

Spatial distribution of nitrogen stable isotope ratio in deer feces in an agro-environment, Osaka

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A rapid increase in the number of sika deer (*Cervus nippon*) in the last decades aroused needs for quantitatively estimating crop herbivory by them, in order to evaluate how much damage they cause to agriculture. Analysis of ingredients in deer feces using observation under microscopes or molecular techniques is useful to reveal whether they consumed crops. Nevertheless, these techniques in common tend to underestimate crop herbivory, because crops are usually digested more easily than wild plants and less likely to remain in the feces. Measurement of fecal nitrogen stable isotope ratio (fecal $\delta^{15}\text{N}$) can be a complement to the molecular technique, considering that application of fertilizer leads to distinctively higher $\delta^{15}\text{N}$ values of crops than the adjacent wild plants. In our previous study using captive deer individuals, we estimated the fecal $\delta^{15}\text{N}$ values are 2.0 to 3.5‰ lower than those of deer diets. Based on the test using captive individuals, the uncertainties of the fecal $\delta^{15}\text{N}$ values associated with the variations in isotopic fractionation were far less than the difference of $\delta^{15}\text{N}$ values between fertilized crops and wild plants. In this study, for a field validation of the fecal $\delta^{15}\text{N}$ measurements as an indicator of crop consumption, we examined the spatial distribution of the fecal $\delta^{15}\text{N}$, assuming the crop consumption should occur in the individuals of sika deer inhabiting close to cropland.

Deer feces were collected in 80 forested sites in the northern part of Osaka prefecture in the 2014 to 2015 winter period. The fecal samples, which were dried at 60°C, ground, and homogenized for each of the fecal mass, were used for $\delta^{15}\text{N}$ measurements. Based on GPS telemetry of sika deer in the region (Ishizuka et al., 2007), we assumed that short-time moving range of sika deer is around 500 m in radius and the accessibility of crops for the deer is reflected by surrounding land use within the distance from sampling points. Land use surrounding sampling points were categorized into four components; forest, crop field, herbal vegetation, residential area and area of each component were calculated. Land use data are obtained from MoE National Surveys on the Natural Environment and area (m²) of the surrounding sampling points. We conducted Spatial AutoRegressive model (SAR) and PCNM-RDA analyses to analyze the effects of surrounding areas of these landscape components on the fecal $\delta^{15}\text{N}$ values and concentrations of nitrogen in the feces.

The surrounding area of crop field was selected as a single variable to explain the fecal $\delta^{15}\text{N}$ values, and the positive correlation between the fecal $\delta^{15}\text{N}$ values and crop field area indicated the availability of crop to deer was a factor of the increase in the fecal $\delta^{15}\text{N}$ values. Based on the result, this study supported our hypothesis that fecal $\delta^{15}\text{N}$ values are an effective indicator of crop consumption by sika deer. In our presentation, we will further discuss about the relationships among concentration of nitrogen in the feces, which is known as an indicator of nutritional status of the defecated individual, estimated deer population density, and land use to elucidate factors inducing crop consuming behavior of sika deer.

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