Mammoth (*Mammuthus*) from the Doeden Gravels, Eastern Montana: Biometric and Molecular Analyses

*Christopher L. Hill and Mary Schweitzer*

Morphological studies of fossils and immunological analyses of proteins can provide a clearer understanding of the phylogenetic relationships of Pleistocene vertebrates (Joger et al. 1995; Lowenstein 1985; Shoshani et al. 1995), as well as assist in interpreting paleobiotic, chronologic, and geospatial patterns. Here we summarize results of biometric and preliminary immunological examinations of *Mammuthus* (mammoth) from terrace deposits along the Yellowstone River in eastern Montana.

Christopher L. Hill, Ice Age Research Program, Museum of the Rockies, Montana State University, Bozeman, MT 59717; e-mail: chill@montana.edu

Mary Schweitzer, Department of Biology and Museum of the Rockies, Montana State University, Bozeman, MT 59717.
The specimen studied is a nearly complete *Mammuthus* cranium. It is part of a Pleistocene vertebrate collection at the Museum of the Rockies (MOR) representing the Rancholabrean age Doeden local fauna (Wilson, in Kurtén and Anderson 1980:71; MOR Fossil Locality No. PL-084). Besides *Mammuthus*, the collection includes *Mammut* (mastodon), *Megalonyx* (ground sloth), *Equus* (horse), and *Camelops* (camel) (Hill 1998a). The deposits containing the fossils are estimated to be over 100,000 years old, based on geomorphic correlations within the Yellowstone basin (cf. Chadwick et al. 1997; Heinrichs 1988).

Biometric attributes (Agenbroad 1994; Saunders and Daeschler 1994; Lister 1996) were used to evaluate the taxonomic status of the Doeden specimen (MOR 604). Both maxillary molars fall within the populations of M6(M3) measured in *Mammuthus columbi* based on plots of width vs. length and length vs. number of plates (Agenbroad 1998; Agenbroad and Brunelle 1994; Graham 1986). With a lamellar frequency (Lf) of 7-10 and 20 plates, characteristics of the more complete right maxillary M6(M3) are within the range of *M. columbi* (Maglio 1973:67). The Lf is similar to *M. columbi jeffersonii* (Jefferson's mammoth) from Montana reported by Dudley (1988) and the Lf of a specimen from the South Fork Deer Creek drainage with attributes of both *M. columbi* and *M. imperator* (Imperial mammoth) (Hill and Davis 1998). The specimen falls within the *M. columbi* group as established by Whitmore et al. (1967).

Nine samples from *Mammuthus*, *Mammut*, and *Camelops* from the Doeden local fauna were tested to determine whether they contained a separable collagen fraction. Most of the samples contained no collagen. However, bone and tooth samples from MOR 604 yielded residue thought to consist of very degraded collagen and associated organics.

Bone was tested for the presence of protein fragments that can be used to help evaluate phylogenetic relationships of proboscideans (Lowenstein and Shoshani 1996; Shoshani, Lowenstein et al. 1985; Shoshani, Walz et al. 1985). Albumin and collagen in the tissue of mammoths preserved under different taphonomic contexts are known to persist to at least 50,000 years (Lowenstein and Shoshani 1996). The geomorphic and taphonomic context of MOR 604 appears to indicate an age of at least 100,000 years, thus providing an opportunity to conduct molecular studies on *Mammuthus* from the middle or early late Pleistocene. Extracts of *Mammuthus* bone tissues from MOR 604 were used as an immunogen to generate polyclonal antisera. These antibodies demonstrated positive reactivity with *Mammuthus* bone extracts, while the pre-immune sera were negative. Based on antibody reactions with extractions of bone polyclonal antisera from various taxa, some phylogenetic information may be conserved in MOR 604 bone protein. Antisera raised against *Mammuthus* bone extracts reacted most strongly with other *Mammuthus*, then elephant and equid, and less strongly with canid or feline, results that would be predicted on the basis of other phylogenetic studies (Lowenstein and Shoshani 1996; Lowenstein et al. 1981; Shoshani et al. 1995).

The antiserum generated against specimen MOR 604 then was tested against *Mammuthus* bone (MOR specimen 91.72.134) dated to around 12,000
yr B.P. (Hill 1998b). Strong reactivity was seen. In a second experiment, antibody reactivity was reduced by at least 50 percent when the extracts were digested first with collagenase, then exposed to the antisera. Based upon these results it seems reasonable to assume that at least some of the preserved epitopes are collagen-derived.

Thus the Doeden mammoth cranium appears to contain genetic information (in the form of protein fragments or epitopes) that may be used in conjunction with morphological attributes to help evaluate the phylogey of *Mammuthus* in western interior North America.

Several other fossils found within the Yellowstone basin have been attributed to *M. columbi*. These include finds near Rosebud (Winchell 1882), in the vicinity of the Tongue River (Hay 1924, Bass 1932), along the Powder River (Hay 1924), near Glendive (Hay 1914), and near the Bighorn River (Graham 1986; Madden 1978), as well as a specimen from the uplands of the South Fork of Deer Creek with biometric traits of both *M. columbi* and *M. imperator* (Hill and Davis 1998). These fossils appear to indicate the persistence of at least one species of *Mammuthus* within the basin during the late Pleistocene and perhaps since the middle Pleistocene, an idea perhaps testable with further immunological studies. The use of a combination of biometric attributes and immunological analyses has the potential of advancing our understanding of the phylogenetic status of *Mammuthus*, especially when specimens can be placed in paleogeographic, taphonomic, and chronologic context.

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References Cited


