Plants, People, Planet **Supporting Information**

Article title: Dogs occupying grassy habitat near protected areas in eastern Madagascar rely on foods from forests

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The following Supporting Information is available for this article:

Method S1. This document includes all details regarding data collection and analysis that are not included in the text of the main manuscript.
Dataset S1. This spreadsheet includes all data obtained from dog feces as part of this study.
Dataset S2. This spreadsheet includes previously-published plant stable isotope datasets from the study region.
Dataset S3. This spreadsheet includes a compilation of previously-published references to observed dog prey.
Dataset S4. This spreadsheet includes previously-published stable isotope datasets from animals for comparison with data from the present study (including compilation of observed differences in stable isotope values between tissue types).

Methods S1

2.2 Data Analysis

2.2.1 *Fecal Dataset Trends*

Distances between dog fecal collection sites and the forests of Andasibe-Mantadia and Analamazoatra were estimated using the NN Join tool in QGIS. Spearmann correlation coefficients were used to explore gradients in C:N, $\delta^{13}C$, and $\delta^{15}N$ values according to distance to forest. To help visualize spatial tendencies in $\delta^{13}C$ and $\delta^{15}N$, isoscapes were created using a Bayesian approach in the IsoMemo application AverageR. To identify significant effects of the presence/absence of certain materials in feces (abundant plant material, animal remains, and human trash) on fecal C:N, $\delta^{13}C$, and $\delta^{15}N$ values while controlling for distance to forest, we used general linear models (GLMs). The R package glmulti (Calcagno & de Mazancourt, 2010) with the Akaike information criterion (AIC) helped to identify the most parsimonious variables to explain the observed variation in fecal C:N, $\delta^{13}C$, and $\delta^{15}N$ values. We used the following approaches to compare stable isotope values of dog feces with plant (2.3.1 and 2.3.2) and potential prey data (2.3.3).

2.2.2 *Plant Carbon Data and Corrections for Comparison*

We compiled 226 previously published plant $\delta^{13}C$ values from Madagascar to help assess whether the dog's meals came from forest (C_3-plant dominated) or grassland (C_4-plant dominated) ecosystems (Dataset S2). Note that the forests include some plants that use CAM photosynthesis, but, given that CAM plants in the region tend to be relatively scarce epiphytes, we assume that they contribute little to food webs that include dogs. The C_3 plant data (n=135) come from sites elsewhere in the humid forest of eastern Madagascar (Tsinjoarivo and Ranomafana) (Crowley et al., 2011), CAM plant data (n=30) come from epiphytes collected in Analamazotroa National Park (Kluge et al., 1995), and C_4 plant data (n=61) come from sites in southwestern Madagascar (Beza Mahafaly, Ranobe, Andrevo, and Ambohimahavelona) (Crowley & Godfrey, 2013; Hixon et al., 2021b). Given that C_4 plant $\delta^{13}C$ values are mostly conserved across aridity and vegetation gradients (unlike C_3 plants, see (Crowley et al., 2012)), we are confident in comparing C_4 plant $\delta^{13}C$ data from arid southwest Madagascar with fecal $\delta^{13}C$ data from mesic east Madagascar. To ease comparison between plant and other $\delta^{13}C$ data, plant $\delta^{13}C$ datasets based on specimens collected during the decades preceding the collection of dog feces in 2018 were corrected to account for the recent depletion in atmospheric $^{13}CO_2$ (Suess Effect), following the approach of Crowley and Godfrey (2013).

Carbon in feces derives from a mixture of protein, cellulose, lipids, and carbohydrates that tends to be ^{13}C enriched relative to the bulk tissue of plants at the base of the food web. This prevents precise comparisons between bulk fecal and bulk plant $\delta^{13}C$ values. On an intuitive level, undigested cellulose should have $\delta^{13}C$ values comparable to those of bulk plant tissue, while herbivore prey tissue (lipids and proteins) should be ^{13}C enriched (DeNiro & Epstein, 1978). Additionally, among consumer tissues, lipids tend to be depleted in ^{13}C relative to protein (up to ~5‰ in some cases (Post et al., 2007)). Fortunately, the large difference in the Suess-corrected $\delta^{13}C$ values of C_3 plants (n=135, m= −30.5‰) and C_4 plants (n=61, m=−14.0‰, with difference in medians of ~16‰), suggests that the signal to noise ratio is sufficiently high to justify using fecal $\delta^{13}C$ values to compare reliance on C_3 versus C_4-based food webs.

With these limitations in mind, we can make an approximate correction that improves the comparison of $\delta^{13}C$ data from bulk dog feces and plants. Both herbivores and carnivores tend to have feces depleted in ^{13}C ~0.9‰ relative to diet (Codron et al., 2007; Codron et al., 2005; Sponheimer et al., 2003). If we assume a dog to be herbivorous, then we can add 0.9‰ to fecal $\delta^{13}C$ values to approximate the $\delta^{13}C$ values of plants at the base of the food web. Herbivore protein is enriched in ^{13}C ~3-5‰ relative to herbivore dietary protein (DeNiro & Epstein, 1978; Lee-Thorp et al., 1989), so, assuming that dog diet is high in herbivore protein, dogs that consume primarily herbivore protein should produce feces enriched in ^{13}C by ~4‰ (2.1-4.1‰) relative to the plants at the base of the food web.

2.2.3. *Plant Nitrogen Data and Corrections for Comparison*

We can approximate dog trophic level based on offsets between dog fecal $\delta^{15}N$ values and the $\delta^{15}N$ values of plants at the base of the given food web. Plant $\delta^{15}N$ values vary significantly according to soil nitrogen cycling, which is sensitive, in part, to water availability (Luo et al., 2018; Vitousek et al., 1997). Because of this variation, it is important to identify $\delta^{15}N$ baseline

when trying to infer trophic level from consumer $\delta^{15}N$ data. Ranomafana and Tsinjoarivo are the closest sites in eastern Madagascar to Andasibe-Mantadia that include plant $\delta^{15}N$ data (all from C_3 plants). The plant $\delta^{15}N$ values at Tsinjoarivo (where MAP≈1,500 mm/yr, n=49, $\bar{x}$=−1.5‰, SD=2.0‰) are significantly lower than those at Ranomafana (where MAP≈1,500 mm/yr, n=86, $\bar{x}$=−0.6‰, SD=1.4‰, t(133)=2.98, p=0.003). Because the magnitude of this difference is small (<1‰) and Andasibe is similarly mesic, we assume that the average plant $\delta^{15}N$ value across Tsinjoarivo and Ranomafana (n=135, $\bar{x}$±SD=−0.9±1.7‰) is a reasonable approximation of plant $\delta^{15}N$ values at Andasibe.

Unlike carbon, the low nitrogen content of feces (n=100, 0.5-10.9‰ by weight, with m=2.9‰) is present only in protein. Feces tend to be ^{15}N enriched by ~1‰ relative to diet (Codron et al., 2007; Sutoh et al., 1987). Thus, we can subtract 1‰ from dog fecal $\delta^{15}N$ values before differencing with plant $\delta^{15}N$ values to estimate the offset that may be explained by trophic level. We assume that consumer protein is ^{15}N enriched by ~3‰ per trophic level (DeNiro & Epstein, 1981), but these estimates vary widely (up to ~6‰ (McCutchan et al., 2003)).

2.2.4. Comparisons with Other Animals

To plot dog fecal stable isotope data relative to those of potential prey (Dataset S3, modified from (Hixon et al., 2021a)), we compiled previously-published $\delta^{13}C$ and $\delta^{15}N$ data and summary statistics based on 803 fur samples of potential prey individuals that were collected within 150 km of the study area (Dataset S4). These potential prey include introduced rodents (n=598, (Crowley et al., 2018; Dammhahn et al., 2017)), lemurs (n=114, (Crowley et al., 2013)), tenrecs (n=81, (Dammhahn et al., 2013)), and endemic rodents (n=10, (Dammhahn et al., 2013)). Dog fecal stable isotope values would be useful to compare also with ancient dog tissue values (to identify dietary change through time and across space) and with data from zebu cattle (*Bos taurus indicus*, a potential source of food scraps from agropastoralists) and fosa (*Cryptoprocta ferox*, a potential competitor and possibly prey). However, bone collagen data from these groups (n=70) exist primarily from arid southwest Madagascar (Hixon et al., 2021a; Hixon et al., 2021b), which has significantly higher $\delta^{15}N$ baselines than the present study region. Thus, we cannot meaningfully compare southwestern Madagascar consumer $\delta^{15}N$ values with the fecal dataset from eastern Madagascar, and we must treat the comparison of $\delta^{13}C$ data with caution due to the distinct vegetation of southwestern Madagascar. Previously published differences in the $\delta^{13}C$ and $\delta^{15}N$ content of different consumer tissues and diet were applied to the compiled fecal, hair, and bone datasets to approximate the isotopic composition of corresponding bulk diet (Dataset S4). This approach to dietary inference is approximate for many reasons, including the fact that we do not propagate uncertainty associated with point estimates of differences in stable isotope values of <5‰ observed among tissue types. As with the plant samples discussed above, bone collagen and fur keratin $\delta^{13}C$ values were corrected to account for the recent depletion in atmospheric $^{13}CO_2$ (Suess Effect), following the approach of Crowley and Godfrey (2013).

Methods S1 References

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