Filling the gaps: A comprehensive understanding of diets and ecosystem interactions within the modern and fossil small mammal communities of Meade Basin, Kansas

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Context and Motivation

- **The modern Great Plains ecosystem began shifting from a C_3 plant-dominated biome to a C_4 grassland by 5 MYA**
- **The Meade Basin in Southwestern Kansas contains a rich and fairly complete fossil record of a Great Plains small mammal community throughout the past 5 MYR.**
  - Stable isotope analysis (SIA) of these fossils provide a paleoenvironmental record of the shift from C_3 plant to C_4 grass biomass
  - SIA of fossils also provide a paleoecological record of species interactions and community dynamics
- **The goal of this project is to fill taxonomic gaps in the modern sample**
  - The majority of the modern Meade dataset was derived from 5 years of live trapping and this sample is inherently biased towards small bodied and nocturnal species
  - Incomplete understanding of modern ecosystem interactions hinders our interpretation of fossil isotopic datasets
  - Our samples are derived from biologic and anthropogenic collections, which contain remains of previously under sampled taxa within the small mammal community
- **This project uses SIA of bone collagen**
  - Collagen sampling allows for a complete modern SI dataset and avoids capture bias
  - Collagen acts as a lifetime average of isotopes, while hair acts as a snapshot into a single time period

Study System

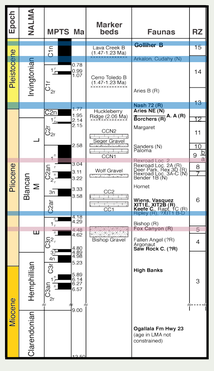


Figure 2. Stratigraphic column of the Meade Basin, blue lines indicate small mammal fossil faunas[1]

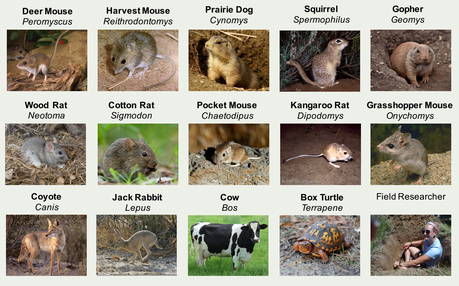


Figure 1. Photos of creatures analyzed in this study

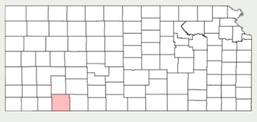


Figure 3. Map of Kansas state, Meade County highlighted in pink

Figure 4. Identifying and taking hair samples from trapped rodents

Specimens

- 250 hair specimens, collected by live trapping
- 60 collagen samples, collected from owl pellets, raptor nests, prairie dog burrows, surface collections, and road kill
- 300 fossil enamel specimens, collected by screen washing

Figure 5. Examples of hair, collagen, and fossil sample type from left to right: road kill, rodent trap, owl pellet, and screen washing

Question 1: Modern Perspective

a.) How are dietary niches partitioned within a Great Plains small mammal* community?
b.) At the community level, how do small mammals reflect plant biomass in a grassland ecosystem?

*And some other common species

$\delta^{13}C$ and $\delta^{15}N$ values of species commonly found in Meade Basin, Kansas

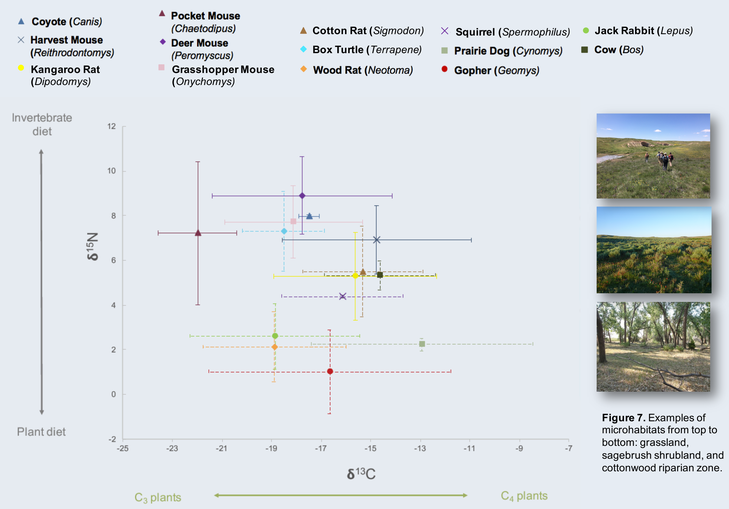


Figure 6. Species averages and standard deviation. Dashed lines indicate this study's collagen data, while solid lines indicate previous study's hair data [2]. Collagen data has been adjusted and are comparable to hair data.

Figure 7. Examples of microhabitats from top to bottom: grassland, sagebrush shrubland, and cottonwood riparian zone.

Question 1a Observations

- Omnivorous generalists like the pocket mouse eat a combination of plant and insect diets and thus have more variable $\delta^{15}N$ values.
- Herbivorous generalists such as the gopher reflect annual and seasonal plant biomass variability, resulting in more variable $\delta^{13}C$ values.

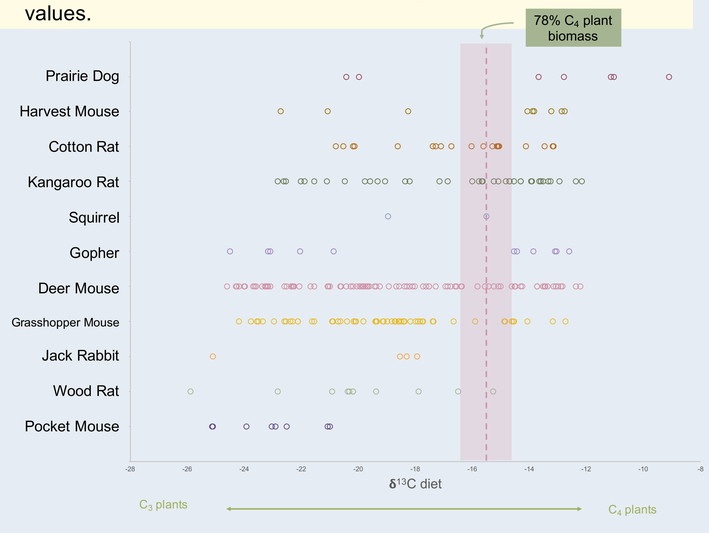


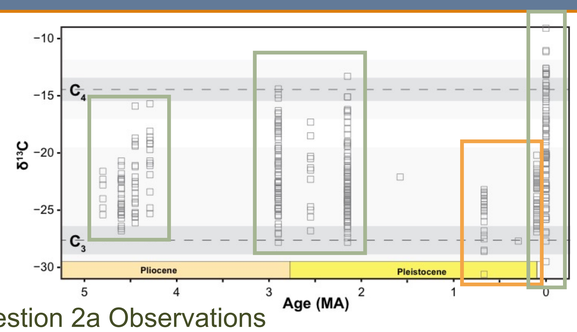
Figure 8. $\delta^{13}C$ values corrected for diet, organized by species. Data is a culmination of previous years hair data and this project's collagen data. Pink shaded box indicates Meade plant biomass $\delta^{13}C$ value mean +/- standard deviation. Average plant biomass $\delta^{13}C$ value estimated using 78% C_4.

Question 1b Observations

- At the community level, small mammal $\delta^{13}C$ values span the full range from pure C_3 to pure C_4 diet. Differences in $\delta^{13}C$ values among taxa reflect niche partitioning.
- The average small mammal community diet underestimates the actual C_4 plant biomass (78%) on the landscape.

Question 2: Geohistoric Interpretations

a.) Does the fossil small mammal $\delta^{13}C$ record reflect changes in C_4 plant biomass over the past 5 million years in the Great Plains?
b.) How have the diets of major small mammal lineages changed in response to an evolving ecosystem?



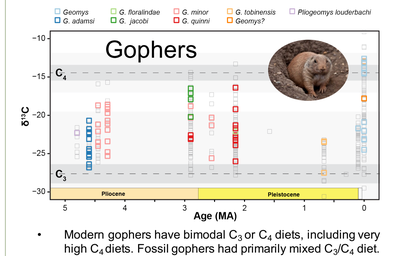
Question 2a Observations

- Overall, small mammal diets expand into C_4 dietary space as C_4 plant biomass increases
- Possible community changes in response to glacial cycles, or taphonomic biases during mid/late Pleistocene

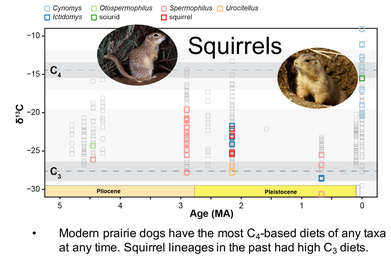
Question 2b Observations

- There is still a gap in modern vole knowledge.

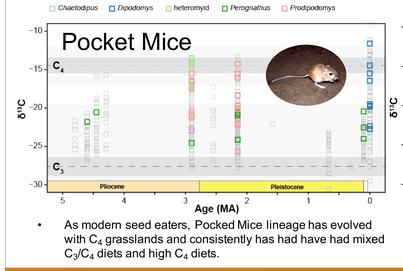
- At all times, mice capture full dietary range. Modern Sigmodon have the most C_4 diet of any mice taxa through time.



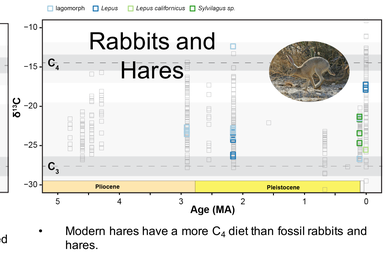
- Modern gophers have bimodal C_3 or C_4 diets, including very high C_4 diets. Fossil gophers had primarily mixed C_3/C_4 diet.



- Modern prairie dogs have the most C_4-based diets of any taxa at any time. Squirrel lineages in the past had high C_3 diets.



- As modern seed eaters, Pocked Mice lineage has evolved with C_4 grasslands and consistently has had have had mixed C_3/C_4 diets and high C_4 diets.



- Modern hares have a more C_4 diet than fossil rabbits and hares.

References and Acknowledgements

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[1]Haveles, A. (2015). *Ecology and Geochemistry of Small Mammals and the Implications for the Fossil Record* (Doctoral defense). Department of Earth Sciences, University of Minnesota, Minneapolis, Minnesota.

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