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BRIEF REPORT

Predation of Arthropods by Southern Bearded Sakis (*Chiropotes satanas*) in Eastern Brazilian Amazonia

LIZA M. VEIGA[1]* AND STEPHEN F. FERRARI[1,2]
[1]*Department of Experimental Psychology, Federal University of Pará, Belém, Brazil*
[2]*Department of Biology, Federal University of Sergipe, São Cristóvão, Brazil*

Bearded sakis are seed predators, but are also known to consume arthropods. This is the first detailed report of arthropod predation in southern bearded sakis (*Chiropotes satanas*). Two groups were monitored–one in continuous forest, and one on a small island–between January 2003 and February 2004. The arthropod prey included spiders and six insect orders. Island group members spent more time foraging for arthropods (3.8% vs. 2.6% of activity time) but ingested less prey (3.7% vs. 4.6% of feeding time). Arthropods accounted for a small proportion of feeding records in most months, but there were occasional sharp peaks due to the exploitation of temporary agglomerations of insects. In November, arthropods accounted for 26.6% and 14.2% of the feeding records of the mainland and island groups, respectively. The results suggest that bearded sakis actively seek arthropods as a dietary supplement, but that they represent a minor resource during most of the year, even under conditions of intense habitat fragmentation (island group). Am. J. Primatol. 68:209–215, 2006.

Key words: *Chiropotes satanas*; foraging behavior; arthropods; diet; Amazon

INTRODUCTION

Bearded sakis (*Chiropotes* spp.) consume large quantities of ripe and immature seeds [Ayres, 1981; Kinzey & Norconk, 1990; Peetz, 2001; Silva, 2003; van Roosmalen et al., 1981], complemented by mesocarp, flowers, and other plant parts. They also feed on arthropods, and studies from Brazil, Surinam, and Venezuela have documented the exploitation of 10 taxonomic orders [Ayres & Nessimian, 1982; Frazão, 1991; Kinzey & Norconk, 1993; Mittermeier et al., 1983; Peetz, 2001; Pinto & Setz, 2005; Silva, 2003; Vieira, 2005]. Two main patterns of arthropod predation are observed in *Chiropotes*: the occasional capture of prey

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*Correspondence to: Liza M. Veiga, Department of Experimental Psychology, Federal University of Pará, Av. Augusto Corrêa, 1, Belém, PA, Cep: 66075-110, Brazil. E-mail: lizaveiga@yahoo.co.uk

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during foraging activities, and the systematic predation of temporary agglomerations of insects.

Typically, then, arthropods contribute to only a small proportion of the bearded saki's feeding time during most months, but they can be seasonally important. For example, Frazão [1991] recorded arthropod predation only during the early dry season (peaking at 17.8% in August) during his 12-month study of bearded sakis in Brazil. Similarly, Peetz [2001] recorded no more than 3.9% arthropod feeding during most months in Venezuela, except for the early wet season months of April and May, when their contribution to the feeding records of *C. chiropotes* rose to 14.5% and 20.8%, respectively.

In this study, arthropod foraging patterns were analyzed in two free-ranging groups of southern bearded sakis (*Chiropotes satanas*). *C. satanas* is endemic to eastern Amazonia east of the Tocantins river, and is the most endangered taxon of bearded saki, whether it is classified as a true species or the nominal subspecies [Hershkovitz, 1985]. The former classification is used here, following the review of Silva-Junior and Figueiredo [2002], which included molecular data. This classification has been adopted by the IUCN [Rylands et al., 2003]. The present study demonstrates that while arthropods made an important contribution to the diet of both groups in some months, they were not a dietary staple, even under conditions of extreme habitat fragmentation.

MATERIALS AND METHODS

The study took place on the right bank of the Tucuruí hydroelectric reservoir on the Tocantins River in southeastern Brazilian Amazonia (4°15′S, 49°31′W). The mean annual precipitation there is 2,250 mm, with a distinct dry season between June and November. Two groups were monitored between January 2003 and February 2004, with four to five complete observation days per group each month except for May and June. The ''mainland'' group occupies a home range of approximately 75 ha in continuous primary lowland terra firme forest on the margin of the reservoir, while the ''island'' group lives on a small (18 ha) island with similar habitat that was formed after flooding in 1985.

The mainland group had 34 members at the start of the study, which increased to 39 by the final month, whereas the island group started with seven and increased to eight. Behavioral data were collected throughout the daily activity period in 1-min scan samples at 5-min intervals [Altmann, 1974], resulting in a total of 20,718 records. Additional records of prey capture were collected in all-events sampling.

Foraging and feeding frequencies were calculated from scan records, and the all-events data contributed only to the list of arthropods consumed. The term ''foraging'' includes visual scanning of vegetation and the manipulation of nonfood items. ''Feeding'' is defined as the removal, opening, biting, ingestion, and mastication of all or part of a food item. Whenever possible, samples of prey were collected for the identification of taxa.

RESULTS

Arthropod Foraging

In both groups members of all age-sex classes foraged for insects, and it was common for several individuals to forage simultaneously, often in the same tree. Foraging patterns included rummaging through and turning over leaves, investigating dry fruits of species such as *Eschweilera coriacea* (Lecythidaceae)

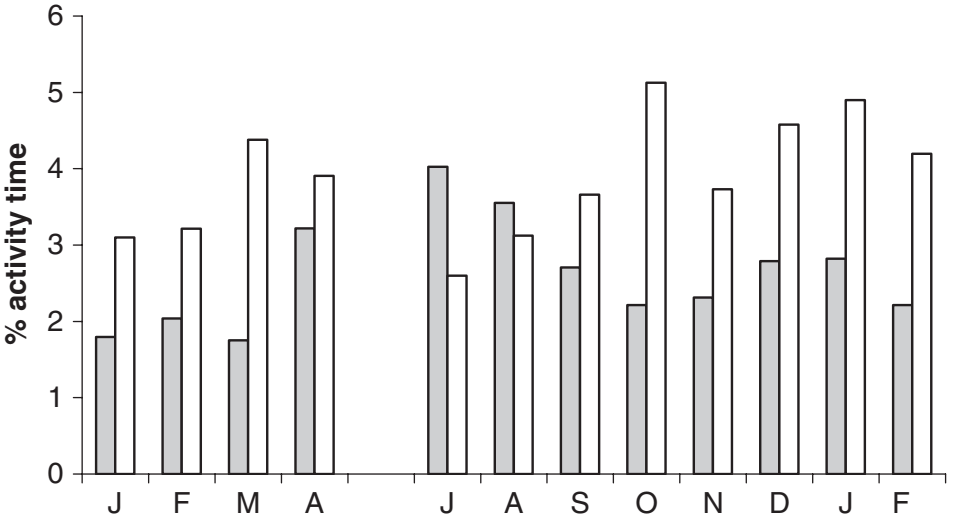

Fig. 1. Time spent foraging for arthropods each month by the mainland (shaded columns) and island (unshaded) sakis as a percentage of scan sample records between January 2003 and February 2004.

and *Manilkara huberi* (Sapotaceae), and manipulating dead twigs and branches. The island sakis were also seen stripping bark off of *Eschweilera subglandulosa* trees to search beneath.

Overall, the mainland sakis dedicated 2.56% of their activity time to arthropod foraging, with monthly values of 1.75–4.03% (Fig. 1). The island sakis spent 3.84% foraging overall, with monthly values of 2.60–5.13%. On a given day, the island sakis devoted 1.01–10.50% of their time to foraging, and mainland sakis spent 0.38–6.58% (on 1 day no records were returned for this group).

Feeding Behavior

Similarly to findings in other bearded sakis, two distinct patterns of arthropod consumption were recorded in *C. satanas*: the systematic capture of arthropods during foraging, and the opportunistic exploitation of temporary agglomerations of prey. During the study the sakis captured a variety of arthropods belonging to seven different orders (Table I). Lepidopteran larvae were the most common prey, in terms of both the number of species and feeding records, although the Hymenoptera and Isoptera were also relatively important overall. There was no overlap between groups in identified prey species.

In contrast to foraging, arthropods contributed to more feeding records for the mainland group (4.60%) than for the island sakis (3.74%). Most mainland group records (62.9%) were collected in November, mainly due to the predation of notodontid caterpillars. The monthly variation in both groups (Fig. 2) reflects the typical dual pattern of arthropod predation, with low ''background'' rates in most months interspersed with intense feeding spikes. The mainland group spiked once, whereas the island sakis peaked in 3 months (9.80–14.15%), which accounted for 68.7% of this group's arthropod feeding records. With peak months excluded, arthropods contributed slightly more to the mainland group's diet (1.91%) compared to the island group (1.49%).

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TABLE I. Identified Arthropod Prey Captured by the Mainland and Island Bearded Saki Study Groups Between December 2002 and February 2004

Order	Family	Species	Item (body length in cm)	Host (when relevant)	Records	Group	Month
Araneae	Unidentified		Adult spider (0.5–2.0)		3	Main	Aug, Oct, Dec
	Unidentified		Adult spider (0.5–2.0)		5	Island	Feb, Sep, Jan 04
Coleoptera	Cerambycidae	*Callipogon armillatum*	Adult longhorn beetle (7.0)		1	Island	Nov
	Buprestidae		Adult jewel beetle (8.0)		8	Island	Apr
Diptera	Cecidomyiidae		Gall fly larvae (0.2)	*Passiflora glandulosa* (Passifloraceae)	1	Main	Jul
	Cecidomyiidae		Gall fly larvae (0.2)	*Forsteronia* sp. (Apocynaceae)	2	Main	Feb 03
Homoptera	Cicadidae	*Fidicina mannifera*	Adult cicada (6.5)		1	Main	Feb 03
	Cicadidae		Adult cicada (6.5)		1	Main	Nov
Hymenoptera	Formicidae		Adult ant (1.0)		1	Main	Apr
	Formicidae		Adult ant (2.0)		1	Island	Jan 03
	Formicidae	*Camponotus renggeri*	Winged carpenter ant (2.0)		1[a]	Island	Dec 02
	Cynipidae		Gall wasp larvae (0.2)	*Mimosa rufescens* (Mimosaceae)	14[b]	Island	Apr, Jul
	Proctotrupoidea		Wasp larvae (0.4)	Cynipid gall wasp larvae	14[b]	Island	Apr, Jul
	Vespoidea		Wasp larvae (2.0)	Unidentified tree	1	Island	Apr
Isoptera			Adult termite (0.5)		2	Main	Apr
			Adult termite (0.5)		3	Island	Nov
	Termitidae	*Labiotermes labralis*	Winged termites (1.4)		18	Island	Feb 04
Lepidoptera	Notodontidae		Caterpillar (1.0–3.0)	*Bertholletia excelsa* (Lecythidaceae)	65	Main	Nov
			Caterpillar (1.5)	*Simarouba amara* (Simaroubaceae)	4	Main	Nov
			Caterpillar (1.0)	*Alexa grandiflora* (Fabaceae)	2	Main	Mar
			Caterpillar (1.5)	*Sclerolobium paraense* (Caesalpiniaceae)	1	Main	Mar
	Notodontidae		Caterpillar (1.0–2.0)	*Pouteria glomerata* (Sapotaccae)	14	Island	Nov
			Caterpillar (1.5)	Unidentified liana	6	Island	Feb 04
			Caterpillar (1.0)	*Eschweilera subglandulosa* (Lecythidaceae)	4	Island	Nov
			Caterpillar (1.5)	*Dialium guianense* (Caesalpiniaceae)	1	Island	Nov
			Prepupal caterpillar (3.5)	*Sclerolobium paraense* (Caesalpiniaceae)	1[a]	Island	Jun
Unidentified			Leaf gall (0.2)	Unidentified tree	5	Main	Nov
			Leaf gall (0.3)	Unidentified tree	1[a]	Island	May

[a]Not included in scan sample records.
[b]Ingested together.

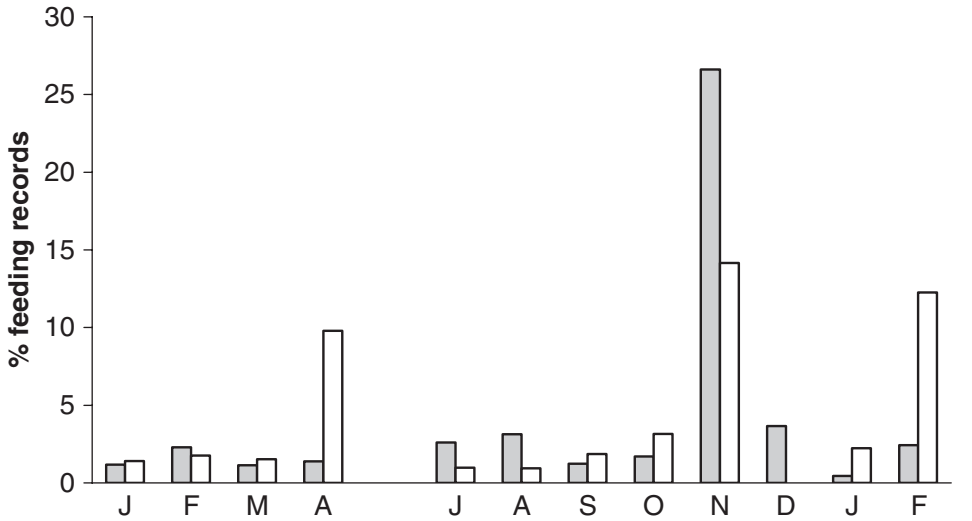

Fig. 2. Contribution of arthropods to the monthly diet of the mainland (shaded columns) and island (unshaded) sakis as a percentage of feeding records between January 2003 and February 2004.

During 3 days in November, the mainland sakis fed intensively on notodontid caterpillars in a Brazil-nut (*Bertholletia excelsa*) tree. The sakis extracted the larvae from young leaves and ate them whole. During feeding, several group members emitted a trill vocalization that was never heard in any other context. This may be similar to the vocalization reported by Ayres [1981] for *Chiropotes albinasus*.

While they ate the caterpillars the sakis scratched their hands constantly in reaction to a chemical irritant—probably a defensive secretion [Attygalle et al., 1993]. However, two tufted capuchins (*Cebus apella*) that fed on the caterpillars in the same crown appeared less perturbed by this chemical. This may have been related to differences in prey manipulation: whereas the sakis ingested the caterpillars whole, the capuchins pulled them apart before that ate selected parts.

The sakis exhibited both dexterity and agility while they captured different types of prey. Gallfly larvae were removed from galls that were only 4 mm in diameter, for example, and adult males were observed capturing large, mobile cicadas. On one occasion, a juvenile was observed repeatedly resting its hands and arms on a branch to let the ants climb onto them, and then ate them directly from its hair.

Caterpillars, which were primarily responsible for November peaks at both sites, accounted for only 25.2% of arthropod feeding records on the island, in contrast to 60.5% on the mainland. The April peak on the island was based on the predation of gall wasps and jewel beetles (Table I), whereas the February peak was due to the consumption of winged termites (*Labiotermes labralis*) from a large swarm, which were plucked from abandoned spider webs or caught on the wing.

DISCUSSION

The members of both study groups foraged actively for arthropods throughout the study period, resulting in a consistent, albeit minor contribution to their diet. Similar arthropod taxa were captured, although none of the

identified species were common to both groups. Caterpillars were the most important prey for both groups, and appear in general to be an important arthropod resource for *Chiropotes* [Ayres & Nessimian, 1982; Frazão, 1991; Norconk, 1996; Peetz, 2001]. Termites and gall wasps were also relatively important for the island group.

Overall, the results of this study are remarkably similar to the findings from Peetz's [2001] study, in which *C. chiropotes* employed the same foraging strategies and consumed a similar range of arthropod taxa from six orders. A comparable proportion of arthropod feeding (3.9%) was observed that was also distributed between low background months and early wet season spikes, due primarily to agglomerations of lepidopteran larvae. Peak insect abundance is often correlated with periods of new leaf flush at the end of the dry season, when the first heavy rains begin [Coley & Barone, 1996].

Arthropods are rich in fats and proteins [Milton, 1984; De Foliart, 1992], and may represent a significant alternative resource for bearded sakis, especially when key resources are scarce or absent, although their potential for exploiting this resource may be limited. Since the bulk of feeding records is provided by occasional agglomerations of insects, it seems unlikely that an increase in foraging effort would result in any significant change in prey capture. In fact, the island group, which foraged more (possibly in response to decreased resource abundance), spent less time overall eating arthropods. Even under intense habitat fragmentation, then, a significant increase in insectivory may be not be a viable foraging strategy for bearded sakis.

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