COMPARISON OF FORAGING BEHAVIOR BETWEEN HOWLER MONKEYS, SPIDER MONKEYS, AND SQUIRREL MONKEYS

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Abstract: Different monkey species have different foraging behaviors based on their preferred food and its availability. We compared foraging behavior of focal individuals of 3 monkey species: *Alouatta palliata* (howler monkey; a folivore), *Ateles geoffroyi* (spider monkey; a frugivore) and *Saimiri oerstedii* (squirrel monkey; an omnivore on fruits and insects). We predicted that howler monkeys would spend a larger proportion of time foraging, and a smaller proportion of time moving, than the other two species. We found that squirrel and spider monkeys spent the greatest proportion of time foraging, the greatest proportion of time moving, and traveled farther than howler monkeys. Proportion of time spent moving, and the total distance traveled by each species, appear to be driven by food availability. However, proportion of time spent foraging appears to depend on overall energy demands and not food quality. We suggest that specific energetic demands and food availability be considered in explaining mechanisms that drive monkey foraging behavior.

Key Words: foraging, Alouatta palliata, Ateles geoffroyi, Saimiri oerstedii

INTRODUCTION

Monkeys spend a large proportion of their time foraging to obtain energy for other activities. However, different species of monkeys prefer different food types. *Alouatta palliata* (howler monkey), *Ateles geoffroyii* (spider monkey) and *Saimiri oerstedii* (squirrel monkey) are three species of New World monkeys commonly found in Corcovado National Park, Costa Rica. Each species has different food preferences: howler monkeys are selective folivores (Mittermeir and Coimbra-Filho 1977), spider monkeys are selective frugivores, and squirrel monkeys consume a wide variety of foods such as fruits, insects, and nectar (Carrillo et al. 1999).

In this study, we compared foraging behavior of these three species. We hypothesized that each species would exhibit different foraging behaviors based on differences in food quality and availability, which we expect to be inversely related. In general, leaves (a low-quality food) are abundant, while fruit (a better-quality food) is less abundant, and insects (a high-quality food) are the least abundant. If we were to assume an inverse relationship between food quality and quantity, we would predict that: (1) time spent foraging is lowest in howler monkeys and highest in squirrel monkeys; (2) time spent moving is lowest in howler monkeys and highest in squirrel monkeys.

However, food availability might not vary according to food quality since we know that not all leaves and fruit are equally edible, and monkeys are discriminating foragers. Then we would not predict the same patterns in time spent foraging, moving, or distance traveled, among the three monkey species.

There is also a relationship between food quality and metabolic rate of the consumer, where low food quality may be associated with lower metabolic rates. Thus, species that depend on high-quality food should be more active, or spend less time resting, than species with lower metabolic rates. Under this hypothesis, howler monkeys would rest the most, and squirrel monkeys would rest the least. We acknowledge that this hypothesis may be too simple, as metabolic rates may be reflected in rate of movement and activity as well as (or instead of) resting time.

METHODS

We observed howler, spider, and squirrel monkeys on 1 - 4 February 2006, along Naranjos, Rio Claro, Espaveles, Ollas, Guanacaste, and Pavo trails in Corcovado National Park, Costa Rica. We observed the monkeys intermittently between 07:30 and 17:30 during two 3-hour intervals on each day. We recorded number of individuals per troop, haphazardly chose focal individual monkeys within troops, and observed them for five minutes. Although we made an effort to choose in an unbiased manner, focal individuals were usually the most visible individuals in the troop. Using five one-minute increments, we categorized animal behavior as foraging (searching for and manipulating food), watching (scanning surrounding ground and vegetation), resting (sitting, lying, or sleeping without any other activity), moving (walking and climbing not accompanied by other activities), or performing other activities (behaviors not fitting into the above categories). We also estimated the total distance each individual moved during the observation period. We collected and identified samples of each species' food resource when possible (Appendix A).

We examined species differences in proportion of time spent foraging, moving, watching, resting, and other behaviors, and total distance traveled using a two-way ANOVA, with troop nested within species. We examined the directionality of results using general linear contrasts. Also, we recorded the number of individuals in each troop and tested the effects of species on troop size using a one-way ANOVA (Appendix B). We performed all analyses with JMP 5.0.1.

RESULTS

During the 5-day sampling period, we observed 99 focal individuals from 39 monkey troops (6 howler, 24 spider, 9 squirrel) varying in size from 2 - 25 individuals. The three species spent similar proportions of time foraging (Fig. 1). Squirrel monkeys spent a greater proportion of time moving than spider monkeys, which spent a greater proportion of time moving than howler monkeys (Fig. 2). Squirrel monkeys and spider monkeys moved further than howler monkeys (Fig. 3). No one species spent a significantly greater amount of time resting than another, but a linear trend in the data suggested that howler monkeys spend the

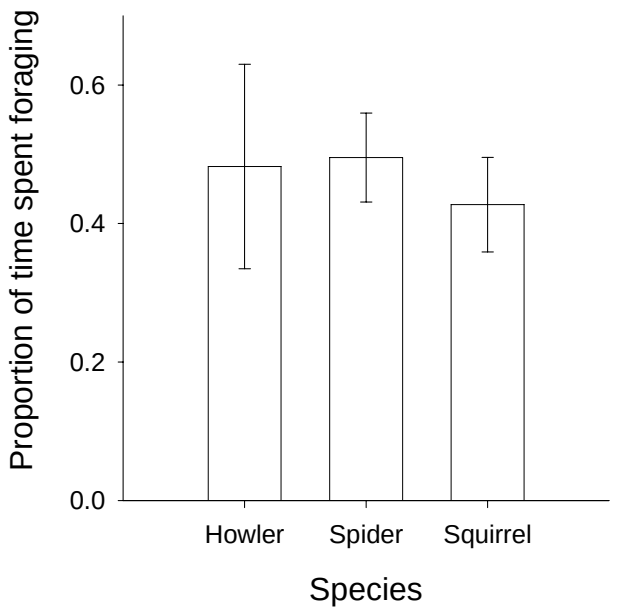

Figure 1. Proportion of time spent foraging during a 5-minute interval (mean ±1 SE) did not differ among monkeys species in Corcovado National Park, Costa Rica ($F_{2, 25} = 0.09$, P = 0.91).

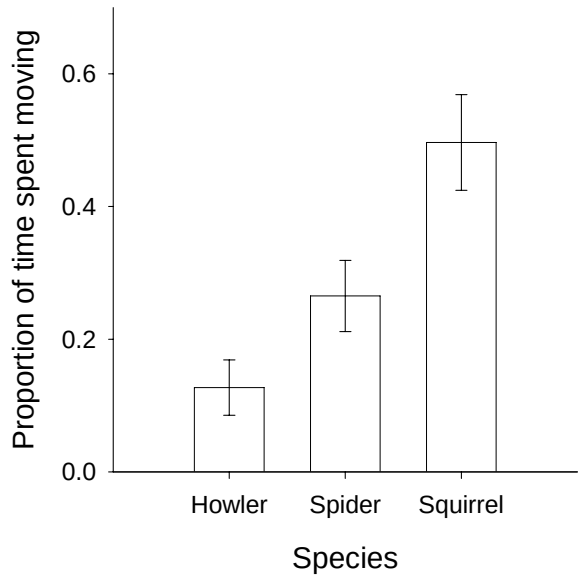

Figure 2. Proportion of time spent moving during a 5-minute interval (mean ±1 SE) for individuals of three monkey species in Corcovado National Park, Costa Rica ($F_{2, 25} = 5.61$, P = 0.011; P = 0.0028 for linear trend).

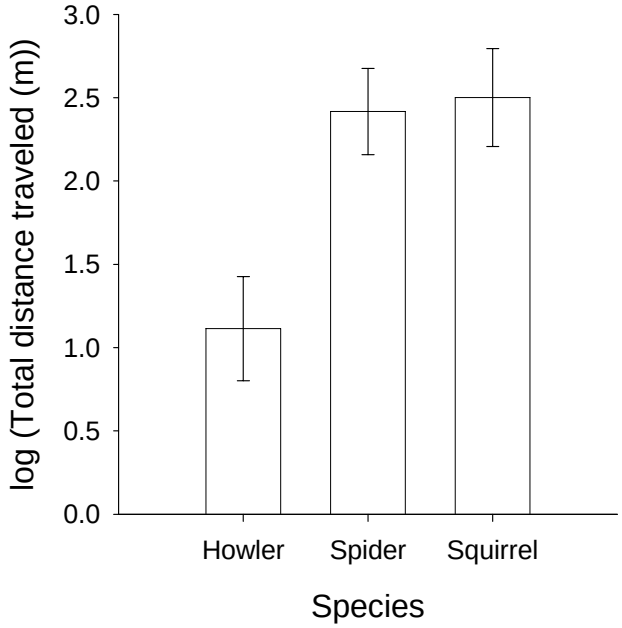

Figure 3. Log of total distance traveled during a 5-minute interval (mean ±1 SE) for individuals of three monkey species in Corcovado National Park, Costa Rica ($F_{2, 25} = 4.57$, P = 0.02; P = 0.03 for linear trend).

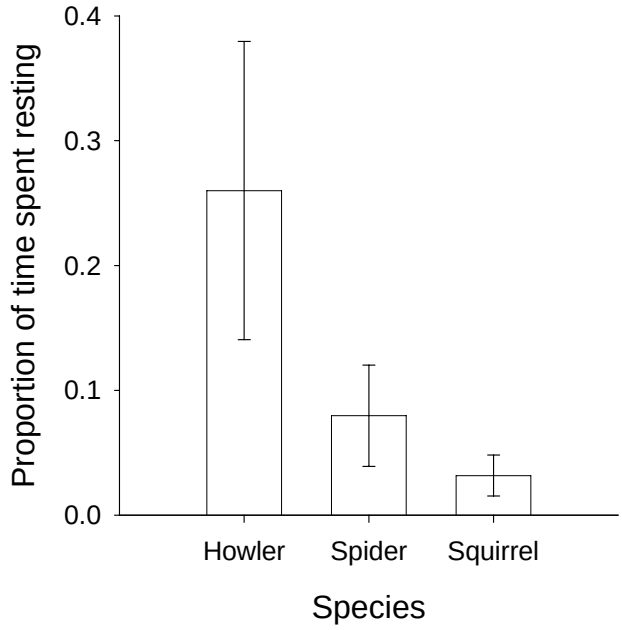

Figure 4. Proportion of time spent resting during a 5-minute interval (mean ±1 SE) for individuals of three monkey species in Corcovado National Park, Costa Rica ($F_{2, 25} = 2.37$, P = 0.012; P = 0.077 for linear trend).

most time resting, while squirrel monkeys rest the least (Fig. 4). No one species spent a greater proportion of time watching or performing other activities than another (all $P > 0.57$).

Troop size varied significantly across species (Appendix B). Food resources collected for all species matched the literature (Carrillo et al. 1999; Mittermeir and Coimbra-Filho 1977; Appendix A).

DISCUSSION

As predicted, the proportion of time spent moving (and the total distance traveled by each species), was associated with food quality. Squirrel monkeys must search for food more than spider monkeys, while howler monkeys apparently search (move) the least. Squirrel monkeys spent a larger proportion of time moving than spider monkeys, yet the total distance traveled is similar to that of spider monkeys. This may simply be a function of body size; squirrel monkeys (0.5 - 1 kg) are much smaller than spider monkeys (5 - 9 kg; Carrillo 1999) and are likely not able to move at the same rate.

Food quality does not appear to be the primary factors influencing the amount of time each species spends foraging. Howlers appear to spend more time resting than either of the other species, and therefore expend less energy searching for food. It is also possible that foraging time is distributed differently throughout the day for different species. For example, because they use fermentation to digest leaves, howler monkeys may spend more time foraging in the earliest part of the day, and less time later in the day. Because we did not observe the monkeys over a wider time range, such as continually from daybreak to sundown, our methods were not designed to detect schedules of foraging behavior.

We believe that our data fairly represent the general foraging behaviors of each species, although our visual estimates of total distance traveled were rough. We suggest that energetic demands and actual food resource availability be examined in more detail for each species to better understand the physiological mechanisms behind foraging behavior. Although we used proportion of time spent watching to evaluate predator avoidance behavior, proportion of time spent moving may also be associated with predator avoidance.

Foraging behavior determined by food quality and availability may influence the distribution of monkey species within an area such as Corcovado National Park. In general, if howlers need to move less to find food, they may have lower space requirements than other monkey species. However, this would depend on the distribution of preferred leaf species.

The monkey community within the park may be dynamic. Lief et al. described spider monkeys and white-faced capuchins (*Cebus capucinus*) as the two most abundant species in Corcovado National Park (1996), but we observed only one troop of white-faced capuchins. It is unclear whether such changes are due to resource availability, space requirements, predation, or disease. However, both our samples and those of Lief et al. (1996) were small, so differences may be due to chance.

LITERATURE CITED

Carrillo et al. 1999. Squirrel Monkey, Mantled Howler Monkey and Geoffroy's Spider Monkey in Costa Rica Mammals. Institute Nacional de Biodiversidad: Santo Domingo de Heredia.

Lief, G.M. et al. 1996. Foraging strategies and niche partitioning in *Ateles geoffroyi* and *Cebus capucinus* in Dartmouth Studies in Tropical Ecology 1996. Dartmouth College: Hanover, NH.

Mittermeier R.A. and Coimbra-Filho A.F. 1977. Primate Conservation, H.R.H. Prince Rainier III and G.H. Bourne (eds.), New York Academic Press.

APPENDIX A. Food resources we observed individuals of each species consuming 1-4 February 2006, in Corcovado National Park, Costa Rica.

Monkey Species	Plant Family	Species	Portion of Plant Consumed
Howler monkey	Morphotype A		Leaf
Spider monkey	Anacardiaceae	*Spondias purpurea*	Fruit and leaf
	Annonaceae	*Guatteria amplifolia*	Fruit
	Arecaceae	*Astrocaryum standleyanum*	Fruit
	Malpighiaceae	*Byrsonima crispa*	Fruit
	Moraceae	*Ficus spp. 1*	Fruit
		Ficus spp. 2	Fruit
Squirrel monkey*	Meliaceae	*Guarea pterorhachis*	Fruit
	Moraceae	*Ficus costaricana*	Fruit

*Squirrel monkeys were also observed consuming insects which we were unable to identify.

APPENDIX B. Maximum, minimum and mean (± SE) troop size for each of three monkey species. Troop size was significantly different across species ($F_{2, 38} = 6.83$, $P = 0.0029$). Data were recorded on 1-4 February 2006, Corcovado National Park, in Costa Rica.

Monkey Species	Maximum	Minimum	Mean
Howler	16	4	7.75 ± 1.88
Spider	12	2	4.25 ± 1.08
Squirrel	30	5	11.78 ± 1.77