



A woolly mammoth (*Mammuthus primigenius*) carcass from Maly Lyakhovsky Island (New Siberian Islands, Russian Federation)



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ABSTRACT

A partial carcass of an adult woolly mammoth (*Mammuthus primigenius*) found in 2012 on Maly Lyakhovsky Island presents a new opportunity to retrieve associated anatomical, morphological, and life history data on this important component of Pleistocene biotas. In addition, we address hematological, histological, and microbiological issues that relate directly to quality of preservation. Recovered by staff from North-Eastern Federal University in Yakutsk, this individual is a relatively old female preserving soft tissue of the anteroventral portion of the head, most of both fore-quarters, and the ventral aspect of much of the rest of the body. Both tusks were recovered and subjected to computed tomographic analysis in which annual dentin increments were revealed as cycles of variation in X-ray attenuation. Measurements of annual increment areas (in longitudinal section) display a pulsed pattern of tusk growth showing cycles of growth rate variation over periods of 3–5 years. These intervals are interpreted as calving cycles reflecting regular shifts in calcium and phosphate demand for tusk growth vs. fetal ossification and lactation. Brown liquid associated with the frozen carcass turned out to include remains of hemolyzed blood, and blood samples examined microscopically included white blood cells with preserved nuclei. Muscle tissue from the trunk was unusually well preserved, even at the histological level. Intestinal contents and tissue samples were investigated microbiologically, and several strains of lactic-acid bacteria (e.g., *Enterococcus faecium*, *Enterococcus hirae*) that are widely distributed as commensal organisms in the intestines of herbivores were isolated.

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1. Introduction

In mid-August, 2012, commercial ivory prospectors hunting for mammoth tusks discovered a partial carcass of an adult woolly

mammoth (*Mammuthus primigenius*) on Maly Lyakhovsky Island. This island is one of the New Siberian Islands, located between the Laptev Sea and the East Siberian Sea (Fig. 1). The remains were found 200 m from the northeast coast of the island, on a low hill. Material that was exposed at the time of discovery included various post-cranial elements, skull fragments, and the mammoth's trunk, which lay across the left tusk.

Recognizing the possible significance of this find, the ivory prospectors recorded its location, notified staff of the Lazarev Mammoth Museum (Institute of Applied Ecology of the North, North-Eastern Federal University, Yakutsk), and agreed to retain, rather than immediately sell, the relatively small tusks they had found with this specimen. During the following months, staff of the Museum and Institute devised a plan to return to the discovery site and extract the specimen.

The goal of this article is to summarize some of the first results of analyses of this specimen. Most other recent discoveries of mammoth specimens with preserved soft tissue have been juveniles (e.g., Shilo et al., 1983; Boeskorov et al., 2007a; Fisher et al., 2012; Kosintsev et al., 2012; Maschenko et al., 2013; Boeskorov et al., 2014) or adolescents (Pitulko et al., 2016), with a smaller number of adult males (e.g., Mol et al., 2001; Boeskorov et al., 2007b). The prospect of retrieving data from another adult, especially if it might turn out to be an adult female, was a strong attraction. The focus of our morphological and anatomical studies is on issues related to sex, life history, and preservation. In relation to the latter point, we especially sought to clarify the nature of a brown liquid discovered in close association with the carcass at the time of its excavation. Its appearance was suggestive of blood, but

entertaining such an idea required us to assess preservation at a variety of levels. In addition to hematological analysis, we evaluated preservation of cell and tissue structures in the first histological examination of this specimen. Finally, we cultured and sequenced numerous microbial taxa from tissues and intestinal contents. Comprehensive description of this specimen is beyond the scope of this paper, but we hope to provide a foundation for a wide range of subsequent studies.

2. Material

2.1. Specimen recovery

Staff from the Museum and Institute departed from Yakutsk on 29 April 2013 and traveled by plane and car to the settlement of Kazachie (Ust'-Yanskiy district). Knowing that significant amounts of soft tissue from this mammoth had been exposed at the surface, and that more probably remained within the permafrost, they planned to execute the recovery under conditions that would remain consistently below freezing, while avoiding the extreme cold of mid-winter. Moreover, it would be necessary not only to reach the discovery site and extract the specimen, but also to return it to the mainland.

A team of three staff from the Museum and Institute, assisted by members of the team of ivory prospectors who had discovered the specimen, set out from Kazachie on snowmobiles pulling sleds loaded with supplies and equipment on 5 May 2013. Normal conditions for this region, at this time of year, would have been well below freezing, but with each year now bringing an earlier end to



Fig. 1. Geographical position of Maly Lyakhovsky Island, north of the Arctic coast of Yakutia (yellow region on map inset; light gray in print version), in the northeastern portion of the Russian Federation. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

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