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# Palaeo-environmental and dietary analysis of intestinal contents of a mammoth calf (Yamal Peninsula, northwest Siberia)

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ABSTRACT

Intestinal samples from the one-month-old Siberian mammoth calf 'Lyuba' were studied using light microscopy and ancient DNA to reconstruct its palaeo-environment and diet. The palynological record indicates a 'mammoth steppe'. At least some pollen of arboreal taxa was reworked, and thus the presence of trees on the landscape is uncertain. In addition to visual comparison of 11 microfossil spectra, a PCA analysis contributed to diet reconstruction. This yielded two clusters: one of samples from the small intestine and the other of large-intestine samples, indicating compositional differences in food remains along the intestinal tract, possibly reflecting different episodes of ingestion. Based on observed morphological damage we conclude that the cyperaceous plant remains and some remains of dwarf willows were originally eaten by a mature mammoth, most likely Lyuba's mother. The mammoth calf probably unintentionally swallowed well-preserved mosses and mineral particles while eating fecal material deposited on a soil surface covered with mosses. Coprophagy may have been a common habit for mammoths, and we therefore propose that fecal material should not be used to infer season of death of mammoths. DNA sequences of *trn*L and *rbc*L genes amplified from ancient DNA extracted from intestinal samples confirmed and supplemented plant identifications based on microfossils and macro-remains. Results from different extraction methods and barcoding markers complemented each other and show the value of longer protocols in addition to fast and commercially available extraction kits.



## 1. Introduction

In May 2007, a frozen, female woolly mammoth calf (*Mammuthus primigenius* Blumenbach, 1799; Fig. 1,1) was discovered by reindeer herders along the Yuribei River on the Yamal Peninsula (68°38′N; 71°40′E; Kosintsev et al., 2010; Fisher et al., in press) and acquired by the Shemanovskiy Museum and Exhibition Center in Salekhard, Yamalo-Nenets Autonomous Okrug. Its bone collagen was AMS-dated at 41,910+550/−450 BP, and intestinal material was dated at 41,700 +700/−550 BP (Kosintsev et al., 2010). The mammoth calf, now known as 'Lyuba', thus lived during the relatively mild Middle Pleniglacial of the Last Ice Age (Marine Isotope Stage 3).

The calf appears outwardly to be in nearly perfect condition, although the "shrunken" cross-sections of her limbs show that she has lost significant water mass, and dissections documented multiple instances of internal postmortem alteration (Fisher et al., in press). Lyuba weighed ca. 50 kg when discovered; she is 85 cm high and 115 cm from trunk to tail. Based on counts of postnatal daily growth increments in dentin, Rountrey et al. (in press) determined her age at death to be about one month. Isotope series from her teeth suggest she was born in spring (climatically late winter), probably before new plant growth had begun (Rountrey et al., in press). Despite the potential lack of high-quality plant foods available to her mother at this time, abundant subcutaneous fat indicates

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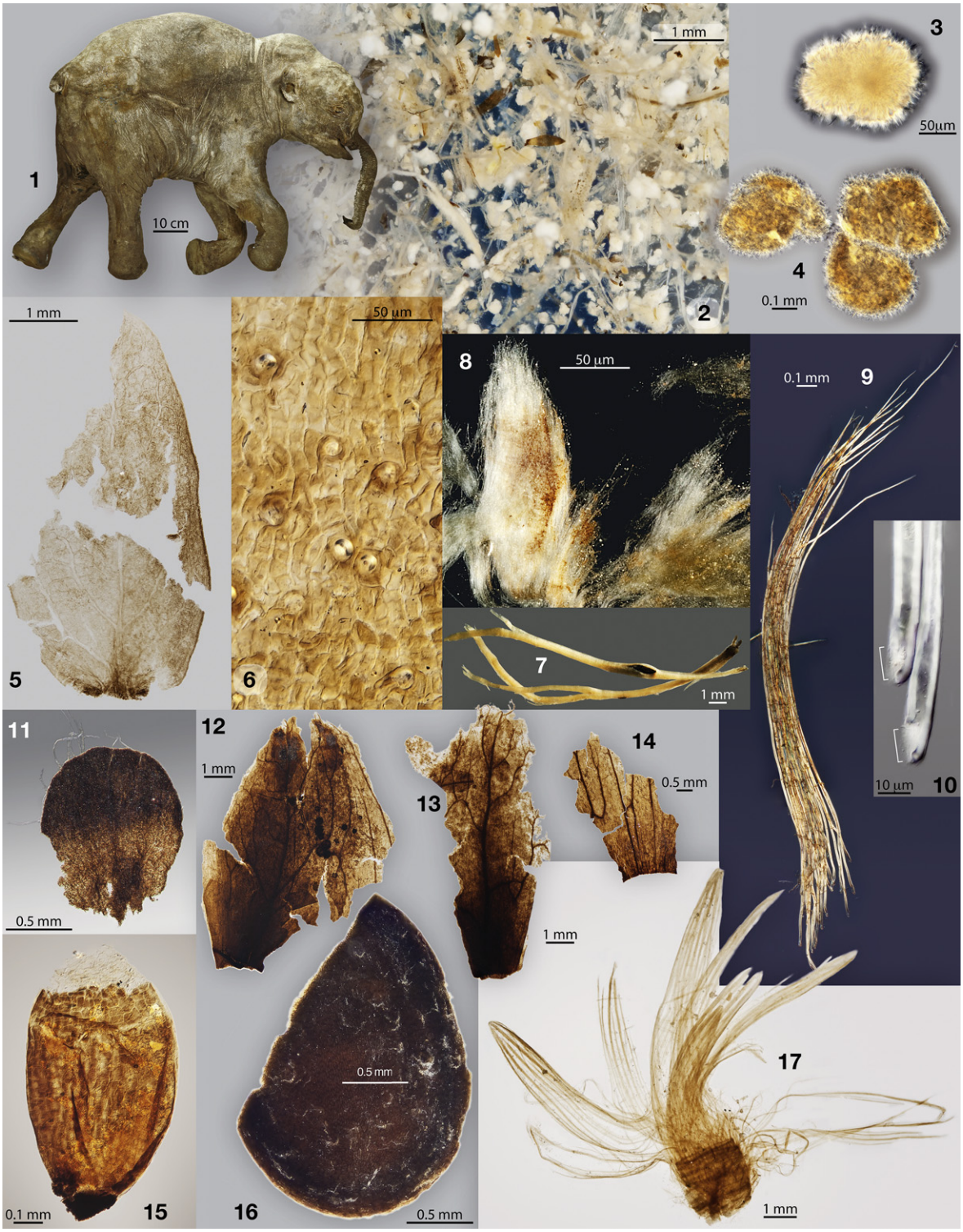


**Fig. 1.** 1: baby mammoth Lyuba; 2: particles of milk-residue (white dots) between plant remains; 3 and 4: milk particles; 5: leaf fragment of *Salix*; 6: *Salix*, epidermis; 7: *Salix*, twigs without bark; 8 and 9: separate bundles of hairs from bud scales or leaves of *Salix*; 10: *Salix,* two leaf hairs, showing asymmetrical basal points of attachment, which keep hairs parallel to the stem axis where they cover leaves or bud scales; 11: *Salix*, leaf or bud scale; 12–14: unidentified leaf or bud scale fragments; 15: cf. *Juncus*, seed; 16: *Menyanthes trifoliata*, incomplete seed; 17: unidentified young plant.

that this mammoth calf was well nourished. At one month of age, Lyuba's nutritional requirements would likely have been met solely by her mother's milk (judging from observations on African elephants; Lee and Moss, 1986; Moss, 1992), and the lack of significant wear on the dP2s (the only teeth that had erupted and come into occlusion) indicates that she would have been incapable of efficiently masticating vegetation. However, plant remains are abundant in some areas of her intestines.

We studied botanical microfossils, macroremains and ancient DNA present in samples from Lyuba's small and large intestines. Contrary to the description of Kosintsev et al. (in press), Lyuba's stomach and small intestine were not empty. Our objective was to