

BRIEF REPORT

Habitat Use by *Chiropotes satanas utahicki* and Syntopic Platyrrhines in Eastern Amazonia

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Primates were surveyed at two sites in the Xingu-Tocantins interfluvium, in eastern Amazonia, where at least eight platyrrhines are known to occur, including the endemic *Chiropotes satanas utahicki*, vulnerable to extinction. Only three other forms; *Alouatta belzebul belzebul*, *Cebus apella apella*, and *Saguinus midas niger*; were recorded at both sites. Data on habitat use (forest type and strata) were collected in standard line transect surveys and analyzed with relation to the availability of forest types, as well as between sites and species. The smallest- (*S. midas*) and largest-bodied (*A. belzebul*) species were relatively common at the continuous forest site, where they exhibited a significant preference for primary *terra firme* forest. At this site, *Cebus* demonstrated a significant preference for liana and flooded forest in contrast with primary or secondary *terra firme* forests. The medium-sized *Cebus* and *Chiropotes* were more common in the isolated forest fragment (where they were also observed together frequently), but no clear habitat preferences were found at this site for any species. *A. belzebul* occupied significantly higher forest strata than other species, which all used relatively similar levels. *C.s. utahicki* was active in much lower forest strata than other bearded sakis, whereas *S. midas* was observed at much higher levels than at other sites in eastern Amazonia. It remains unclear whether and to what extent observed patterns are determined by differences between taxa, populations, or ecosystems, but the data indicate that *C.s. utahicki* is relatively tolerant of habitat disturbance. Am. J. Primatol. 50:215–224, 2000. © 2000 Wiley-Liss, Inc.

Key words: Platyrrhini; habitat preferences; eastern Amazonia; *Chiropotes satanas utahicki*; conservation

INTRODUCTION

Uta Hick's bearded saki, *Chiropotes satanas utahicki*, is the only platyrrhine taxon endemic to the Xingu-Tocantins interfluvium in eastern Amazonia. This

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interfluvium has been the scenario of a number of major development projects over the past three decades, including the Grande Carajás mining complex, the Tucuruí hydroelectric power station, and the first leg of the TransAmazon highway. The resulting colonization of the region has led to extensive deforestation, which together with the bearded sakis' apparent intolerance of habitat disturbance [Johns & Ayres, 1987] and hunting pressure [Silva Jr., 1991; Lopes, 1993] has serious implications for the long-term survival of *Chiropotes s. utahicki* populations in the wild. This taxon, named by Hershkovitz [1985], is thus among the few Amazonian primates to be included in the "vulnerable" Mace-Lande category by Rylands et al. [1996]. Practical problems for the conservation of this saki include an almost complete lack of data on its behavior in the wild [Bobadilla & Ferrari, 1998].

While fundamental to the ecology of any species [Boulière, 1985; Rylands, 1987], relatively few studies have dealt specifically with habitat use in Amazonian primate communities [but see, e.g., Mittermeier & van Roosmalen, 1981; Terborgh, 1983; Peres, 1993]. Nevertheless, habitat preferences are fairly well documented in some taxa, such as tamarins, *Saguinus* spp. [Rylands, 1996], for which vertical stratification is an important aspect of niche separation in syntopic congeners [Terborgh, 1983; Garber, 1992; Peres, 1992].

Among the pitheciins, habitat preferences are fundamental to the allopatry of the closely-related *Chiropotes* and *Cacajao* [Ayres, 1989], and the differential use of habitats and forest strata is an important aspect of niche separation in sympatric *Chiropotes* and *Pithecia* [Mittermeier & van Roosmalen, 1981; Kinzey & Norconk, 1993; Walker, 1996]. Bearded sakis generally appear to prefer the upper strata of primary *terra firme* forests [Ayres, 1981; Mittermeier & van Roosmalen, 1981; Johns & Ayres, 1987; Lopes, 1993], in specific contrast with liana and secondary forests [van Roosmalen et al. 1981; Johns, 1986].

Here, data on the use of habitat by *Chiropotes s. utahicki* and syntopic platyrrhines at two sites are presented and analyzed in relation to factors such as habitat availability and interspecific competition. The results of the study provide new insights into the ecology of this bearded saki and reveal unexpected characteristics of the other species studied, especially *Saguinus midas*. These data are relevant to the conservation of these primates and the forest ecosystems in which they occur.

METHODS

The two study sites presented here, the Ferreira Penna Scientific Station (ECFPn) and the Fazenda Arataú, were selected originally with the specific aim of evaluating the conservation status of Uta Hick's bearded saki, *Chiropotes satanas utahicki*, which is endemic to the Xingu-Tocantins interfluvium in eastern Amazonia [Bobadilla, 1998; Bobadilla & Ferrari, 1998]. At least six other diurnal platyrrhines also occur in this interfluvium [Ferrari & Lopes, 1996], although only three, *Alouatta belzebul belzebul*, *Cebus apella apella*, and *Saguinus midas niger*, were observed frequently enough to permit a systematic analysis of their habitat preferences. Two other species, *Callithrix argentata* and *Saimiri sciureus*, were observed at ECFPn and Arataú, respectively.

The ECFPn encompasses the northernmost ten percent of the 330,000-ha Caxiuanã National Forest, located in the northwestern extreme of the lowland floodplain of the Xingú-Tocantins interfluvium (1°45'S, 51°27'W). The Fazenda Arataú is a cattle ranch in the south of the interfluvium, closer to the Tocantins river (3°50'S, 50°20'W). At the latter site, surveys were carried out in a 7,500 ha fragment of submontane forest which has been both selectively logged and iso-

lated from surrounding forest for at least the last 20 years. The two sites thus represent distinct patterns of human disturbance, which is negligible at ECFPn [Almeida et al., 1993; Lisboa, 1997]. Primates are not hunted at either site.

Straight-line trails totalling 69.2 km and 15.5 km, respectively, were prepared at ECFPn and Arataú [Bobadilla, 1998], and line-transect surveys were carried out following standard methods for the study of primate populations [National Research Council, 1981; Brockelman & Ali, 1986]. At ECFPn, 532.9 km were surveyed between January and October 1996, while a total of 101.3 km were carried out at Arataú from May to August of the same year. At each sighting of a primate or other mammal, standard data were collected [Bobadilla, 1998], including observer-animal and animal-trail distances, sighting angle, group size, the type of forest in which the animal was sighted (see Table I), and its activity (locomotion, forage, or rest) and height above the ground when first observed.

The availability of the four different types of forest at the two study sites was quantified on the basis of the dominant habitat observed at randomly-selected points (36 at Arataú, 74 at ECFPn) along the trail systems. For the analysis of habitat preferences, the expected number of sightings in each forest type were calculated according to their distribution at each site, corrected according to sampling effort (Table II). These were compared with observed frequencies using the chi-square test [Norusis, 1993]. Interspecific differences in the use of forest strata were assessed using the two-sample Kolmogorov-Smirnov test.

RESULTS

One basic aspect of the habitat preferences of the four species considered here is the marked contrast in their relative abundance at the different study sites. Since no significant between-site differences were found in sighting distances [Bobadilla, 1998], and differences in mean group size were small (but significant in *Cebus a. apella*), sighting rates (sightings per 10 km of survey) can be considered reliable estimates of relative abundance, given the problems of small sample size for the calculation of population densities [see Lopes & Ferrari, in press]. Comparing sites (Table III), the largest- and smallest-bodied species (*Alouatta belzebul* and *Saguinus midas*, respectively) are approximately twice as

TABLE I. General Characteristics of the Four Main Types of Forest Identified During the Present Study [Following Braga, 1979; Rylands, 1987]^a

Forest type	Canopy height	Frequency of			
		Pioneer species ^b	Lianas	Palms	Flooding
Primary <i>terra firme</i>	High (>30 m)	Low (<20 inds/ha) ^c	Low (<30 inds/ha) ^d	Low (<30 inds/ha) ^c	No
Secondary <i>terra firme</i>	Medium (20–30 m)	High (>20 inds/ha)	Low	High (>30 inds/ha)	No
Liana	Low (<20 m)	Low	High (>30 inds/ha)	Low	No
<i>Igapó</i>	Low (<20 m)	Low	Low	High	Yes

^aSpecies abundance based on sixteen (four from each habitat type) randomly-selected 20 m × 20 m sample plots at ECFPn and 12 plots at Arataú.

^b*Cecropia* spp. and *Porouma* spp.

^cDBH ≥10 cm.

^dDBH ≥8 cm.

TABLE II. Relative Distribution of Different Forest Types at the Two Study Sites, Corrected According to Sampling Effort (Proportion of the Survey Carried Out Along Each Sector of the Trail System)

Site	Percentage of sampling effort:			
	Primary	Secondary	Liana	Igapó
ECFPn	81.2	6.0	4.8	7.6
Arataú	47.2	16.7	36.1	0.0

abundant at ECFPn in comparison with Arataú, whereas *Cebus* and *Chiropotes* exhibit a markedly opposite trend. *Saimiri* was observed at Arataú only.

The overall pattern of sightings contradicts expectations on the basis of known habitat characteristics and preferences. The absence of *Callithrix argentata* from the southern half of the Xingu-Tocantins interfluvium has been linked to habitat differences related to the nutrient-poor soils of the Brazilian shield [Ferrari & Lopes, 1990]. It would thus seem reasonable to expect primates to be less, rather than more abundant at Arataú, although it is possible that the effects of habitat-related factors are taxon-specific, i.e., to callitrichines. In this case, while tamarins typically prefer more disturbed forest [Sussman & Kinzey, 1984; Rylands, 1996], such as that at Arataú, other factors may determine the relatively low sighting rate of *Saguinus m. niger* at this site. The very much higher sighting rates of both *Chiropotes* and *Saimiri* at Arataú are also unexpected, given that bearded sakis are generally thought to be relatively intolerant of habitat disturbance [Mittermeier & van Roosmalen, 1981; Johns & Ayres, 1987; Lopes, 1993], and squirrel monkeys are specialized behaviorally for the exploitation of flooded forest habitats [Terborgh, 1983], present only at ECFPn.

Interspecific associations were observed on four occasions at Arataú, but never at ECFPn. In all four cases, the association involved groups of *Cebus* and *Chiropotes*, which moved cohesively together in the same forest strata. On one occasion, the two species were also accompanied by a group of *Saimiri s. sciureus*, which typically associates with *Cebus* groups throughout the Amazon [Terborgh, 1983; personal observation]. However, neither *Alouatta* nor *Saguinus* were observed in proximity to groups of other species. The lack of records of interspecific associations at ECFPn may thus have been at least partly a result of the small number of sightings of *Chiropotes* (and absence of *Saimiri*) at this site, given that approximately one fifth of all sightings of these primates and *Cebus a. apella* at Arataú involved associations.

The small number of sightings of *Chiropotes s. utahicki* at ECFPn prohibits a more detailed analysis of its habitat preference at this site, although all six sightings occurred in primary *terra firme* forest, as expected [Mittermeier & van

TABLE III. Sighting Rates of Primates at the Two Study Sites

Primate	Sightings per 10 km surveyed at	
	ECFPn	Arataú
<i>Alouatta belzebul belzebul</i>	2.08	0.99
<i>Cebus apella apella</i>	0.47	1.78
<i>Chiropotes satanas utahicki</i>	0.11	2.07
<i>Saguinus midas niger</i>	1.11	0.49
<i>Saimiri sciureus sciureus</i>	–	0.39
Total	3.77	5.72

Roosmalen, 1981]. The remaining three species exhibited significant preferences for a given type of forest (Table IV), on the other hand. Both *Alouatta* and *Cebus* were observed in all four forest types, but the former species used primary forest significantly more than expected, whereas the latter demonstrated a highly significant preference for both liana and *igapó* forest, using the primary forest half as frequently as expected. *Saguinus m. niger* was not observed in the *igapó*, preferring liana forest and primary *terra firme* forest, in marked contrast with other sites in eastern Amazonia [Lopes & Ferrari, 1996; Oliveira, 1996].

Observations at Arataú (Table V) were less conclusive, however, possibly because of the smaller number of sightings, at least in the case of *Alouatta*, which once again exhibited a strong preference for primary forest, and *Saguinus*. In contrast with ECFPn, *Saguinus* was observed in liana forest, and the single record in secondary forest was as expected given its availability at this site (see Table II). Records of both *Cebus* and *Chiropetes* were nevertheless sufficient to confirm an apparent absence of preference for any given type of forest (Table V).

Primates were sighted at heights of between 3 and 43 meters at the two study sites (all four sightings of *Saimiri* were at 10 m), although *A.b. belzebul* and *C.s. utahicki* were never observed in the lowest strata, whereas neither *C.a. apella* nor *S.m. niger* were recorded at heights above 35 m (Fig. 1). Overall (Table VI), *Alouatta* used significantly higher strata than either *Cebus* (Kolmogorov-Smirnov, $Z=3.514$, $P < 0.001$, two-tailed), *Chiropetes* ($Z=2.124$, $P < 0.001$), or *Saguinus* ($Z= 2.308$, $P < 0.001$). But while *Chiropetes* did use the highest strata on occasion (Fig. 1), its mean height was virtually the same as that of the tamarins (Table VI), and in fact its use of vertical space differed little from that of either *Saguinus* ($Z = 0.830$, $P = 0.497$) or *Cebus* ($Z=0.919$, $P = 0.367$). Unexpectedly, *Saguinus* used significantly higher strata than *Cebus* ($Z = 2.031$, $P < 0.001$).

As height may have been influenced by forest type (given differences in canopy height; see Table I), vertical spacing in the category most used by all species (primary *terra firme* forest) was analyzed separately. As expected, the mean height of all species increased when considering primary forest only (Table VI), but all interspecific differences decreased, and in fact, the mean height recorded for *Chiropetes* passed that of *Saguinus*. Despite these alterations, *Alouatta* still used significantly higher strata than *Chiropetes* ($Z = 1.462$, $P < 0.05$), *Saguinus* ($Z = 1.836$, $P < 0.003$), or *Cebus* ($Z = 2.086$, $P < 0.001$), but the differences between all other pairs of species were not statistically significant (all $Z < 0.9$, $P > 0.4$).

In addition to forest type, a monkey's activity may also influence its use of different strata. However, locomotion was the most frequent activity recorded for all species (47.11–66.67% of sightings), and there was no significant interspecific difference in the relative frequency of this category ($\chi^2 = 5.628$, $P > 0.10$, d.f. = 3).

TABLE IV. Observed and Expected (see Table II) Frequency of Use of Different Forest Types at ECFPn

Forest type	<i>Alouatta b. belzebul</i>		<i>Cebus a. apella</i>		<i>Chiropetes s. utahicki</i>		<i>Saguinus m. niger</i>	
	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.
Primary	90.6	104	20.4	9	—	6	48.2	53
Secondary	6.7	2	1.5	1	—	0	3.5	1
Liana	5.3	3	1.2	7	—	0	2.8	5
<i>Igapó</i>	8.4	2	1.9	8	—	0	4.5	0
N observations	111		25		6		59	
χ^2 (3 d.f.)	11.153, $P= 0.011$		54.147, $P<<0.01$		Not applicable		8.492, $P= 0.037$	

TABLE V. Observed and Expected (see Table II) Frequency of Use of Different Forest Types at Fazenda Arataú

Forest type	<i>Alouatta b. belzebul</i>		<i>Cebus a. apella</i>		<i>Chiropotes s. utahicki</i>		<i>Saguinus m. niger</i>	
	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.	Exp.	Obs.
Primary	4.7	8	8.5	9	9.9	13	—	4
Secondary	1.7	1	3.0	5	3.5	3	—	1
Liana	3.6	1	6.5	4	7.6	5	—	0
N observations	10		18		21		5	
χ^2 (2 d.f.)	4.483, $P=0.106$		2.324, $P=0.313$		1.932, $P=0.381$		Not applicable	

There was also little evidence of any significant difference in the strata used for different activities (Table VII), although at least in the case of *Cebus* and *Chiropotes*, sample size is prohibitively small for a more conclusive analysis.

Even allowing for habitat and behavioral differences, then, *Chiropotes s. utahicki* tended to be observed in the middle forest strata, at levels highly similar to those occupied by both *Cebus* and *Saguinus*. This contrasts considerably with all other studies of both bearded sakis [Ayres, 1981; Mittermeier & van Roosmalen, 1981; Lopes, 1993] and tamarins, including *Saguinus m. niger* [Lopes & Ferrari, 1996; Oliveira, 1996].

DISCUSSION

Overall, the results of the present study contradict most data on the use of habitat not only by bearded sakis, but also by the other platyrrhine species found in the study area. The rarity of *Chiropotes s. utahicki* at the ECFPn, part of one of the most extensive and best-preserved tracts of lowland *terra firme* forest in eastern Amazonia, is especially equivocal and cannot be attributed to the vagaries of sampling effort (few other surveys of Amazonian primates have been longer than 400 km). While sighting rates of between 0.2 and 0.5 groups per 10 km are common in surveys of *Chiropotes* populations [e.g., Ayres, 1981; Emmons, 1984; Martins et al., 1988; Nunes et al., 1988; Sussman & Phillips-Conroy, 1995; Lopes & Ferrari, 1996; Ferrari et al., 1999a,b], a rate of less than 0.2/10 km has been recorded only once, at a heavily hunted site in eastern Amazonia [Lopes & Ferrari, 1996].

The exceptional abundance of bearded sakis in the forest fragment at the Fazenda Arataú is equally unexpected and, while this survey was shorter, data from a second survey at the same site (A.P. Nunes, personal communication) indicate that its estimate is reasonably reliable. To date, however, only one other survey of *Chiropotes*, in western Amazonia [Ferrari et al., 1999b], has returned a sighting rate of over one group per 10 km of survey, and even then, only slightly over half the value recorded at Arataú in the present study.

Of the other species, the between-site difference in the abundance of *Saguinus m. niger* was the most intriguing, given that this tamarin, like most other callitrichines, appears to prefer secondary forest at other sites in eastern Amazonia [Lopes & Ferrari, 1996; Oliveira, 1996]. This tamarin was not only more than twice as common at ECFPn in comparison with Arataú but was also exhibited a significant preference for primary forest at the former site.

Bearded sakis at other sites also tend to utilize the upper forest strata [Ayres, 1981; Mittermeier & van Roosmalen, 1981; Lopes, 1993], especially in compari-

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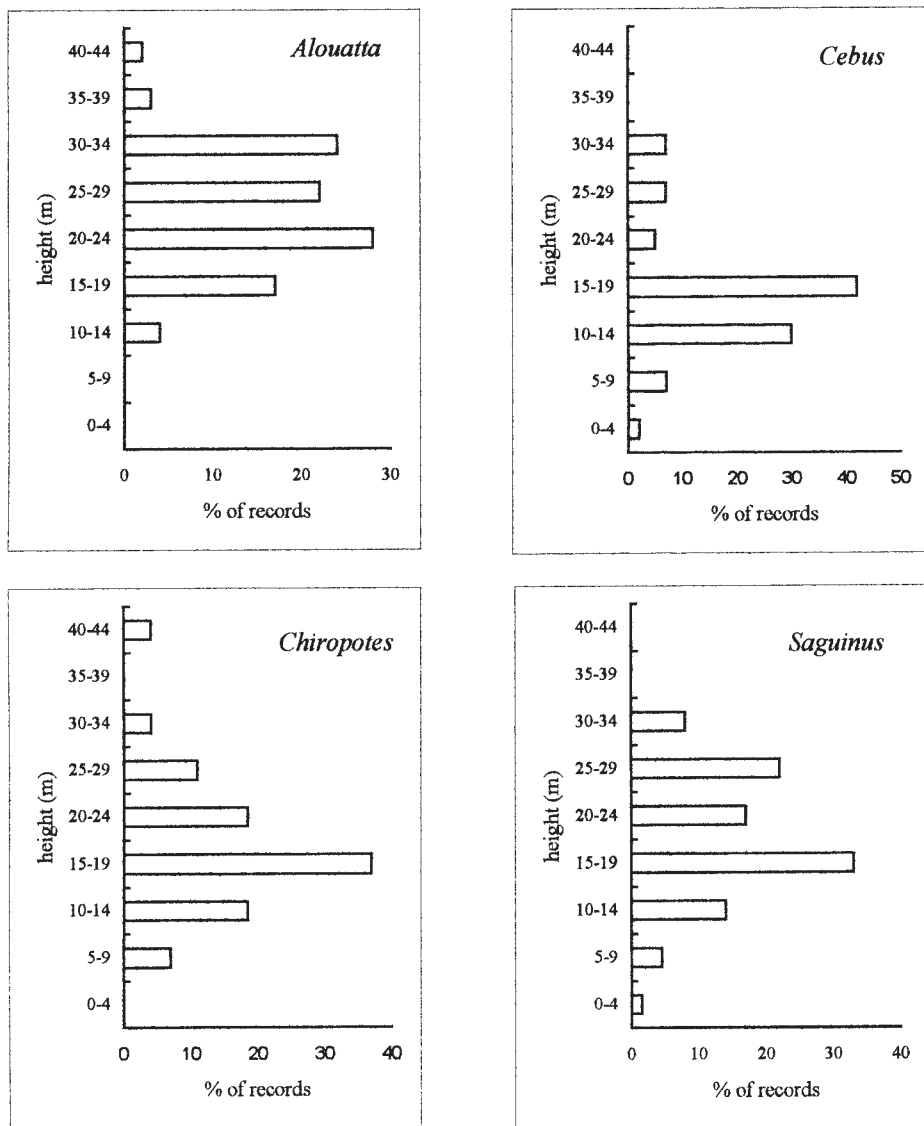


Fig. 1. Use of different forest strata by *Alouatta*, *Cebus*, *Chiropetes*, and *Saguinus*.

TABLE VI. Mean Height by Species and Forest Type

Primate	Mean height (m) in	
	All records	Primary forest only
<i>Alouatta b. belzebul</i>	24.3 ± 6.3	24.8 ± 6.1
<i>Cebus a. apella</i>	15.6 ± 6.1	17.7 ± 7.9
<i>Chiropetes s. utahicki</i>	17.8 ± 7.2	20.3 ± 6.9
<i>Saguinus m. niger</i>	18.1 ± 6.5	19.2 ± 6.5

TABLE VII. Mean Height by Species and Behavior (Primary *Terra Firme* Forest Only)

Primate	Mean height (m)			ANOVA
	Locomotion	Forage	Rest	
<i>Alouatta b. belzebul</i>	23.9 ± 6.3	24.5 ± 5.7	26.7 ± 6.1	$F(2, 105) = 2.187, P = 0.117$
<i>Cebus a. apella</i>	18.1 ± 7.1	20.0 ± 10.4	15.4 ± 9.1	$F(2, 15) = 0.327, P = 0.726$
<i>Chiropotes s. utahicki</i>	21.5 ± 7.5	17.2 ± 5.8	22.5 ± 10.6	$F(2, 15) = 0.676, P = 0.524$
<i>Saguinus m. niger</i>	20.5 ± 6.2	14.3 ± 8.5	17.5 ± 6.4	$F(2, 53) = 2.568, P = 0.086$

son with syntopic *Pithecia* [but see Ferrari et al., 1999b]. East of the Tocantins, *Chiropotes s. satanas* was typically found in the upper forest strata [Lopes, 1993], together with *Alouatta b. belzebul*, whereas *Cebus a. apella* and *Saguinus m. niger* occupied the middle and lower strata. In Surinam, *Chiropotes s. chiropotes* not only exhibited a clear preference for the upper strata, but was also observed rarely in liana forest, especially in comparison with *Pithecia pithecia* [Mittermeier & van Roosmalen, 1981]. In the present study, however, *Chiropotes s. utahicki* not only occupied significantly lower strata than *Alouatta b. belzebul*, but used effectively the same levels as *Cebus a. apella* and *Saguinus m. niger*, and, at least at Arataú, exhibited no clear preference for primary *terra firme* forest in comparison with either secondary or liana forest.

The reasons for these unexpected patterns of abundance and habitat use by *Chiropotes s. utahicki* are unclear, but the fact that *Saguinus m. niger* also exhibited apparently atypical preferences does appear to suggest that ecological factors, rather than taxon-specific characteristics, are relevant here. In the specific case of *Chiropotes s. utahicki*, ecological factors may include the absence of syntopy with *Pithecia* [see Ferrari et al., 1999b], and the exploitation of alternative resources, such as the immature seeds of lianas (e.g., *Anemopaegma* and *Arrabidaea*: Bignoniaceae), the mesocarp of babaçu palm fruits (*Orbignya martiana*), and even *Cecropia* fruits [Bobadilla, 1998]. Babaçu is not only especially abundant at Arataú (300–600 individuals per hectare) but is also typically found in the middle to lower canopy (10–20 m in height).

Data on the feeding ecology of *Chiropotes* at Arataú are limited, however, and it remains unclear whether the situation observed at this site is the result of an exceptionally favorable combination of local factors or is indicative of the potential flexibility of bearded sakis in general. Whatever the case, the data presented here do indicate clearly that southeastern Amazonian bearded sakis may more tolerant of habitat fragmentation than was previously assumed [Johns & Ayres, 1987]. This has important implications for the conservation and management of remaining populations, given the continuing fragmentation of habitat throughout a large part of southern Amazonia.

CONCLUSIONS

1. Sightings of *Chiropotes satanas utahicki* were unexpectedly rare at ECFPn, an extensive area of well-preserved forest, whereas the sighting rate recorded at the Fazenda Arataú, in an isolated fragment of forest, was the highest yet recorded for the genus.

2. *Chiropotes s. utahicki* used the middle forest strata, at levels similar to those occupied by syntopic *Cebus apella* and *Saguinus midas*, whereas *Alouatta belzebul* used significantly higher levels.

3. *Cebus* and *Chiropotes* used similar forest strata and were both more abun-

dant at Arataú, where they were also observed forming interspecific associations. Similar ecological factors may thus determine the abundance of these two genera, at least in the Xingú-Tocantins interfluvium.

4. The apparent ecological flexibility of *Chiropetes s. utahicki* may be important for the conservation and management of this taxon.

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