Landscape, climate and mammoth food resources in the East European plain during the Late Paleolithic

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SUMMARY: The second half of the Late Pleistocene was a time when *Mammuthus primigenius* existed in the East European Plain. Under conditions of great aridity most of the modern tundra, forest and steppe zones were replaced by a periglacial hyperzone. To estimate food supply for mammoths, data on productivity and food value of modern plant communities (analogs of Pleistocene periglacial vegetation) were used.

1. Introduction

The second half of the Late Pleistocene was a time when *Mammuthus primigenius* existed in the East European Plain. Under conditions of great aridity most of the modern tundra, forest and steppe zones were replaced by a periglacial hyperzone. To estimate food supply for mammoths, data on productivity and food value of modern plant communities (analogs of Pleistocene periglacial vegetation) were used.

The most favorable conditions for mammoths existed in the west-central part of the periglacial hyperzone. It was relatively rich in food resources and water (rivers fed by glaciers and thermokarst lakes). The productivity of plant communities reached 800-1700 kg/ha for periglacial steppe and 2500 kg/ha for meadows. Warming at the transition to the Holocene was accompanied by permafrost degradation, development of bogs, and an increase in snow, unfavorable to the existence of mammoth. Therefore mammoths could not survive these climate conditions at the glacial/interglacial transition.

The Late Pleistocene species *Mammuthus* primigenius (Blumembach) inhabited periglacial areas of Northern Eurasia. The time at which mammoth of so-called early type was replaced by typical *Mammuthus primigenius* can be inferred from the data on Paleolithic campsites along the Dniester River. Mousterian layers at these sites contain mammoths of early type, while the late mammoth remains are found in the Late Paleolithic layers (Chernysh 1982; Ivanova 1977). According to radiocarbon dates on the cultural layers of the Dniester sites, the Mousterian culture persisted here until 35–40 ka BP, and the Late Paleolithic appeared about 30 ka BP.

2. Spatial Environmental Reconstructions of the Typical Mammoth Epoch

The great majority of typical mammoth remains are dated to the Pleniglacial, including the period of maximum cooling and extremely severe cryogenic conditions (20 to 18 ka BP, OIS2, Shackleton 1987). The major part of the East European Plain was within permafrost limits (Velichko & Nechaev 1984, 1992). In the north (north of 57–56° N) the frozen ground was up to 200 m thick, with widespread ice wedges. Permafrost reached as far south as 48–49° N.

Under extra-arid conditions, a vast hyperzone of periglacial, primarily open landscapes occurred in place of the modern tundra, boreal forests and steppes (Velichko 1984). According to Grichuk (1982), a narrow strip along the ice sheet margin was covered by a complex vegetation consisting of tundra and steppe-type

herb communities, with local open woodlands of birch and pine, while larch was present in the northeast. Farther south, vast interfluves were dominated by periglacial steppe vegetation, with pioneer plants on disturbed or immature soils. Meadow occurred in wetter habitats, such as the dried floors of thermokarst depressions. In more favorable biotopes, spruce, larch and *Pinus sibirica* occurred in open woodlands along with birch and pine, as well as cold-tolerant shrubs (*Betula nana, B. humilis, Alnaster fruticosus*). The southern part of periglacial area was occupied by periglacial steppe, with tree species less frequent even within the river valleys.

According to the paleoclimatic reconstructions for the time of greatest Late Pleistocene cooling (Velichko 1984), winter temperatures were as low as –39° C, that is, 10 to 15° C below those of today in the north, and 20 to 22° in the south of the East European periglacial region. In the north summer temperatures were 5 to 7°C lower than present, and 4 to 5°C lower in the south. The total annual precipitation was about 350 mm or less; attributable to the fact that in high and middle latitudes the Atlantic Ocean was under ice for the major part of the year.

3. The Existence of Mammoths in Periglacial Environments

A herd of mammoths included 10 to 30 individuals on the average (remains of 33 or 34 mammoths are found in the Sevsk site, the Desna drainage basin, 55% of them belonged to mature individuals – Mashchenko 1998). By analogy with present-day elephants, it seems reasonable to suggest that daily need of one adult mammoth amounted to about 175–200 kg of plant material.

To estimate the quantity of available foodstuff, one can use data on productivity and nutritive value of those types of modern herb and grass vegetation which may be considered as analogous to Pleistocene periglacial communities. Steppe meadows (closely resembling communities of river valleys in the periglacial zone) yield about 800 to 1700 kg/ha per year (Nomokonov 1978). Wetter meadows and high grass communities typical for wetter biotopes could produce up to 2000–2500 kg/ha (judging from modern mesic floodplain meadows). Periglacial steppe communities on high terraces and interfluves were less closed and therefore less productive; they were comparable with meadows, however, in nutritive value and protein content. Dry floors of thermokarst lake basins (typical of periglacial cryogenic complex) were covered with highly productive – up to 2500 kg/ha – grazing areas (Tomirdiaro 1980; Ustinov 1978). To estimate the area needed for a mammoth herd, the productivity of periglacial herb and grass communities was taken as 2000 kg/ha, and daily food requirements for an adult mammoth – as 200 kg (though it could be in fact 150 or 175 kg), and an average number of animals in a herd is about 30, of which more than a half are mature, and the rest are young animals. Total vegetable mass daily consumed by the herd is taken as equivalent to that eaten by 20 adult animals. Therefore, the daily requirements of plant material of the herd may be estimated at 4000 kg; the product of 2 hectares. Accordingly, the herd would require 60 hectares of grazing area per month, and about 7 km^2 per year.

Geomorphologically, the area inhabited by mammoths was not uniform, and particular types of terrain were differently used according to season. In summer, the floodplains were too wet (due to floods and melting of seasonally frozen soils) and the soft ground could not support mammoths with their great weight and rather small feet. At that time the herds would prefer dry sites on high interfluves covered with loess. It should be taken into account, when estimating the required grazing area, that even in summer, when the animals could forage over vast interfluvial plains, part of the area was inaccessible because of cryogenic features; so the grazing area must be estimated as three to four times greater than the value given above.

In winter, interfluves could not support mammoth herds. In river valleys, however, frozen ground of floodplains made it accessible for mammoths which could easily feed on grass and

bushes grown during summer, especially as snow cover was usually thin. The main reason of the seasonal migrations from one type of biotope to another was access to water. Even in winter, at low temperatures, one mammoth would require about 150 liters per day (Haynes 1993), and a herd under consideration would take 20 times as much. Stable sources of water could be icings in river channels. As follows from calculations, a conventional mammoth herd needs about 4 hectares of grazing area per day, that is about 10 km^2 for the whole cold season (about 7 months). Making allowance for unproductive areas (the river channel, oxbow lakes, point bars, and sites heavily disturbed by cryogenic fissures), the required area may increase by an order of magnitude, that is, up to 100 km^2. Taking the width of floodplain and lower terraces to be 2 to 5 km, a herd would require a section of valley about 30 to 40 km long.

A consequence from the above is that the food supply, and therefore potential abundance of mammoths, would have varied considerably from warm to cold season within the same region. To take one example, we consider the region known for its Late Paleolithic sites in the middle reaches of the Desna River about 20,000 to 25,000 km^2 in area. In summer it could support several hundred mammoth herds, while only 10 to 20 herds could survive through the winter. Evidently, such a drastic reduction in food resources during the cold season put a limitation on mammoth population in the periglacial regions.

4. General Pattern of Mammoth Distribution

The west central part of the Late Pleistocene periglacial hyperzone was the most favorable for mammoths; as is strongly suggested by the fact that most mammoth finds are concentrated there. The abundance of fossil remains decreases both eastward and southward, which is probably attributable to drier climate and consequently more scarce and less productive periglacial vegetation. Northern regions were even less suitable for mammoths because of low productive capacity of tundra plant communities and poor fodder base.

At the time of maximum cooling, mammoth was the main source of food for Late Paleolithic man, and humans would follow mammoth. Thus, in the east of the periglacial zone environments were unsuitable for mammoth, and this region practically lacks Paleolithic campsites (Velichko & Kurenkova 1990).

A typical mammoth was adapted to specific conditions of periglacial landscapes and climates, and the drastic change in climate and biotopes at the Pleistocene/Holocene boundary resulted in its extinction.

5. Acknowledgements

The authors wish to express a special gratitude to Mrs. Amanda Petel (Geography Department, University of California, Los Angeles) for reviewing the English version of the manuscript.

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