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Survival of indicator species of the mammoth fauna large mammals in the Holocene of Yakutia (East Siberia, Russia)

G G Boeskorov

Diamond and Precious Metals Geology Institute, SB RAS, Yakutsk, Russia

E-mail: gboeskorov@mail.ru

Abstract. Global climate change at the end of the Pleistocene led to extinction across the huge territories of the Northern Hemisphere of indicator species of large mammals of the mammoth fauna. Undoubtedly, in some more densely populated regions, the mammoth fauna underwent pressure from Upper Paleolithic humans hunting activity. Previously it was thought that the megafauna of the “Mammoth complex” had become extinct in the territory of Yakutia by the beginning of the Holocene. However, the latest data indicate that extinction of the mammoth fauna was significantly delayed in the north of Eastern Siberia. Radiocarbon data show that wild horses inhabited the north of Yakutia during 5300–2200 cal yr BP. Musk oxen lived here about 3400 – 2600 cal yr BP. Some bison remains from Yakutia belong to the early Holocene. The following circumstances could have facilitated the survival of representatives of the mammoth fauna in Yakutia. The cool, dry climate in this region is favorable to steppe associations, the habitats of these mammals. The small number of Stone Age hunting tribes in the northern part of Yakutia was probably another factor that contributed to the survival of some mammoth fauna representatives.

1. Introduction

It is well known that global climate change at the end of the Pleistocene led to the extinction across the huge territories of the Northern Hemisphere of indicator (or typical) species of the mammoth fauna. Its members include woolly mammoth, woolly rhino, wild horse, steppe bison, musk ox, and cave lion [1-3]. Undoubtedly, in some more densely populated regions, the mammoth fauna also underwent pressure from Upper Paleolithic humans, whose hunting activity could have also played a role in decreasing the number of mammoths and other representatives of the megafauna [2, 4]. Each species reacted differently to the effects of climate change, redistribution of the habitat, and human distribution. Climate change can explain the extinction of some species, such as the Eurasian musk ox and probably the woolly rhino. Some specialists consider that the combination of climatic and anthropogenic influences is apparently the cause of the extinction of other species, such as the Eurasian bison and wild horse [5].

It has already been noted that the global extinction of the mammoth fauna, which took place in Eurasia at the transition from the Pleistocene to the Holocene, was significantly delayed in the north of Eastern Siberia [6, 7]. The following circumstances could have contributed to this process. The exceptionally cold and dry climate of this region allowed for the conservation of large areas with steppe vegetation (the main habitats of large mammals of the mammoth fauna) in the Holocene. Areas of relic steppes in Yakutia are still preserved. The long-term preservation of some representatives of the mammoth fauna in the north of Eastern Siberia must also have been facilitated by the small number of Stone Age hunting tribes. Until recently, sites of Late Paleolithic and Mesolithic age were not found in



the Arctic zone of the mainland of Eastern Siberia from the Taimyr Peninsula to the lower reaches of the Yana River; few of them were found in the Indigirka and Kolyma River basins [8]. In recent decades, in the Arctic zone of Yakutia, a Mesolithic site was discovered on Zhokhov Island and an Upper Paleolithic site in the lower reaches of the Yana River [9, 10]. In addition, a permanent population inhabited the eastern Siberian Arctic 45,000–36,000 cal yr BP; traces of the hunting activity of ancient humans have been found here [11]. Nevertheless, this region was most likely sparsely populated by humans during the Late Pleistocene and the beginning of the Holocene, as it continues to be at the present time.

Below we list convincing evidence of the existence of typical species of mammoth megafauna in the north of Yakutia during the Holocene.

Table 1. Holocene finds of mammoth fauna large mammals in Yakutia territory.

Species	Locality	Radiocarbon date, ^{14}C yr BP	Calibrated age, ^{14}C cal yr BP	Source
Woolly mammoth <i>Mammuthus primigenius</i>	New Siberian Islands, New Siberia Island	9470±40; 9650±60	10,719±60; 11,004±140	[16]
Wild horse <i>Equus</i> sp. and Lena horse <i>E. lenensis</i>	New Siberian Islands, Bolshoi Lyakhovsky Island	2220±50	2239±70	[7]
	Khromskaya Gulf, Moichoon Lake	2310±80	2336±130	[22]
	New Siberian Islands, Kotelny Island	3000±45	3197±80	[18]
	Batagai settlement vicinity, Verkhoyansky District	4400±35	4969±60	[23]
	Bykovsky Peninsula, eastward to the Lena River Delta	4610±40	5374±60	[7]
	Oyyagossky Yar, shore of Dmitry Laptev Strait	4630±35	5384±60	[19]
	Chasovnya R., Khangalassky District	9790±60	11,214±30	[17]
Musk ox <i>Ovibos pallantis</i>	Tumat settlement vicinity, Ust-Yansky District	2535±30	2612±110	[20]
	Bykovsky Peninsula, eastward to the Lena River Delta	3180±100; 3200±40	3407±120; 3425±30	[7]
Steppe bison <i>Bison priscus</i>	Batagai settlement vicinity, Verkhoyansky District	about 8215	about 9200	[23]
	The shore of Lake Chukchalakh, Ust-Yansky District	9310±45	10509±60	[24]

2. Large mammals of the mammoth fauna in Yakutia during the Holocene

2.1. Woolly mammoth *Mammuthus primigenius* (Blumenbach)

A significant decrease in the distribution of *M. primigenius* took place during the Sartanian, the last glaciation. The radiocarbon data indicate that mammoths lived 17,000–14,000 cal yr BP across almost the entire area of their Pleistocene range in Northern Eurasia. Mammoth remains younger than 14,000 cal yr BP are found only in the Arctic part of Siberia [3, 12, 13].

At one time, it was supposed that mammoths went extinct in Eurasia by the beginning of the Holocene because no remains had been found that were younger than 11,000 cal yr BP. However, in the 1990s, evidence from radiocarbon dates on mammoths from Wrangel Island indicated that they survived into the Holocene, from 8500 to 4400 cal yr BP [12, 14]. Radiocarbon dating of the mammoth remains younger than 4400 cal yr BP still have not been obtained anywhere, so it is believed that this island population of *M. primigenius* was the last one.

On the continental part of Eurasia, the youngest mammoth radiocarbon dates belong to the very beginning of the Holocene, 11,500–10,950 cal yr BP (Gydan Peninsula, Taimyr Peninsula) [15]. Not so long ago, this was also confirmed for the territory of Yakutia-- the last mammoths lived here up to the beginning of the Holocene in the territory of the New Siberian Islands (these islands were then connected to the mainland) [16] (table 1).

2.2. Lena horse *Equus lenensis* Russanov

This horse was one of the most numerous ungulate species of the Yakutia Late Pleistocene. Numerous bone remains of horses are found in many Upper Paleolithic sites. Among the several hundred Holocene human sites in Yakutia, the remains of the horse were found only in the Neolithic site Kulatty near Yakutsk-City. In our opinion, this fact is the result of mixing of the stratigraphy.

Recently, an Early Holocene dating of the Lena horse was obtained from Central Yakutia, Chasovnya River [17] (Table 1).

To date, there are already several radiocarbon dates of horse remains from the north of Yakutia, which fall in the Middle and Late Holocene time frame [7, 18–21] (table 1, figure 1). These dates clearly indicate that in the far north of Eastern Siberia, wild horses (most likely the Lena horse) lived in the Middle and Late Holocene, at least 5300–2200 cal yr BP.

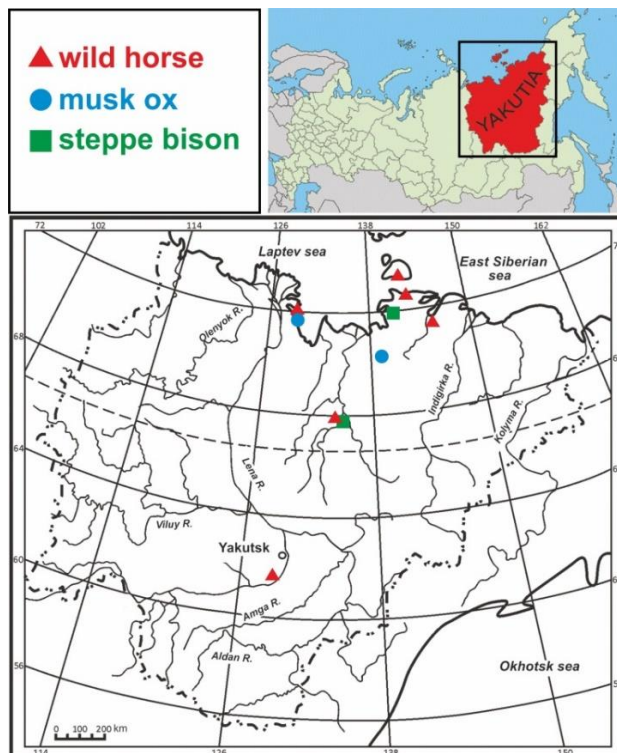


Figure 1. Localities for mammoth fauna large mammals in the Holocene of Yakutia.

Moreover it is possible that some populations of *E. lenensis* persisted longer in the Extreme North. Horse remains were found in an ancient Eskimo settlement on the Bolshoy Baranov Cape (western Chukotka, eastward from the Kolyma river mouth) dated to the 8th – 9th centuries AD [22].

2.3. Primeval musk ox *Ovibos pallantis* H. Smith

This species went extinct in most of its former range in Eurasia by the beginning of the Holocene. Earlier it was noted that this species existed longer on the Taimyr Peninsula and the last population of *O. pallantis* lived there until 3400 – 2600 cal yr BP [2, 15]. Not long ago, similar dates were obtained on musk ox bones from the Lena River delta, about 3400 cal yr BP. [7] (table 1, figure 1).

Table 2. Survival of the Mammoth fauna large mammals in Yakutia into the Holocene.

Mammoth fauna large mammal species, Late Pleistocene (126,000- 11,700 cal yr BP)	Holocene			
	Early (Preboreal, Boreal, 11,700- 8000 cal yr BP)	Middle (Atlantic, Subboreal, 8000- 2500 cal yr BP)	Late (Subatlantic, 2500 cal yr BP – present)	Modern fauna
Grey wolf <i>Canis lupus</i>	+	+	+	+
Arctic fox <i>Vulpes lagopus</i>	+	+	+	+
Brown bear <i>Ursus arctos</i>	+	+	+	+
Wolverine <i>Gulo gulo</i>	+	+	+	+
Cave lion <i>Panthera spelaea</i>	-	-	-	-
Woolly mammoth <i>Mammuthus primigenius</i>	+	-	-	-
Lena horse <i>E. lenensis</i> and wild horse <i>Equus</i> sp.	+	+	+	-
Woolly rhino <i>Coelodonta antiquitatis</i>	-	-	-	-
Red deer <i>Cervus elaphus</i>	+	+	+	+
Moose <i>Alces americanus</i>	+	+	+	+
Reindeer <i>Rangifer tarandus</i>	+	+	+	+
Steppe bison <i>Bison priscus</i>	+	-	-	-
Siberian saiga antelope <i>Saiga tatarica borealis</i>	-	-	-	-
Musk ox <i>Ovibos pallantis</i>	?	+	-	-
Siberian snow sheep <i>Ovis nivicola</i>	+	+	+	+

Notes: “+” – presence of species, “-” – absence of species, “?” - no remains of the species were found, but perhaps it was present.

Recently, an even younger dating was obtained on muskox remains from the Ust-Yansky District of Yakutia [23] (table 1). This date indicates that the Holocene distribution of musk ox in Eurasia was greater than previously believed. Holocene remains of musk ox have been found across the vast territory from the Taimyr Peninsula to the Yana-Indigirka Lowland. On the other hand, it is not yet known whether this area was contiguous or consisted of separate, isolated populations. The musk ox in the north

of Siberia existed until almost before the Common Era and became extinct as a result of climate change, or were extirpated by humans.

2.4. *Primeval, or steppe, bison* *Bison priscus* Boj.

K. Flerov [24] believed that the Late Pleistocene bison lived in the North-East of Siberia up to the beginning of Holocene. To date, frozen mummies of two early Holocene bison have been discovered in Yakutia [21, 25] (table 1, figure 1), which confirms the opinion of K.Flerov. In addition, to date, finds of early Holocene bison from Taimyr [26], Western Chukotka [27] and Wrangel Island [28] are also known.

Several finds of the remains of Holocene-age bison in northeastern Asia present valid evidence that the species survived the Pleistocene-Holocene boundary, and continued to inhabit the vast territory from the Taimyr Peninsula in the west, to the Chukotka Peninsula in the east, and Wrangel Island in the north, in the early Holocene between 10,500 – 9000 cal yr BP.

3. Conclusion

Of the 15 species of large mammals of the mammoth fauna, 8 species are present in the modern fauna of Yakutia (table 2). This is 53.3% of the total composition of the megafauna of the Late Pleistocene of Yakutia. These species survived here safely from the Pleistocene to the present day. But, about 50% of the large mammals of the mammoth fauna died out. Some indicator species of mammoth fauna became extinct in Yakutia by the end of the Pleistocene, such as: cave lion, woolly rhino, and saiga antelope (table 2). However, some indicator species of the mammoth fauna survived the Pleistocene-Holocene climate crisis. At the very beginning of the Holocene, individual populations of mammoths, horses, bison and musk oxen persisted here. Horses and muskoxen lasted the longest in this region. Musk oxen became extinct here (or were hunted to extinction by humans), apparently, about 2600 cal yr BP. Wild horses survived longer, possibly until the Middle Ages.

Thus, the previously expressed opinion that the north of Eastern Siberia (including Yakutia) was a refugium for some Mammoth fauna large mammals is confirmed by new radiocarbon dating.

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