Seasonal ecology of ring-tailed lemurs: a comparison of spiny and gallery forest habitats

Marni LaFleur & Michelle Sauther

Introduction

Ring-tailed lemurs are a remarkably flexible edge or weed species (Sussman, 1977; Gould et al., 1999; Sauther et al., 1999) that persist in a variety of habitats in southwestern Madagascar including: spiny and xerophytic forests, gallery and deciduous forests, anthropogenically induced savanna, scrub and brush land, and the mesic high altitude forests of the Andringitra mountain range (see Goodman et al., 2006). Each of these habitat types likely present unique challenges in terms of finding food, water and shelter, yet to date, we know little about how these proximate variables affect ring-tailed lemur behavior, nutrition, and ultimately fitness (see Gould, 2006). In two different forest types (spiny and gallery), we examined feeding behavior of ring-tailed lemurs and the nutritional content of their plant foods in order to examine differences between: plant food species and plant part consumed, and intake of macronutrients (crude protein, soluble carbohydrates) and fiber (acid-detergent).

Methods

Study sites: TNP and BMSR are both on the Mahafaly Plateau of southwestern Madagascar and are separated by a distance of approximately 150km. Both sites are highly seasonal with the vast majority of rainfall occurring between November and April. BMSR (23.67°S, 44.60°E) Data were collected in the riparian forests of parcel one during 1987-1988 (MS). This region has an average annual rainfall of 470mm (Ratsirarson and Richard, 2010). The dry season dramatically reduces food availability, however, this habitat is dominated by Tamarindus indica trees (e.g. Sussman and Rakotosazafy, 1994), which are a particularly important resource for these ring-tailed lemurs as the trees produce leaves, flowers and fruits year-round and asynchronously (Sauther et al., 1999; Yamashita, 2002, 2008). TNP (24.09°S, 43.83°E). Data were collected in the dry spiny dwarf forests during 2010-2011 (NL). Annual rainfall is usually under 300mm and the dry season may be longer than that of BMSR. Tamarind trees are present at TNP, but at a low density, and the ring-tailed lemurs do not appear to use tamarind resources to the same extent they do in other gallery forest habitats.

Study species: Lemur catta are semi-terrestrial, group-living species with strict female dominance (Jolly, 1966). They have restricted seasonal reproduction with an annual mating period in April or May, depending on locality. Infants are born from late September to early October, and reproductive females lactate during the later portion of the dry season and well into the wet season. Ring-tailed lemurs are opportunistic folivore/frugivores (Sauther, 1994). Behavioral data collection: Scan sampling data (Altman, 1974) were collected at 5-minute intervals for all visible adult animals in the focal group. When individual lemurs were feeding, the plant species and part were noted.

Plant food data: Representative plant foods were collected and dried in the shade, before being transported to the Department of Animal Ecology and Conservation at Humboldt University in Germany. Chemical analyses included: crude protein (nitrogen x 6.25, kjeldahl method), soluble carbohydrates (equivalent of galactose after acid hydrolysis of 50% of the methanol extract), and acid detergent fiber (modified Ankrom fiber analyser). Abiotic data: Millimeters of rainfall were measured daily at BMSR and TNP. Data analyses: We compared the most frequently consumed plants and plant parts at each study site for each month of both studies. Of the top five most frequently consumed plant foods per month at each site, we created index of each nutritional component measured using the following formula: Protein index = \sum_{i=1}^{5} \frac{obs_{i}}{n} x 15 \% of top five foods consumed * % of protein in food. We then used the Student’s T-Test to detect variation within the number of times a plant part (i.e. leaf, flower, fruit) was selected by focal animals, and the monthly index values for nutritional components of the plant foods. ADF content was not obtained for T. indica fruits because of methodological problems with the sample. In order to account for the fiber content present in tamarind fruits we carried out calculations using the following substitute values for ADF content: 0% (no ADF present), 7.6% (Gould et al. 2011). The literature value of 7.6% ADF for tamarind fruit pulp is likely closest to the actual value, while substituting 0% ADF likely under-estimates the fiber content.

Results

BMSR received about twice the precipitation of TNP during the study periods (BMSR= 506.7mm, TNP= 232.9mm) (Figure 1). Moreover, although BMSR received at least some precipitation in every month of data collection (n=7), TNP did not (n=4). Of the top five foods consumed by ring-tailed lemurs in spiny and gallery forests only Gymnocalcium mihanovichii (Kotipoke) was common to both. We found no significant site-specific differences in the type of plant part consumed per month (flower (n=1,99, df=12, p=0.68); fruit (n=1,03, df=12, p=0.087); leaf (n=0.44, df=12, p=0.664). During each month of the study period, the BMSR lemur’s plant food index was significantly higher than the TNP lemurs (t=4.434, df=12, p<0.001) (Figure 2). Although the BMSR lemur’s plant food index of soluble carbohydrates was lower than the TNP lemurs in each month of the study, these differences were not significant (t=1.32, df=12, p=0.241) (Figure 3). There was no significant difference found between the BMSR and TNP lemur plant foods ADF content when the fiber content of tamarind fruits were not accounted for (t=1.76, df=12, p=0.110). However, when using the literature value of 7.6% ADF for T. indica fruit pulp (Gould et al. 2011) we find that the BMSR lemur foods contain significantly more fiber when compared to the TNP lemur foods (t=2.198, df=12, p=0.048) (Figure 4).

Discussion

The behavioral ecology of ring-tailed lemurs has been largely typified by data from gallery forest habitats. However, this species persists in a suite of habitat types and is able to adjust to significant environmental perturbations. Comparative data from non-gallery forest habitats are important for understanding the proximate and ultimate causes of plasticity in ring-tailed lemurs.

Our results suggest that gallery forest ring-tailed lemur food sources are much higher in crude protein, in part because tamarind trees 1) provide a near steady supply of proteinaceous foods (leaf buds = 64% crude protein, the highest concentration of any measured plant) and because 2) tamarind trees are highly concentrated in dense riparian forests. Conversely, lack of protein-dense foods may be a function of reduced rainfall in spiny forest habitats and comparatively low densities of tamarind trees. The most protein dense plants measured from TNP were Gymnocalcium mihanovichii (Kotipoke) flowers (crude protein TNP= 28%), which have significantly less protein than most protein dense fruit from BMSR (64%).

Our results also indicate that galaxy forest ring-tailed lemur food sources are higher in ADF. Again, this dietary disparity is likely due to the inclusion of tamarind foods in the BMSR lemurs’ foods. Tamarind leaf buds were a top food in both the BMSR and these leaves contained the highest measured ADF content (51%). The most ADF dense foods at TNP were the fruits of Picus marmorata (44%), but these compose a relatively small component of the diet (6% October, 6% November). High fiber levels can interfere with nutrient uptake, including protein absorption (Ulrey et al., 2003; Campbell et al., 2000), however, these relationships are not well understood and can vary even between closely related species (see Sponheimer et al., 2003).

Data presented here were collected during the annual time period when female ring-tailed lemurs are lactating, an energetically demanding physiological process. Protein is thought to be a particularly important macronutrient during gestation and lactation, because it provides the nitrogenous building blocks which are essential for DNA replication, body growth and maintenance, and regulation of bodily functions (Ulrey et al., 2003). Although the vast majority of our knowledge on ring-tailed lemur ecology comes from gallery forest sites, comparative data from the other habitats where these animals persist are important for understanding their ecological flexibility and the limits of their tolerance. Here, we demonstrate that habitat can affect certain macronutrients and fiber content in the plant foods of ring-tailed lemur. It is possible that the BMSR ring-tailed lemurs benefit from a fitness advantage given the relatively elevated protein content of consumed plant foods, however this needs to be explored further alongside data the effects of fiber intake, and how these influence infant survivorship and subsequent reproduction.