Isotopes and the Analysis of the Diet and Environments of Mammoth Species

Grace Larson, Chance Hannold, Dr. Yang Wang

Introduction

- This paper analyzes carbon and oxygen isotopes present in enamel samples of both Pygmy and Columbian mammoths.
- The goal of this analysis is to paint a clearer picture regarding the mammoths' lives and how their diets shaped them.
- Two sets of samples from each type of mammoth were used to graph the relationships between the types of isotopes digested by these animals.
- Isotopic values allow us to estimate the dominance of C3 and C4 plants in the respective environments.
- The types of plants present during the animals' lives serve to more accurately paleoenvironmental conditions.
- C3 plants are indicative of a cool and wet environment, while C4 plants are typical of warmer seasons and drier environments.
- Because mammoths consume water regularly the oxygen isotopes found in enamel should reflect the isotopic composition of drinking water consumed.

Results

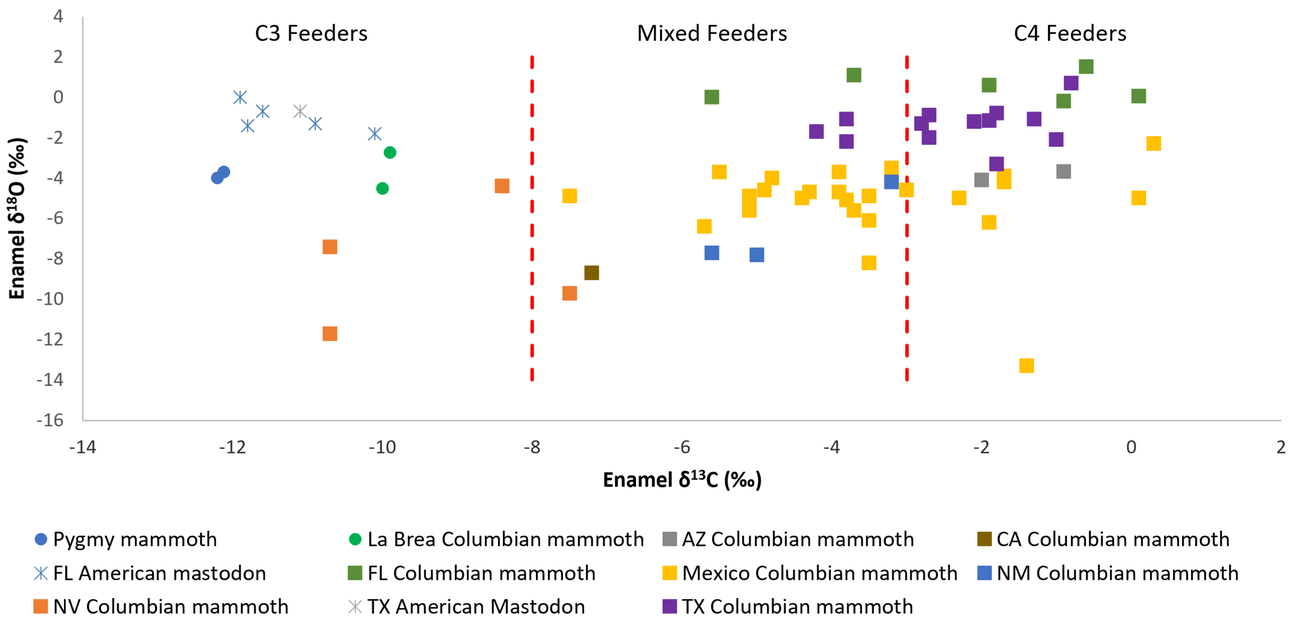

Figure 1: Relationship of Carbon and Oxygen Isotopes in Regards to C3 vs C4 Plant Consumers

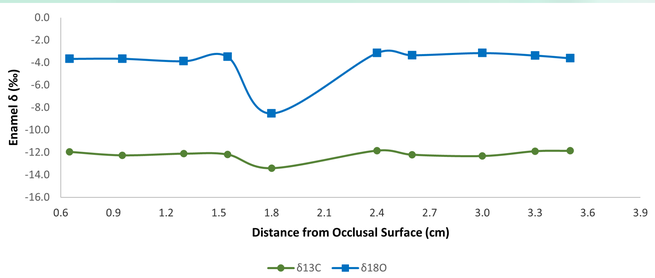

Figure 2: Pygmy Mammoth δ13C and δ18O Serial Values

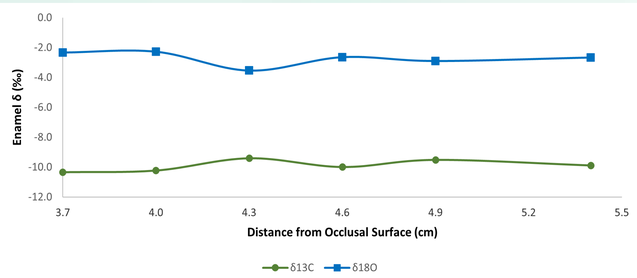

Figure 3: Columbian Mammoth δ13C and δ18O Serial Values

Discussion

- A fractionation factor of 14 accounts for differences between scientific samples and isotope values of diets.
- C3 feeders have -8 per mil (corresponding to a -22 per mil threshold for pure C3 plants) or lower δ13C, while C4 feeders have -3 per mil (corresponding to a -17 per mil threshold for C3 plants or higher δ13C).
- Similarity between the isotopic values found in the La Brea Columbian and the Pygmy mammoths indicate:
  - Closed canopy environment
  - Wet and cool conditions
- Environmental conditions suggest consumption of shrubs or cold-season grasses, but browsing is less consistent with dental morphology and function.
- Values to the right of the C4 bound represent species whose diets were dominated by C4 plants and presumably lived in warm and dry climates.
- Oxygen isotopes suggest similar water sources to reflecting rainwater.
- Changes of δ13C and δ18O values imply that the environment and resources faced little changes throughout the species' lifetime.

Methods

Treatment process of samples:

- Remove organic matter with NaOCL
- Rinsed and treated with acetic acid to remove secondary carbonates
- Rinsed, frozen overnight, freeze dried for 2-3 days
- Data collection by use of isotope mass spectrometer with gas bench

Conclusion

- The similar C3 values of the La Brea Columbian and Pygmy mammoth indicate that they shared similar environments and food sources dominated by C3 plants.
- The presence of C3 plants in an environment would imply that the conditions of the mammoths' habitats were typically wet and cold.
- Environmental conditions of La Brea and the Channel Islands are indicated to be wetter and colder than any of the mammoths found in the literature review.
- Figure 2 and 3 indicate that the resources available to both mammoths remained constant with the exception of the δ18O dip seen in Figure 2.
- Multiple factors such as shifts in amounts of ocean and rainwater could have been the cause of the oxygen shift in Figure 2.

Acknowledgements & References

Special Thanks: Chance Hannold and Dr. Yang Wang

References:

Fricke, & O'Neil, J. R. (1996). Inter- And Intra-Tooth Variation In The Oxygen Isotope Composition Of Mammalian Tooth Enamel Phosphate: Implications For Palaeoclimatological And Palaeobiological Research. Palaeogeography, Palaeoclimatology, Palaeoecology, 126(1), 91–99. Https://Doi.org/10.1016/S0031-0182(96)00072-7

Cerling, & Harris, J. M. (1999). Carbon Isotope Fractionation Between Diet And Bioapatite In Ungulate Mammals And Implications For Ecological And Paleoecological Studies. Oecologia, 120(3), 347–363. Https://Doi.org/10.1007/S004420050868