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Investigation of Spatial Isotope Ratios in Soil and the Effects of Fertilizer on Plant Isotope Ratios

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Investigation of spatial isotope ratios in soil and the effects of fertilizer on plant isotope ratios

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Abstract
A previous Honors study analyzed diet of thirteen-lined ground squirrels at the Andrews University Airpark by studying δ13C and δ15N isotope values of their fecal pellets (Chacko, 2013). Fecal samples collected within 25m of a cornfield had elevated isotope values. High δ13C values indicate greater consumption of C4 plants, such as corn (Ehleringer et al., 1986); high δ15N values indicate increased consumption of animal matter (DeNiro and Epstein, 1981). However, the spatial pattern may be due to variation in the soil, reflecting long-term patterns in the vegetation.

Soil samples were taken throughout the airpark and analyzed for δ13C and δ15N. These baseline values were removed from fecal values, but the patterns of the fecal samples still held. Application of fertilizer to vegetation resulted in a significant increase in δ15N. Thus, the δ15N pattern observed in the fecal samples appears to be due to enrichment in corn.

Methodology
Soil samples were collected throughout the airpark (Fig. 1) and analyzed for δ13C and δ15N isotope values by the Stable Isotope Ratio Facility for Environmental Research (SIRFER). Baseline values of δ13C and δ15N were calculated for each fecal sample (Chacko, 2013) by averaging the soil isotope values within 15m of the fecal sample. These baseline values were then subtracted from the fecal sample values in order to see if the spatial pattern persisted. T-tests were conducted between fecal sample isotope values within 25m of the cornfield and those further away.

The AU Department of Agriculture provided the cow manure and ammonium nitrate that was used to fertilize the cornfield. Eight plots were set up around the airpark, and each plot contained five separate 0.25 m² areas that were used as experimental groups (Fig. 2). The five groups were: 1) nothing added, 2) only water, 3) water and ammonium nitrate, 4) water, cow manure, and 5) water, ammonium nitrate, and cow manure (Fig. 4). After 8 weeks, grass clippings were collected and measured for δ13C and δ15N. The data were analyzed using a One-Way Analysis of Variance (ANOVA) then a post-hoc Tukey multiple comparisons test.

Results

Soil Study:
Soil δ13C and δ15N values were not significantly higher near the cornfield (Fig. 1). After the baseline soil δ13C and δ15N values were removed from the fecal sample isotope values, the spatial pattern of elevated ratios near the cornfield remained (Fig. 3).

Figure 3 – Fecal sample δ13C and δ15N isotope values plotted by location on a map of the AU Airpark, before and after soil baseline removal. The bar graphs indicate the isotope value means of the fecal samples obtained near the cornfield (within 25m) and further away. Error bars: +/- 1 SE.

Fertilizer Experiment:
The One-Way ANOVA indicated a significant variance across the groups (p<0.010; F=4.207, df=4, 34) (Fig. 4). The post hoc test (Tukey HSD) found significant difference between the water only and the water and ammonium nitrate (NH4NO3) groups (p<0.015).

Figure 4 – Average plant δ15N values after 8 weeks of different types of fertilizer treatment. Error Bars: +/- 1 SE

Conclusion
The spatial pattern of the δ13C and δ15N isotopes in the fecal samples did persist even after the baseline soil isotope averages were removed. Thus, the δ13C pattern does seem to be due to greater consumption of corn, a C4 plant. However, there are two possible explanations for the δ15N pattern: the squirrels are consuming more insects near the cornfield, or the corn itself is enriched in N-15 due to fertilizer application.

Animals preferentially excrete N-14, which results in an accumulation of N-15 as one moves up the trophic levels (DeNiro and Epstein, 1981). The spatial variation of δ15N values may thus be indicative of greater consumption of insects and other animal matter. Due to the effect that the ammonium nitrate fertilizer has on plant material, however, it seems more likely that the spatial pattern in the fecal δ15N values is due to N-15 enrichment in the corn due to fertilizer.

Bibliography