erl-12851	24,159-23,398	charcoal
		OSL	19,700±2,100	BL3-1,4		sediments
		OSL	26,500±2,600	BL3-1,4		sediments
		OSL	20,200±2,400	BL3-1,3		sediments
		AMS	21,950±90	DeA-3685-1,1	26,421-25,940	charcoal
		OSL	29,300±2,900	BL3-1,3		sediments
		AMS	24,153±112	DeA-3688-1,1	28,516-27,875	charcoal
		OSL	18,000±2,800	BT1286		sediments
		OSL	18,100±2,900	BT1285b		sediments
		OSL	19,000±3,000	BT1285		sediments
		OSL	20,500±2,900	BT1285a		sediments
		OSL	21,100±3,800	BT1287		sediments
		OSL	22,600±3,000	BT1286		sediments
		OSL	23,000±3,100	BT1287		sediments
		OSL	24,300±3,000	BT1285b		sediments
	OSL	25,900±3,400	BT125a		sediments	

		OSL	26,000±3,500	BT1285b		sediments
Bolshaya Akkarzha	III	14C	19,200±200	Ki-11307	23,632-22,608	bison bone
		14C	19,055±200	Ki-11340	23,466-22,495	bison bone
		14C	18,760±210	Ki-11306	23,190-22,190	bison bone
Borshevo 5		14C	14,060±110	LE-6809	17,457-16,707	horse bone
		14C	17,400±2,000	LE-5571	27,673-16,975	mammoth bone
		14C	20,000±300	LE-6947	24,967-23,370	mammoth cheektooth
		14C	22,500±700	GIN-10239	28,130-25,522	mammoth bone
Brynzeni	III	AMS	23,400±220	OxA-7001	27,923-27,263	bone
		AMS	19,780±260	OxA-4899	24,485-23,140	horse bone
		AMS	20,140±260	OxA-4898	25,013-23,615	horse mandible
		AMS	26,200±360	OxA-4124	31,030-29,597	horse bone
		AMS	26,600±370	OxA-4122	31,292-29,964	reindeer bone
		AMS	22,330±230	OxA-4121	27,179-26,085	horse bone
		AMS	14,700±130	OxA-4120	18,232-17,565	horse bone
		AMS	22,530±250	OxA-4119	27,366-26,230	horse bone
		AMS	19,220±180	OxA-4118	23,624-22,676	reindeer bone
		AMS	20,300±160	OxA-6999	24,955-23,995	horse bone
		AMS	16,600±160	OxA-4123	20,445-19,616	bone
AMS	21,680±270	Lv-2186	26,568-25,446	bone		
Buda-Ofalul Viei		14C	23,810±190	GrN-23072	28,330-27,580	bone
Buki 4	Pieny 1	14C	23,100±280	Le-1434b	27,815-26,776	bone
		14C	25,200±350	LE-1434v	30,285-28,570	bone
		14C	21,600±350	LE-1434a	26,702-25,169	bone
Ciuntu		AMS	18,510±200	OxA-4125	22,838-21,891	bone
		AMS	21,000±220	OxA-4426	25,794-24,660	horse bone
		AMS	22,100±220	OxA-4774	26,965-25,920	bone
Climăuți II	II(lower)	14C	24,840±410	LU-2480	29,920-27,974	/
	I(upper)	14C	20,350±230	LU-2481	25,175-23,949	bone
Corpaci-Más		AMS	24,020±220	OxA-7000	28,557-27,704	bone
Corpaci	4	14C	25,250±300	GrN-9758	30,205-28,684	charcoal
Cosăuți	10	AMS	18,980±200	OxA-5254	23,395-22,449	bone
	9	14C	19,410±100	GrN-21795	23,668-23,038	charcoal
		AMS	19,080±220	OxA-5253	23,529-22,487	bone
		AMS	19,060±200	OxA-5252	23,472-22,497	bone
		AMS	19,060±220	OxA-5251	23,472-22,497	bone
	8	AMS	19,070±100	GrA-7567	23,338-22,640	charcoal
	7	AMS	19,440±100	GrA-6746	23,710-23,063	charcoal
		AMS	18,980±220	OxA-5250	23,435-22,430	bone
	6d	AMS	19,120±100	GrA-7555	23,404-22,729	charcoal
	6c	14C	18,935±160	AA-1864	23,242-22,444	charcoal
		AMS	18,860±200	OxA-5255	23,276-22,360	bone
	6b	14C	19,200±130	GrN-21361	23,517-22,785	charcoal
		AMS	18,940±220	OxA-5249	23,404-22,404	bone
		AMS	18,560±200	OxA-5256	22,896-21,936	bone
	6a	14C	18,780±200	OxA-5248	23,177-22,256	bone
		AMS	18,780±165	AA-1862	23,052-22,346	charcoal
		AMS	18,260±210	GrA-5218	22,531-21,592	charcoal
	5	AMS	18,140±200	OxA-5247	22,431-21,489	bone
		AMS	18,060±180	OxA-5238	22,358-21,427	bone
		14C	17,030±180	GIN-4152	21,011-20,076	charcoal
Cotu Miculinti	VII	14C	20,140±410	GrN-12662	25,371-23,320	charcoal
	V	14C	18,810±300	GrN-12661	23,466-22,036	charcoal and ashes
Crasnaleuna-Staniște	IV	14C	19,460±220	Bln-1443	23,990-22,905	bone
	VII	14C	21,700±800	GrN-12671	27,640-24,340	charcoal
Dorochivtsy III	6	14C	22,300±100	GrA-44217	26,698-26,204	charcoal
	4	14C	20,976±76	COL-1114.1.1	25,560-25,098	charcoal
	3	14C	20,700±90	GrA-44705	25,264-24,558	charcoal
		14C	20,504±83	COL-1115. 1.1	25,034-24,365	charcoal
Gagarino		14C	21,800±300	GIN-1872	26,840-25,520	burned bone
		14C	21,600±140	GIN-7989	26,114-25,630	mammoth ivory
		14C	19,160±130	GIN-7990	23,482-22,722	mammoth ivory
		14C	17,900±120	GIN-7991	22,016-21,317	mammoth ivory
		14C	30,000±1,900	IGAN-83	40,042-30,950	mammoth bone
		14C	17,930±100	LE-1432a	21,997-21,410	mammoth bone
		14C	20,150±300	LE-1432b	25,125-23,560	mammoth bone
		14C	20,820±300	LE-1432v	25,750-24,343	mammoth bone
Galich I	3	14C	25,100±450	Ki-8928	30,434-28,285	charcoal
	3	14C	24,900±450	Ki-8929	30,175-28,019	charcoal
	2	14C	24,600±450	Ki-8930	29,666-27,770	charcoal
	2	14C	24,200±600	Ki-8931	29,676-27,345	bone
	1	14C	23,500±600	Ki-8932	28,915-26,510	bone
Giurgiu-Malu Roșu	Ia	AMS	21,140±120	GrA-5094	25,755-25,196	charcoal
		AMS	22,790±130	GrA-6037	27,443-26,726	charcoal
		OSL	27,000±3,000	/		loess
Jaksice II		AMS	21,190±140	Poz-48868	25,820-25,215	reindeer radius
		AMS	23,460±150	Poz-42517	27,855-27,399	mammoth cheektooth
		AMS	23,640±180	Poz-48869	27,896-27,362	reindeer scapula
		AMS	24,140±180	Poz-51589	28,592-27,807	mammoth burned bone
		14C	15,100±700	GIN-3772	20,132-16,615	burned bone
		AMS	15,120±110	GrA-21619	18,641-18,067	bone
		14C	15,350±550	GIN-3472	20,025-17,417	burned bone
		AMS	15,360±80	GrA-21708	18,804-18,442	bone
		14C	15,400±1,200	GIN-2940	22,255-15,943	burned bone
AMS	15,590±80	GRA-17957	19,011-18,667	/		

		AMS	15,610±80	GRA-18349	19,037-18,686	/
		AMS	15,760±100	GrA-21711	19,285-18,787	bone
		AMS	15,900±90	GRA-21479	19,456-18,935	/
Khotylevo 2		AMS	23,050±150	OxA-27223	27,632-27,082	wolf bone
		AMS	23,160±160	OxA-27224	27,707-27,166	bird bone
		AMS	23,240±160	OxA-27001	27,751-27,237	mammoth bone
		AMS	22,900±150	OxA-27002	27,754-26,866	mammoth bone
		AMS	23,020±210	OxA-X-2500-11	27,708-26,891	reindeer bone
		AMS	22,720±150	OxA-27225	27,399-26,611	bone
		14C	23,660±270	LU-359	28,353-27,386	mammoth cheektooth
		AMS	23,470±170	OxA-27000	27,888-27,380	bone
		14C	21,170±260	GIN-8497	26,007-24,854	mammoth cheektooth
		14C	23,300±300	GIN-8497a	28,041-27,008	mammoth cheektooth
		14C	22,660±120	GIN-8496	27,323-26,598	mammoth cheektooth
		14C	21,720±170	GIN-8495	26,333-25,673	mammoth cheektooth
		14C	22,700±200	GIN-8406	27,436-26,516	mammoth cheektooth
		14C	21,850±170	GIN-8886	26,486-25,791	burned bone
		14C	24,220±110	GrN-21899	28,581-27,937	bone
		14C	23,870±160	GrN-22216	28,320-27,650	bone
		14C	24,960±400	IGAN-73	30,140-28,180	mammoth bone
Kirillovskaya		AMS	19,200±250	OxA-718	23,735-22,526	mammoth cheektooth
Korman IV	7	14C	24,500±500	GIN-1099	29,703-27,666	charcoal
		14C	25,140±350	LU-586	30,221-28,508	charcoal
	5	14C	18,000±400	GIN-719	22,699-20,765	charcoal
Korman 9	I	14C	18,560±2,000	SOAN-145	28,723-18,375	charcoal
		14C	17,950±80	GrA-59996	21,977-21,481	charcoal
Kostienki 1/I		AMS	20,315±200	AA-4800	25,072-23,953	burned bone
		AMS	20,855±260	AA-4799	25,717-24,446	burned bone
		AMS	23,600±440	GrA-5244	28,675-27,089	charcoal ( <i>Picea</i> sp.)
		AMS	24,030±440	GrA-5243	29,002-27,436	charcoal ( <i>Picea</i> sp.)
		AMS	17,200±210	OxA-6436	21,362-20,215	charcoal ( <i>Picea</i> sp.)
		AMS	24,030±440	GrA-5143	29,002-27,436	charcoal
		14C	22,300±230	GIN-1870	27,155-26,061	burned bone
		14C	23,500±200	GIN-2527	27,971-27,356	burned bone
		14C	23,000±500	GIN-2528	28,121-26,169	burned bone
		14C	24,100±500	GIN-2529	29,267-27,422	burned bone
		14C	22,800±200	GIN-2530	27,505-26,600	burned bone
		14C	22,300±200	GIN-2533	27,114-26,095	burned bone
		14C	21,300±400	GIN-2534	26,409-24,560	burned bone
		14C	22,800±300	GIN-3632	27,638-26,426	burned bone
		14C	22,600±300	GIN-3633	27,469-26,210	burned bone
		14C	22,200±300	GIN-3634	27,184-25,916	burned bone
		14C	21,150±200	GIN-4231	25,888-25,042	burned bone
		14C	20,800±300	GIN-4851	25,735-24,321	burned bone
		14C	22,200±500	GIN-4903	27,491-25,650	burned bone
		14C	22,600±300	GIN-6249	27,469-26,210	mammoth cheektooth
		14C	21,950±250	GIN-8041	26,871-25,755	mammoth cheektooth
		14C	22,330±150	GrN-17118	27,074-26,178	charcoal
		14C	21,180±100	GrN-17119	25,762-25,254	burned bone
		14C	20,950±100	GrN-17120	25,581-25,015	burned bone
		14C	22,760±250	LE-2800	27,542-26,479	mammoth cheektooth
		14C	21,800±200	LE-2801	26,505-25,703	
		14C	19,860±200	LE-2949	24,389-23,425	mammoth bone
		14C	19,010±120	LE-2950	23,267-22,535	mammoth cheektooth
		14C	23,770±200	LE-2951	28,310-27,536	mammoth cheektooth
		14C	22,700±250	LE-2969	27,501-26,418	mammoth cheektooth
		14C	23,010±300	LE-3276	27,765-26,621	mammoth cheektooth
		14C	20,100±680	LE-3277	25,829-22,759	burned bone
		14C	21,680±700	LE-3279	27,455-24,500	mammoth cheektooth
		14C	18,230±620	LE-3280	23,592-20,582	burned bone
		14C	19,620±460	LE-3281	24,831-22,554	burned bone
		14C	22,020±310	LE-3282	27,081-25,762	mammoth cheektooth
		14C	23,640±320	LE-3283	28,446-27,320	mammoth cheektooth
		14C	23,490±420	LE-3286	28,578-26,999	burned bone
		14C	23,260±420	LE-3287	28,292-26,604	mammoth cheektooth
		14C	23,260±680	LE-3289	28,809-26,124	mammoth cheektooth
	14C	22,060±500	LE-3290	27,424-25,504	bone	
	14C	19,540±580	LE-3292	25,121-22,375	burned bone	
	14C	18,400±3,300	LE-4351	43,165-15,759	mammoth cheektooth	
	14C	24,570±3,950	LE-4352	47,575-23,344	mammoth cheektooth	
Kostienki 3		14C	19,800±210	GIN-8022	24,358-23,323	mammoth bone
Kostienki 4	I	AMS	20,290±150	OxA-8310	24,915-24,000	bone
		14C	23,000±300	GIN-7994	27,757-26,614	charcoal
		14C	22,800±120	GIN-7995	27,447-26,773	mammoth rib
Kostienki 5	II	14C	20,600±140	GIN-7996	25,243-24,397	mammoth rib
		14C	20,900±100	GIN-8029	25,553-24,918	mammoth bone
		14C	22,920±140	GIN-8571	27,554-26,951	horse bone
Kostienki 8/I		14C	22,900±120	GIN-7997	27,510-26,980	mammoth cheektooth
	14C	22,000±160	GIN-7998	26,618-25,904	mammoth rib	
Kostienki 11/II		14C	21,880±200	GIN-2531	26,590-25,770	burned bone
	14C	15,200±300	TA-34	19,116-17,776	bone	
Kostienki 11/Ia		14C	19,900±350	GIN-2532	24,936-23,095	burned bone
		14C	18,700±80	GIN-8079	22,796-22,383	mammoth bone
		14C	12,000±100	LE-1403	14,096-13,587	mammoth bone
		14C	14,610±120	LE-1637	18,078-17,485	mammoth bone
		14C	16,040±120	LE-1704a	19,652-19,008	bone

Kostienki 18	sepulture	14C	17,310±280	LE-1704b	21,696-20,212	bone	
		AMS	21,020±180	OxA-7128	25,790-24,865	human vertebra	
		AMS	19,830±120	GrA-9304	24,186-23,541	bone	
		14C	17,900±300	GIN-8028	22,395-20,919	mammoth bone	
		14C	20,600±140	GIN-8032	25,243-24,397	mammoth bone	
	upper 4a	14C	19,300±200	GIN-8576	23,780-22,740	mammoth bone	
		14C	9,610±190	LE-936	11,405-10,376 (93.5%)	bone	
Kostienki 19		AMS	20,000±350	GIN-77	25,092-23,249	humiferous loam	
		14C	9,840±370	Gd-719	12,495-10,374 (94.0%)	charcoal	
		14C	11,800±500	GIN-107	15,316-12,723	bone	
		14C	18,700±600	GIN-8577	24,104-21,194	mammoth bone	
		14C	17,420±150	LE-1705a	21,486-20,625	bone	
Kostienki 21	II	14C	18,900±300	LE-1705b	23,579-22,189	bone	
		14C	19,100±150	LE-1437a	23,443-22,598	bone	
		14C	20,250±100	LE-1437b	24,600-24,015	bone	
		14C	22,900±150	LE-1437c	27,554-26,866	bone	
		14C	19,050±130	LE-1437d	23,356-22,571	bone	
		III	AMS	22,270±150	GrN-7363	27,017-26,122	charcoal
	AMS		22,860±320	GrN-24968	27,700-26,449	charcoal	
	AMS		21,260±340	GrN-10513	26,184-24,643	charcoal	
	AMS		16,960±300	LE-1043	21,291-19,727	charcoal	
	Kozarnika	0I	14C	22,230±100	GrA-14669	26,828-26,122	charcoal
14C			11,490±120	Gif-10991/GifA98346	13,551-13,106	/	
I		14C	11,550±100	Gif-10991/GifA98345	13,573-13,177	/	
		14C	7,840±70	Gif-A97285	8,610-8,454 (81.8%)	/	
III		14C	19,780±270	Gif-10674	24,447-23,117	/	
III/IVa		14C	18,890±270	Gif-10673	23,500-22,265	/	
IVa		14C	26,010±270	Gif-A97286	30,836-29,571	/	
IVb		14C	26,120±100	Gif-10677	30,793-30,029	/	
V		14C	25,650±730	Gif-10994	31,147-28,427	/	
Krakow Spadzista B		Level 6/Layer 3	AMS	23,020±180	Poz-242	27,665-26,994	mammoth bone
	AMS		23,750±140	Poz-1248	28,121-27,583	mammoth bone	
	AMS		23,770±160	Poz-1251	28,205-27,576	mammoth bone	
	AMS		23,980±280	Poz-225	28,629-27,625	mammoth bone	
	AMS		24,000±300	Poz-268	28,675-27,616	mammoth bone	
	AMS		23,750±150	LuS-7417	28,151-27,572	mammoth bone	
	14C		23,040±170	GrN-6636	27,655-27,040	mammoth bone	
	14C		20,600±1050	Ly-631	27,262-22,646	mammoth bone	
	14C		23,770±1540	LE-4456	31,977-25,244	mammoth cheektooth	
	14C		19,200±200	LE-2946	23,632-22,608	mammoth cheektooth	
Leski		14C	18,020±350	Bln-808	22,580-20,900	charcoal	
		14C	18,110±300	Bln-806	22,570-21,121	charcoal	
		14C	17,620±320	Bln-805	22,170-20,530	charcoal	
Mitoc Malul Galben	6a	AMS	19,100±120	GrA-8243	23,406-22,651	bone	
		AMS	17,460±140	GrA-8399	21,515-20,687	bone	
		14C	22,050±1250	Gx-9420	29,325-23,815	charcoal	
		14C	17,300±2100	Gx-9423	28,124-16,469	charcoal	
		14C	19,000±1050	Gx-9429	25,718-20,690	bone	
		14C	20,945±850	Gx-8503	27,201-23,435	charcoal	
		6b	AMS	24,070±180	GrA-1020	28,534-27,762	charcoal
			14C	25,140±210	GrN-14036	29,691-28,707	charcoal
			14C	26,180±290	GrN-18811	30,967-29,702	charcoal
			AMS	25,540±210	GrA-13298	30,355-29,114	charcoal
	14C		26,100±800	GrN-15449	31,732-28,572	charcoal	
	14C		25,610±220	GrN-15450	30,470-29,200	charcoal	
	14C		25,610±500	GrN-20440	30,835-28,775	charcoal	
	5a	AMS	24,650±450	OxA-1780	29,736-27,794	bone	
		AMS	23,650±400	OxA-1779	28,620-27,218	bone	
		AMS	23,290±100	GrA-14671	27,724-27,344	charcoal	
		14C	27,150±750	GrN-12635	33,170-29,760	charcoal	
		14C	23,000±0	GrN-15448	27,491-27,168	bone	
		14C	23,830±330	GrN-14034	28,603-27,455	charcoal	
		14C	23,390±280	GrN-20438	28,063-27,135	charcoal	
		14C	24,620±810	GX-9422	30,652-27,504	charcoal	
		14C	23,490±280	GrN-15805	28,190-27,230	bone	
		5b	AMS	24,780±120	GrA-14670	29,130-28,514	charcoal
	14C		19,910±990	Gx-8724	26,430-21,920	charcoal	
	14C		28,700±0	GX-8725	33,111-32,540	charcoal	
	14C		21,990±0	Gx-9424	26,360-26,015	charcoal	
	14C		24,820±850	Gx-9425	30,816-27,615	charcoal	
	14C		23,990±250	GrN-20439	28,586-27,660	charcoal	
	4b	14C	27,500±0	Gx-8723	31,445-31,140	charcoal	
	4a	AMS	23,850±100	GrA-1353	28,141-27,680	charcoal	
	4b	AMS	27,500±600	OxA-1778	33,129-30,655	bone	
	4b	AMS	33,000±0	Gx-8723	37,496-36,635	charcoal	
	III	14C	23,850±330	GrN-14030	28,617-27,470	charcoal	
	3b	AMS	20,540±110	GrA-5000	25,133-24,374	charcoal	
	2a	14C	20,150±210	GrN-13765	24,894-23,720	bone	
	Molodova V	8	14C	> 24000	LU-14	>28,198-27,808	charcoal
			AMS	23,000±170	GrA-9455	27,641-26,991	charcoal
		7	AMS	25,170±210	GrA-9457	29,735-28,727	charcoal
			AMS	23,650±140	GrA-22909	28,000-27,515	charcoal
			AMS	25,130±220	GrA-9564	29,706-28,685	charcoal
			AMS	21,070±150	GrA-9443	25,755-25,063	charcoal
			AMS	23,120±330	GrA-27614	27,887-26,647	charcoal
			14C	23,000±800	MO-11	28,880-25,796	charcoal

		14C	23,700±320	GIN-10	28,492-27,368	humific soil	
	6	14C	20,320±210	GrN-23575	25,101-23,945	charcoal	
		AMS	20,470±110	GrA-22904	25,054-24,285	humific soil	
		14C	16,750±250	GIN-105	20,832-19,598	charcoal	
Muralovka		14C	18,780±300	LE-1438	23,429-21,994	bone	
		14C	19,630±200	LE-1601	24,116-23,098	bone	
Novgorod-Severskyi		14C	19,800±350	OxA 698	24,777-22,968	mammoth bone	
		14C	15,340±60	GrA-41725	18,765-18,462	<i>Dicrostonyx</i> sp. mandible	
Obollonnya	Boiling room (2010)	14C	15,200±200	SPb-442	18,850-17,987	mammoth long bone	
	Exc. 2011	14C	20,730±120	Ox-28035	25,340-24,535	mammoth bone	
Oselivka I		14C	22,600±300	GIN-4834	27,469-26,210	/	
Ostrovskaya		14C	18,700±200	GIN-1907	23,081-22,127	mammoth bone	
Piatra Neamț-Poiana Cireșului	IV (Grav III)	AMS	27,321±234	ER-11859	31,551-30,921	charcoal	
		AMS	26,677±244	ER-11860	31,204-30,487	charcoal	
		AMS	26,610±230	OxA-36915	31,158-30,440	bos/bison bone	
		AMS	26,480±230	OxA-36914	31,100-30,271	bos/bison bone	
		AMS	26,347±387	ER-9962	31,140-29,676	charcoal	
		AMS	26,250±140	OxA-36791	30,920-30,197	charcoal	
		AMS	27,185±379	ER-9963	31,890-30,645	charcoal	
		AMS	26,070±340	Beta-206707	30,943-29,519	charcoal	
		AMS	25,860±170	Beta-224157	30,620-29,570	charcoal	
		AMS	25,760±160	Beta-244073	30,491-29,476	charcoal	
		AMS	25,650±150	OxA-36792	30,340-29,380	charcoal	
		AMS	25,460±200	OxA-36768	30,232-29,033	charcoal	
		III (Grav II)	AMS	25,390±140	OxA-36790	29,895-29,030	charcoal
	AMS		25,135±150	Beta-244,072	29,556-28,801	charcoal	
	AMS		24,820±120	OxA-36789	29,187-28,553	charcoal	
	AMS		24,566±88	RoAMS-61.33	28,827-28,369	charcoal	
	AMS		24,540±120	OxA-36788	28,854-28,283	charcoal	
	AMS		24,410±127	RoAMS-60.33	28,753-28,115	charcoal	
	AMS		23,820±110	OxA-36787	28,128-27,656	charcoal	
	AMS		23,420±310	OxA-X-2762-25	28,200-27,112	bos/bison bone	
	AMS		16,850±63	RoAMS-63.33	20,529-20,100	charcoal	
	AMS		18,607±87	RoAMS-67.33	22,696-22,300	bone	
	AMS		18,819±96	RoAMS-68.33	22,941-22,450	tooth	
	II (Grav I)		AMS	19,320±80	OxA-36785	23,538-22,992	charcoal
			AMS	19,459±96	ER-12.162	23,730-23,085	charcoal
		AMS	19,440±130	OxA-X-2762-24	23,779-23,020	tooth	
		AMS	19,555±80	OxA-36786	23,856-23,265	charcoal	
		AMS	19,571±67	RoAMS-65.33	23,850-23,320	charcoal	
		AMS	19,615±105	RoAMS-64.33	23,960-23,319	charcoal	
		AMS	19,640±87	RoAMS-69.33	23,948-23,390	tooth	
		AMS	19,710±64	RoAMS-62.33	23,981-23,506	charcoal	
		AMS	19,790±180	OxA-X-2762-23	24,277-23,385	reindeer tooth	
		AMS	19,836±83	RoAMS-66.33	24,125-23,610	charcoal	
		AMS	19,881±91	RoAMS-71.33	24,195-23,645	tooth	
		AMS	20,020±110	Beta-224.156	24,380-23,790	charcoal	
		AMS	20,050±110	Beta-244071	24,408-23,828	charcoal	
		AMS	20,053±88	ER-9.964	24,370-23,869	charcoal	
		AMS	20,076±185	ER-9.965	24,601-23,648	charcoal	
		AMS	20,154±97	ER-12.163	24,484-23,959	charcoal	
		I (Epigrav I)		no dating			
	Pushkari I	Exc. II	14C	16,775±605	QC-899	21,861-18,911	burned bone
		Exc. V	14C	19,010±220	AA-1389	23,463-22,446	burned bone
			14C	20,500±500	GIN-11311b	25,825-23,604	bone
			14C	20,900±900	GIN-11311a	27,260-23,275	bone
			14C	20,600±1200	GIN-8529	27,613-22,410	mammoth bone
			14C	20,700±500	GIN8529a	25,978-23,820	mammoth bone
			14C	21,000±400	GIN-3382	26,041-24,315	bone
			14C	21,100±400	GIN-3381	26,135-24,388	burned bone
		Exc. VII	14C	22,350±150	GIN-11307	27,092-26,199	burned bone
			14C	19,500±240	Ki-11901	24,068-22,906	horse bone
			14C	20,160±180	GIN-11310	24,808-23,791	burned bone
			14C	20,350±180	GIN-10195	25,065-24,023	burned bone
			14C	20,500±500	GIN-11311	25,825-23,604	mammoth bone
14C			20,840±190	GIN-11309	25,592-24,538	burned bone	
Pushkari 9 (lower level, Pogon, 5 meters)		14C	20,900±600	GIN-11311a	26,470-23,788	mammoth bone	
		14C	18,690±770	LU-361	24,565-20,753	mammoth bone	
		14C	22,300±500	GIN-10193	27,547-25,745	bone	
	14C	22,500±450	GIN-10194	27,584-25,958	bone		
	14C	23,800±700	GIN-11315	29,551-26,632	bone		
Radomyshl'		14C	24,000±1,200	GIN-11312	30,927-26,133	bone	
		AMS	19,000±300	OxA-697	23,666-22,325	mammoth cheektooth	
		AMS	19,600±350	Ki-6210	24,451-22,766	burned bone	
Rașkov VIII		no dating					
Sagaidak I		14C	21,240±200	LE-1602a	25,936-25,156	mammoth cheektooth	
		14C	20,300±200	LE-1602b	25,055-23,935	mammoth cheektooth	
		14C	28,580±420	LE-4115	33,605-31,535	bone	
Temnata	TD I, 3a	14C	10,880±370	Gd-2488	13,560-11,750	charcoal	
		14C	16,600±300	Gd-2578	20,795-19,297	bone	
		14C	24,800±700	Gd-2581	30,572-27,728	bone	
		14C	10,880±370	Gd-4022	13,560-11,750	charcoal	
		14C	10,480±280	Gd-4025	12,871-11,336	charcoal	
		14C	13,600±200	Ly-3439	17,033-15,854	/	
		14C	20,100±900	Gd-4028	26,391-22,365	/	

	base 3d	14C	10,440±400	Gd-4026	13,130-11,140	charcoal
		14C	11,200±1600	Gd-4027	18,653-9487	charcoal
	TD-II: IV[=3c]	14C	25,400±1550	Gd-4229	33,746-27,082	bone
	TD II, 3c/3d	14C	22,400±900	Gd-42300	28,655-24,982	/
		TL	22,900±2100	Gd-210		burned flint
	TD II, 3d	TL	23,900±5100	Gd-214		burned flint
		TL	24,000±0			/
		14C	24,400±600	Gd-6126	29,924-27,476	bone
		14C	29,700±700	Gd-4231	35,246-32,108	/
		14C	19,940±800	Gd-4029	25,935-22,400	charcoal
		14C	21,200±900	Gd-4030	27,463-23,615	charcoal
		14C	21,200±380	Gd-2785	26,200-24,503	/
	TD-1, 3f base	TL	24,000±0	Gd-241		burned flint
	TD-1, 3f base	14C	28,900±1000	Gd-4233	34,976-31,117	bone
Valea Morilor	Sector 1	14C	20,770±90	GrA-46004	25,350-24,620	mammoth bone
	Sector 2	14C	20,570±80	GrA-52424	25,110-24,450	mammoth bone
	Sector 3	14C	20,560±80	GrA-52425	25,098-24,437	mammoth bone
Yami		14C	19,300±180	Ki-10356	23,728-22,787	bone
Zaraysk	Zaraysk 3	AMS	20,570±150	GrA-22037	25,232-24,347	charred bone
	Zaraysk 6	AMS	21,270±240	GrA-22072	26,026-25,091	charred bone
	Zaraysk 4	AMS	17,890±110	GrA-22038	21,971-21,336	charred bone
	Zaraysk 5	AMS	19,950±140	GrA-22039	24,356-23,640	charred bone
	Zaraysk 1	AMS	19,350±210	GrA-22075	23,866-22,795	charred bone
	/	14C	16,200±1,000	GIN-2487	22,419-17,537	burned bone
	upper/hearth 1	14C	16,700±1,200	GIN-3726	23,646-17,717	burned bone (hearth)
	pit 4	14C	18,300±200	GIN-3727	22,554-21,663	mammoth bone
	pit 1	14C	22,300±300	GIN-3998	27,255-25,990	mammoth cheektooth
	upper/hearth 1	14C	15,600±300	GIN-6035	19,612-18,224	burned bone (hearth)
	/	14C	15,600±300	GIN-6095	19,612-18,224	burned bone
	square N-3, pit	14C	19,200±300	GIN-8396	23,850-22,476	burned bone
	/	14C	19,100±200	GIN-8397	23,513-22,524	burned bone
	square E-4	14C	21,000±430	GIN-8484	27,014-25,033	mammoth cheektooth
	/	14C	21,600±300	GIN-8485	26,533-25,278	mammoth cheektooth
	square N-2	14C	19,900±260	GIN-8486	24,597-23,269	burned bone
	/	14C	19,000±200	GIN-8487	23,416-22,461	burned bone
	hearth 2	14C	21,400±50	GIN-8488	25,881-25,586	burned bone
	upper/hearth 1	14C	17,900±200	GIN-8865	22,238-21,111	humus
	hearth 3	14C	19,100±260	GIN-8975	23,637-22,451	burned bone
	fossil soil beneath of the cultural layer	TL	35,000±9,000	RTL-313		sediments
	upper/hearth 1	TL	20,000±5,000	RTL-310		/
		TL	19,000±4,500	RTL-308		loam
		TL	22,000±5,000	RTL-307		loam
	/	AMS	21,150±230	GrA-22083	25,942-24,937	burned bone

1505

1506 Annex 2. Number of individuals (MNI) for each species from all the archaeofaunal spectrum for three range of  
1507 time different between 31.0 and 21.5 ka cal BP (26.0-18.0 ka <sup>14</sup>C BP) (named A, B and C): adjusted residuals  
1508 (AR) of the MNI and Khi2 values comparing two contiguous range of time period; significant values are  
1509 indicated in bold (1P<0.001; 2P<0.01; 3P<0.05).

Taxa	A: 31.0-27.5 ka cal BP (26.0-23.0 ka BP)			B: 27.5-24.0 ka cal BP (23.0-20.0 ka BP)			C: 24.0-21.5 ka cal BP (20.0-18.0 ka BP)		
	MNI	AR	Khi <sup>2</sup> of contribution	MNI	AR	Khi <sup>2</sup> of contribution	MNI	AR	Khi <sup>2</sup> of contribution
<i>Mammuthus primigenius</i>	154	<b>4.99<sup>1</sup></b>	10.6	231	<b>-18.16<sup>1</sup></b>	22.41	139		
<i>Equus sp.</i>	44	<b>3.05<sup>2</sup></b>	6.1	55	<b>-6.43<sup>1</sup></b>	3.16	53		
<i>Caelodonta antiquitatis</i>	6	1.18	1	7	0.03	0.0001	21		
<i>Rangifer tarandus</i>	35	1.94	2.5	52	<b>1.97<sup>3</sup></b>	0.29	115		
<i>Cervus elaphus</i>	2	0.76	0.4	8	<b>-3.08<sup>2</sup></b>	0.75	5		
<i>Megaloceros giganteus</i>	2	-1.33	1.3	1	0.34	0.009	2		
<i>Alces alces</i>	1	0.58	0.2	1	0.25	0.005	4		
<i>Bison sp.</i>	20	<b>-4.48<sup>1</sup></b>	14.4	9	<b>12.34<sup>1</sup></b>	10	441		
<i>Bos primigenius</i>	1	-1.49	1.6	0	/	/	0		
<i>Saiga tatarica</i>	0	1.16	1	3	1.11	0.98	4		
<i>Large canids</i>	5	<b>3.44<sup>1</sup></b>	8.2	47	<b>-10.04<sup>1</sup></b>	7.86	10		
<i>Vulpinae</i>	6	<b>3.83<sup>1</sup></b>	10.1	57	<b>-9.07<sup>1</sup></b>	6.35	29		
<i>Ursus sp.</i>	3	0.79	0.4	11	<b>-2.94<sup>2</sup></b>	0.68	10		
<i>Panthera spelaea</i>	1	0.96	0.7	6	<b>-3.74<sup>1</sup></b>	0.026	1		
<i>Lynx lynx</i>	0	0.67	0.3	1	0.01	0.00001	3		
<i>Crocota crocota spelaea</i>	0	/	/	0	0.57	0.026	1		
<i>Mustela putorius</i>	0	0.67	0.3	1	0.83	0.055	1		
<i>Mustela erminea</i>	0	/	/	0	0.81	0.53	2		
<i>Mustela nivalis</i>	0	/	/	0	1.28	0.131	5		
<i>Gulo gulo</i>	0	0.95	0.7	2	1.17	0.109	2		
<i>Meles meles</i>	0	1.16	1	3	<b>-2.33<sup>3</sup></b>	0.432	1		
<i>Lepus sp.</i>	3	<b>7.50<sup>1</sup></b>	35.7	123	<b>-16.44<sup>1</sup></b>	20.274	30		

<i>Marmota bobak</i>	0	1.65	2	6	-1.66	0.216	37
<i>Castor fiber</i>	0	0.95	0.7	2	-1.68	0.226	1
<i>Spermophilus citellus</i>	0	0.95	0.7	2	<b>2.75<sup>2</sup></b>	0.59	35
<i>Ochotona pusilla</i>	0	/	/	0	<b>5.79<sup>1</sup></b>	2.57	98
« Lemmings »	0	/	/	0	<b>20.63<sup>1</sup></b>	22.5	856
<b>Σ</b>	<b>283</b>			<b>628</b>			<b>1906</b>
<b>Khi<sup>2</sup></b>	<b>135.55<sup>1</sup></b>			<b>1255.6<sup>1</sup></b>			

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Annex 3. Number of individuals (MNI) for main species from all the archaeofaunal spectrum for three range of time different between 31.0 and 21.5 ka cal BP (26.0-18.0 ka <sup>14</sup>C BP) (named A, B and C): adjusted residuals (AR) of the MNI and Khi2 values comparing two contiguous range of time period; significant values are indicated in bold (1P<0.001; 2P<0.01; 3P<0.05).

Taxa	A: 31.0-27.5 ka cal BP (26.0-23.0 ka BP)	A vs B		B: 27.5-24.0 ka cal BP (23.0-20.0 ka BP)	B vs C		C: 24.0-21.5 ka cal BP (20.0-18.0 ka BP)
	MNI	AR	Khi <sup>2</sup> of contribution	MNI	AR	Khi <sup>2</sup> of contribution	MNI
<i>Mammuthus primigenius</i>	154	<b>4.72<sup>1</sup></b>	10.3	231	<b>-9.65<sup>1</sup></b>	13.04	139
<i>Equus sp.</i>	44	<b>2.89<sup>2</sup></b>	6.3	55	<b>-2.12<sup>3</sup></b>	0.79	53
<i>Rangifer tarandus</i>	35	1.79	2.5	52	<b>2.83<sup>2</sup></b>	1.35	115
<i>Bison sp.</i>	20	<b>-4.38<sup>1</sup></b>	15.8	9	<b>20.57<sup>1</sup></b>	54.56	441
<i>Large canids</i>	5	<b>3.54<sup>1</sup></b>	10	47	<b>-6.45<sup>1</sup></b>	7.6	10
<i>Vulpinae</i>	6	<b>3.94<sup>1</sup></b>	12.3	57	<b>-4.86<sup>1</sup></b>	4.23	29
<i>Lepus sp.</i>	3	<b>7.68<sup>1</sup></b>	42.8	123	<b>-10.42<sup>1</sup></b>	18.42	30
<b>Σ</b>	<b>267</b>			<b>574</b>			<b>817</b>
<b>Khi<sup>2</sup></b>	<b>117.15<sup>1</sup></b>			<b>524.62<sup>1</sup></b>			

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Annex 4. Number of individuals per species of all the faunal spectrum between the different regions between 31.0 and 21.5 ka cal BP (26.0-18.0 ka <sup>14</sup>C BP): adjusted residuals (AR) and Khi2 values; significant values in bold (1P<0.001; 2P<0.01; 3P<0.05).

Taxa	regions			
	Extracarpatic area			plain
	MNI	AR	Khi <sup>2</sup> of contribution	MNI
<i>M. primigenius</i>	159	<b>4.92<sup>1</sup></b>	1,8	364
<i>Equus sp.</i>	99	<b>-14.38<sup>1</sup></b>	19,0	38
<i>C. antiquitatis</i>	9	0,66	0,0	24
<i>R. tarandus</i>	147	<b>-18.73<sup>1</sup></b>	31,4	45
<i>C. elaphus</i>	10	<b>-4.40<sup>1</sup></b>	1,9	4
<i>M. giganteus</i>	4	<b>-3.08<sup>2</sup></b>	0,9	1
<i>A. alces</i>	6	<b>-4.55<sup>1</sup></b>	2,0	0
<i>Bison sp.</i>	40	<b>-10.58<sup>1</sup></b>	10,7	6
<i>B. primigenius</i>	0	0,54	0,0	1
<i>S. tatarica</i>	0	0,93	0,1	3
<i>Large canids</i>	14	0,09	0,0	47
<i>Vulpinae</i>	12	<b>2.03<sup>3</sup></b>	0,4	76
<i>Ursus</i>	9	<b>2.61<sup>2</sup></b>	0,7	10
<i>P. spelaea</i>	1	0,68	0,0	7
<i>L. lynx</i>	0	1,08	0,1	4
<i>C. c. crocuta</i>	0	0,54	0,0	1
<i>M. putorius</i>	1	0,93	0,1	1
<i>M. erminea</i>	0	0,76	0,1	2
<i>M. nivalis</i>	0	1,21	0,1	5
<i>G. gulo</i>	0	0,93	0,1	3
<i>M. meles</i>	0	0,93	0,1	3
<i>Lepus sp.</i>	10	<b>4.95<sup>1</sup></b>	2,2	145
<i>M. bobak</i>	0	1,00	0,1	32
<i>C. fiber</i>	0	0,93	0,1	3
<i>S. citellus</i>	0	<b>3.30<sup>2</sup></b>	1,0	37
<i>O. pusilla</i>	0	<b>5.45<sup>1</sup></b>	2,8	98
« Lemmings »	0	<b>19.78<sup>1</sup></b>	24,2	856
<b>Σ</b>	<b>527</b>			<b>1816</b>
<b>Khi<sup>2</sup></b>	<b>1025.62<sup>1</sup></b>			

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