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A Primate Survey in Northern Bolivia, with Special Reference to Goeldi's Monkey, *Callimico goeldii*[1]

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We conducted a 5-month survey on primates; with special attention to Goeldi's monkey (Callimico goeldii)*, in the rain forest of northwestern Bolivia. Goeldi's monkey is one of the least documented of all South American primates, and very little is known about its distribution. We report observations on distribution, abundance, and habitat of* Callimico goeldii *and other primates, incidental sightings of other mammals, and preliminary behavioral observations on* Callimico *and two associated callitrichid monkey species:* Saguinus fuscicollis *and* S. labiatus. *We found a locality that appears to be particularly suitable for detailed field observations on* Callimico *on the north bank of the lower Río Tahuamanu.*

KEY WORDS: *Callimico goeldii*; distribution; vocalization; polyspecific association; *Saguinus*; conservation.

INTRODUCTION

Goeldi's monkey (*Callimico goeldii*) is one of the least-documented South American primates. Although its geographical distribution extends from southern Colombia through eastern Perú and northwestern Brazil to northwestern Bolivia (Hershkovitz, 1977), it has been observed rarely in the wild (Buchanan-Smith, 1991a; Cameron, 1989; Izawa, 1979; Masataka, 1981a, b; Pook and Pook, 1981, 1982). Previous field studies were con

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ducted in the Pando Department in northwestern Bolivia. The limited field observations led to controversy as to whether the social organization of *Callimico* is based on family groups of two to four animals or whether groups might contain as many as nine individuals (Buchanan-Smith, 1991a).

In order to assess the distribution of primates in northwestern Bolivia, we undertook a 5-month survey from March 1991 until the end of July 1991, with special attention to Goeldi's monkey (*Callimico* g*oeldii*). We made five excursions, each starting from Cobija (Fig. 1). In the first part of this paper, we report observations on the distribution, abundance, and habitat of *Callimico* and other primates and incidental sightings of other mammals. We found one locality that appears to be particularly suitable for detailed field observations of *Callimico*. In the second part of this paper we report preliminary behavioral observations on *Callimico* and two frequently associated callitrichid species, *Saguinus fuscicollis* and *S. labiatus*.

MATERIAL AND METHODS

Study Area, Vegetation, and Climatic Conditions

The study area is the Pando Department in northwestern Bolivia (Fig. 1), which lies in the upper Amazon basin. The Pando covers an area of about 63,000 km^2 and has a population density of 0.9 people/km^2 – the lowest of all Bolivian departments. The forests are exploited mainly for brazil nuts and gum, which are collected and sold by the inhabitants. The vegetation consists mainly of a seasonally dry, generally undisturbed tropical rain forest, most of which is still primary forest. In the forest, three canopy levels were clearly distinguishable: the lowest at 6–10 m, the second and principal level at 25–35 m, and a few emergents reaching heights of 35–45 m. We recognized three different types of forest during this study: primary, secondary, and riverine. The characteristics of each forest type are summarized in Table I, and specimen views of each are shown in Fig. 2. For several parts of this region, steep hills and valleys are characteristically situated at 110–220 m above sea level. The lower areas are seasonally flooded by numerous rivers and streams.

The climate in the Pando Departement is tropical. The wettest months are from November to February (summer), and a marked dry season with little or no rain extends from May to September (winter). In June and July a cool wind often blows from the south, sometimes causing the temperature at night to drop to 10°C. Annual rainfall is 1600–1900 mm and the mean annual temperature is 24.7°C (Montes de Oca, 1989). Figure 3 shows mean temperatures measured during the 5 months of this study. Variation in day length amounts to only about half an hour over the year.

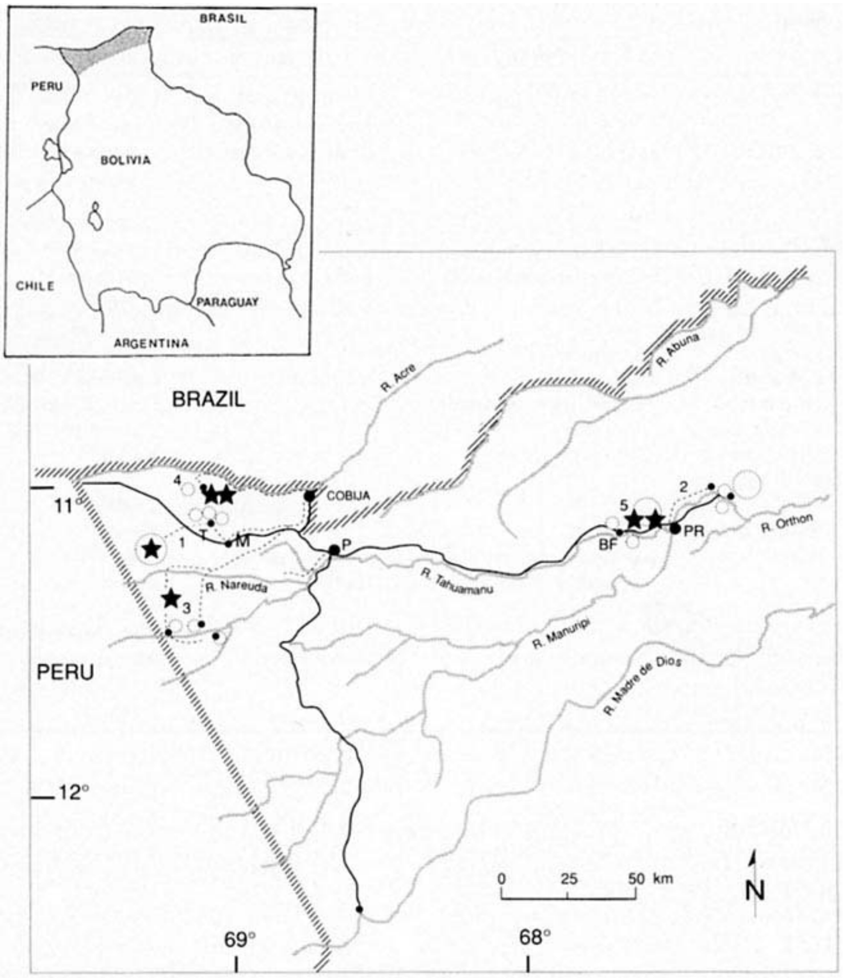

Fig. 1. Map of the Pando Department showing survey sites 1–5. Stars indicate localities where we observed *Callimico*. BF, Bella Flor; M, Mucden; P, Porvenir; PR, Puerto Rico; T, Triunfo.

Survey Method

During the five survey excursions, we covered nearly 1000 km through the forest on foot. The areas of the Pando Department that we surveyed are shown in Fig. 1 and the lengths and durations of the five excursions are listed in Table II. During the survey, we recorded all sightings of mammals in detail. We conducted our survey in the period from March

Table I. Types of Forest

	Forest		
	Primary	Secondary	Riverine
Occurrence	Most of the forest	Around chacos and huts and where disturbed by people	Up to 2-3 km wide along streams and big rivers
Vegetation			
Typical plants	Castaña (*Bertholletia excelsa*), goma elastica (*Hevea brasiliensis*)	Bamboo thicket, ambaibo (*Cecropia*), balsa (*Ochoma* lagopus)	*Hevea brasiliensis,* Palmas, Musaceae, *Papyrus*
Palm trees	Several	None	Common
Lianes	Common	None	Common
Epiphytes	Common	Occasional	Common
Ground vegetation	Dense layer of small plants	Absent	Dense layer of small plants
Undergrowth	Not very dense	Fairly to very dense	Variable
Tree dimensions:			
Height	25-35 m	10-20m, e.g. bamboo	25-35 m
Emergents	35-45 m	35 m	35-45 m
Width	1-2 m in diameter, buttress roots	No very large tree trunks	1-2 m in diameter, buttress roots, brace root
Ground	Seasonally dry	Seasonally dry	Always moist; small lagoons remain

to the end of July, while previous studies were made in the period from July to January (Buchanan-Smith, 1991a; Izawa, 1979; Masataka, 1981a, b; Pook and Pook, 1979, 1981).

Sound Analysis

Christen made all tape recordings in the area of Bella Flor with a Sony WM-D3 tape recorder equipped with a Sennheiser ME 80 (+K3U) directional microphone. Geissmann digitized the tape-recorded vocalizations on a Macintosh IIci computer using the SoundRecorder device (Farallon). The sampling rate is defined as “the number of intervals per second used to capture a sound when it is digitized” (Schmidt *et al.*, 1989, p. 222) and determines the highest frequency the system can record. Unless otherwise stated, we sampled all sounds at a 22-kHz sampling rate, thereby removing frequencies above 11 kHz (Schmidt *et al.*, 1989). Sonagrams of all vocali-

Fig. 2a. Forest types surveyed: (a) primary; (b) secondary; (c) primary riverine.

Fig. 2b. Continued

Fig. 2c Continued

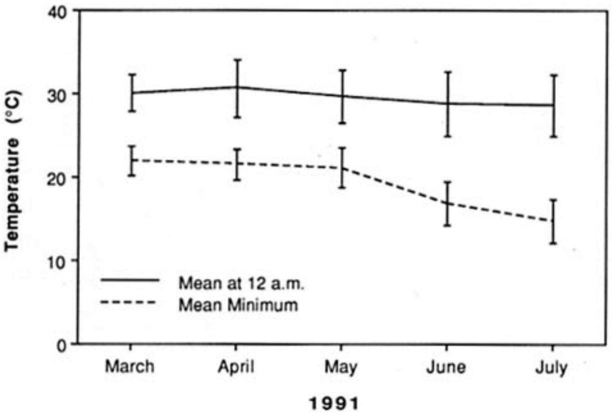

Fig. 3. Temperatures recorded during the present study, showing the monthly means of maximum temperature (solid line) and minimum temperature (dashed line). Vertical (error) bars are standard deviations.

Table II. Duration of Survey Walks and Distances Covered in Five Localities

Excursion				Distance
No.	Survey area	Date of survey (1999)	Hours walked	covered (km)
1	Tres Corazones (SWW Cobija)	3/21–4/8	83	~200
2	Puerto Rico (SEE Cobija)	4/13–4/29	40	120
3	Tres Estrellas, Fortalezza (SW Cobija)	5/2–5/23	68	288[a]
4	Río Acre (WNW Cobija)	5/27–6/3	22.5	90
5	Bella Flor (SE Cobija)	6/8–7/20	97	270

[a] Thirty-five kilometers of this distance was surveyed from a canoe on the Río Tahuamanu.

zations by *Callimico* were generated with the program SoundEdit, Version 2.0.1 (Farallon). We perfomred statistical calculations via StatView II statistics software; statistical tests are two-tailed.

Acoustic Terms and Definitions

A *note* is any single, continuous sound of any distinct frequency modulation, produced by either an inhaled or an exhaled breadth. A *phrase* is a larger and looser collection of notes identifying a single vocal activity. These definitions were developed by Haimoff (1984) for the study of gibbon vocalizations. A *duet* is defined here as the joint vocalization of two individuals, coordinated in time or in selection of distinct note types (Wickler, 1974).

Survey Areas

1. Excursion: Tres Corazones and Loma Alta. Tres Corazones and Loma Alta are situated about 100–200 km southwest of Cobija. They are characterized by steep hills and valleys, with height differences ≥20–30 m and many small rivers borderd by bamboo thickets and swamps. This area was particularly rich in monkeys.

2. Excursion: Puerto Rico. Puerto Rico lies 200–300 km east of Cobija at the Río Tahuamanu and Río Orthon. Contrary to the first survey area, it is characterized by flat countryside, with many swamps and small rivers alongside the main watercourses. There are definitly fewer monkeys in this region, as it is more heavily populated.

3. Excursion: Tres Estrellas, Fortalezza. Tres Estrellas is situated 100–200 km south–southwest of Cobija, close to the border of Peru. It resemles Tres Corazones but it is less hilly.

4. Excursion: Río Acre. This region was reached by an 12-h boat trip. It is situated about 170 km west of Cobija, adjacent to the Brasilian border, which is formed by the Río Acre. The area exhibits many swamps and small rivers, and monkeys are more abundant here.

5. Study site: Bella Flor. Bella Flor is situated in a artificial savanna on the north bank of the Río Tahuamanu, 167 m above sea level (11°7.5’S, 67°47.5’W). Because it is a center of trade in gum and Brazil nuts, monkeys are less abundant than in area 4. The advantages of this region are that it can be reached during the whole year, either by boat (during the rainy season) or by car and on foot (during the dry season), and that basic food-stuffs are available for the investigator. The main study site is situated to the east of Bella Flor and consists mostly of primary and riverine forest, which becomes swampy near Río Tahuamanu. In addition to the already existing 600-m siringa trail (for gum collection), we cut about 2000 m of additional trail in order to follow the monkeys..

SURVEY RESULTS

Mammals Other than Primates

Table III lists all mammals other than primates observed during this study. The most commonly encountered species were opossums (*Philander*

Table III. Mammals that We Observed

Species	Family	Type of forest[a]	Survey area No.
Cabassous unicinctus (southern naked-tailed armadillo)	Dasypodidae	1	3
Philander opossum (gray opossum)	Didelphidae (Marsupialia)	1, 2, 3	1, 4, 5
Tamandua tetradactyla (southern anteater)	Myrmecophagidae	1	4
Potos flavus (kinkajou)	Procyonidae	2	3
Nasua nasua (South American coati)	Procyonidae	1, 2, 3	4, 5
Eira barbara (tayra)	Mustelidae	1	5
Lutra longicaudis (southern river otter)	Mustelidae	1	1
Felis jaguarundi (jaguarundi)	Felidae	2	5
Felis concolor (puma): footprints only	Felidae	1, 3	1, 3
Panthera onca (jaguar): footprints only	Felidae	1, 3	1, 3, 5
Tapirus terrestris (tapir): footprints only	Tapiridae	1	2
Tayassu sp. (pekari)	Tayassuidae	1	1-5
Mazama gouazoubira (grey brocket deer)	Cervidae	Savanna	1, 3
Hydrochaeris hydrochaeris (capybara)	Hydrochaeridae	1, 2, 3	1
Agouti paca (paka)	Agoutidae	1	1, 3, 5
Sciurus sp. (squirrels, various species)	Sciuridae	1, 2, 3	1-5
Chiroptera (various species)			1-5

[a] 1, primary; 2, secondary; 3, riverine.

opossum), coatis (*Nasua nasua*), tayras (*Eira barbara*), pekaries (*Tayassu* sp.), brocket deer (*Mazama gouazoubira*), capybaras (*Hydrochaeris hydrochaeris*), paccas (*Agouti paca*), and several species of squirrels and bats. Less common sightings include a pair of kinkajous (*Potos flavus*), a pair of southern river otters (*Lutra longicaudis*), a pair of jaguarundis (*Felis jaguarundi*), and, on two occasions, a southern anteater (*Tamandua tetradactyla*). We saw footprints of jaguar, puma, and tapir repeatedly but never saw the animals.

Primates

Inventories of the primate species observed during each survey and informations on the type of forest where they were encountered are listed in

Table IV. Sometimes it was possible to exactly count or reliably estimate the number of individuals in a group. These findings are listed in Table V.

Howling monkeys (*Alouatta seniculus*) and black spider monkeys (*Ateles paniscus*) are hunted heavily, their large size probably being responsible for the fact that they are the most frequently eaten monkeys. In survey areas 1 and 3 we often heard and directly observed howlers. But we

Table IV. Primate Species Observed at Five Localities

Survey area	Species	Number of sightings[a]	Type of forest[b]
1. Tres Corazones (SWW Cobija)	*Alouatta seniculus*	1 (heard daily)	1
	Aotus nigriceps	1	1
	Callicebus sp.	3 (+heard once?)	1-3
	Callimico goeldii	1	1
	Cebuella pygmaea	1	2
	Cebus albifrons	1	1
	C. apella	10	1, 2
	Pithecia irrorata	2	1-3
	Saguinus fuscicollis	9	1-3
	S. labiatus	1	1
	Saimiri boliviensis	2 (+heard once)	1
	S. fuscicollis + *S. labiatus*	1	1
2. Puerto Rico (SEE Cobija)	*Alouatta seniculus*	1	1
	Callimico goeldii	1	1
	Pithecia irrorata	1	1
	Saguinus fuscicollis	6	1
	S. labiatus	3	1, 3
	Saimiri boliviensis	2	3
	Callimico goeldii + *S. fuscicollis*	1	1
	S. fuscicollis + *S. labiatus*	1	3
3. Tres Estrellas, Fortalezza (SW Cobija)	*Alouatta seniculus*	2 (heard daily)	1
	Aotus nigriceps	1	1
	Callicebus sp.	3 (heard frequently)	3, bamboo
	Callimico goeldii	1	1
	Cebus albifrons	2	1, 3
	Cebus apella	2	1
	Pithecia irrorata	1	1
	S. fuscicollis	14	1-3
	S. labiatus	2	1, 2
	Saimiri boliviensis	2	3
	Callimico goeldii + *S. fuscicollis*	1	1
	S. fuscicollis + *S. labiatus*	2	1, 2

Table IV. Continued

Survey area	Species	Number of sightings[a]	Type of forest [b]
4. Río Acre (WNW Cobija)	*Callicebus* sp.	(Often heard)	
	Callimico goeldii	1	1
	Cebus apella	3	1
	Pithecia irrorata	1	1
	S. fuscicollis	8	1
	S. labiatus	3	1
	Saimiri boliviensis	1	1
	Callimico goeldii, S. fuscicollis, + *S. labiatus*	1	1
	Pithecia irrorata + *S. fuscicollis*	1	1
	S. fuscicollis + *S. labiatus*	2	1, 2
5. Bella Flor (SE Cobija)	*Alouatta seniculus*	(Rarely heard)	1
	Aotus nigriceps	(Heard once)	1
	Callicebus sp.	(Heard almost daily)	1
	Callimico goeldii	5	1, 2
	Cebus apella	1	2
	Pithecia irrorata	1	2
	Saguinus fuscicollis	23	1, 2
	S. labiatus	20	1, 2
	Saimiri boliviensis	1	3
	Callimico goeldii, S. fuscicollis, + *S. labiatus*	3	1
	Callimico goeldii + *S. fuscicollis*	1	1
	Pithecia irrorata + *S. fuscicollis*	1	2
	S. fuscicollis + *S. labiatus*	18	1, 2

[a] Repeated sightings of the same group are listed only once, except species in polyspecific troops, which are listed again separately below each species listing.

[b] 1, primary; 2, secondary; 3, riverine.

never saw black spider monkeys during this survey, though they were said to occur in survey area 5.

The emperor tamarin (*Saguinus imperator*) was said to occur around Deposita, on the south bank of the Río Tahuamanu near the Peruvian border (survey area 3). Although the local guide said he saw them daily, we did not find them during this survey.å

During the first excursion, we heard *Callimico* and observed them only once to the north of the river Nareuda, about 3 km southwest of a locality called Nareudita and 35 km east of the Peruvian border (Fig. 1, star). The local guide said that he had seen them at the same place on several occasions. The group consisted of three adult-sized animals. We

Table V. Estimated Group Sizes of Primates: Mean, Standard Deviation, and Number of Groups (in Parentheses)[a]

Species	Survey area No.					Total
	1	2	3	4	5	
Alouatta seniculus	10 (1)	—	—	—	—	10 (1)
Aotus nigriceps	—	—	4 (1)	—	—	4 (1)
Callicebus sp.	2 (2)	—	4 (1)	—	—	2.7 ± 1.2 (3)
Callimico goeldii	2.5 (1)	4.5 (1)	—	3 (1)	3.3 ± 0.6 (3)	3.3 ± 0.8 (6)
Cebuella pygmaea	4.5 (1)	—	—	—	—	4.5 (1)
Cebus albifrons	10 (1)	—	10 (1)	—	—	10.0 (2)
Cebus apella	2.4 ± 0.3 (9)	—	4 (1)	5.2 ± 42 (3)	3 (1)	3.1 ± 2.0 (14)
Pithecia irrorata	3.5 (1)	—	3 (1)	4 (1)	3 (1)	3.4 ± 0.5 (4)
Saguinus fuscicollis	4.4 ± 1.9 (8)	4.0 ± 0.9 (4)	4.8 ± 0.7 (9)	6.8 ± 4.2 (4)	5.6 ± 1.9 (11)	5.1 ± 2.0 (36)
Saguinus labiatus	6 (1)	5.2 ± 1.2 (3)	—	5.5 (1)	4.6 ± 2.0 (12)	4.8 ± 1.8 (17)
Saimiri boliviensis	23.8 (2)	10 (1)	15 (1)	20 (1)	10 (1)	17.1 ± 6.4 (6)

[a] Counts of polyspecific troops are included in this list. Maximum and minimum estimates for the same group are entered as mean values.

encountered them in primary forest near a small river, at a height of about 20 m. They were with a group of five to six *S. fuscicollis*. The following day we failed to relocate them.

During the same excursion we spent 2 weeks searching the vicinity of Mucden and Triunfo (Fig. 1) with the help of local guides, but without finding any trace of *Callimico*. Buchanan-Smith (1991a), Cameron (1989), Izawa (1979), Masataka (1981a, b), and Pook and Pook (1981) had recorded them there.

During the second excursion, we heard *Callimico* uttering long calls near a locality on Río Tahuamanu called Bella Flor. We found the group in primary forest. It consisted of at least five individuals. We sighted them at a height of 8–10 m, together with a group of *S. fuscicollis*. Upon noticing the observer, the tamarins climbed upward in the tree and looked down. In contrast, the Goeldi’s monkeys immediately fled in big jumps from branch to branch, others, head down like squirrels, climbed downward and disappeared in the undergrowth, where we could no longer see them.

In area 3, we sighted two *Callimico* in association with a group of *S. fuscicollis* at a distance of 20 m and a height of 5 m,. Again, the Goeldi’s monkeys rushed downward into the undergrowth.

During the fourth survey excursion, in a primary forest with numerous little rivers, we encountered two or three Goeldi’s monkeys three times at a height of 3–4 m. They were in association with two tamarin species: *S. fuscicollis* and *S. labiatus*.

Finally, we observed several polyspecific troops of *Callimico goeldii*, *S. fuscicollis*, and *S. labiatus*, in survey area 5 (the study site).

RESULTS FROM THE MAIN STUDY SITE

The survey area near Bella Flor (No. 5) appeared to be particularly well suited for a field study on the behavioral ecology of *Callimico*. We report results of our pilot study there.

Group Composition

At located at least eight callitrichid groups at Bella Flor (Fig. 4). Each group was composed of *S. fuscicollis* and *S. labiatus*. In four of the eight groups, we observed *Callimico goeldii* among them, and we heard *Callimico* long-calls from within three other groups. The main study group (group 2) was composed of 5 or 6 *S. labiatus*, 7 or 8 *S. fuscicollis*, and 3 adult-sized *C. goeldii*, for a total of 15–17 animals. The uncertainty in the number of animals derives from a minimum of two juvenile tamarins that

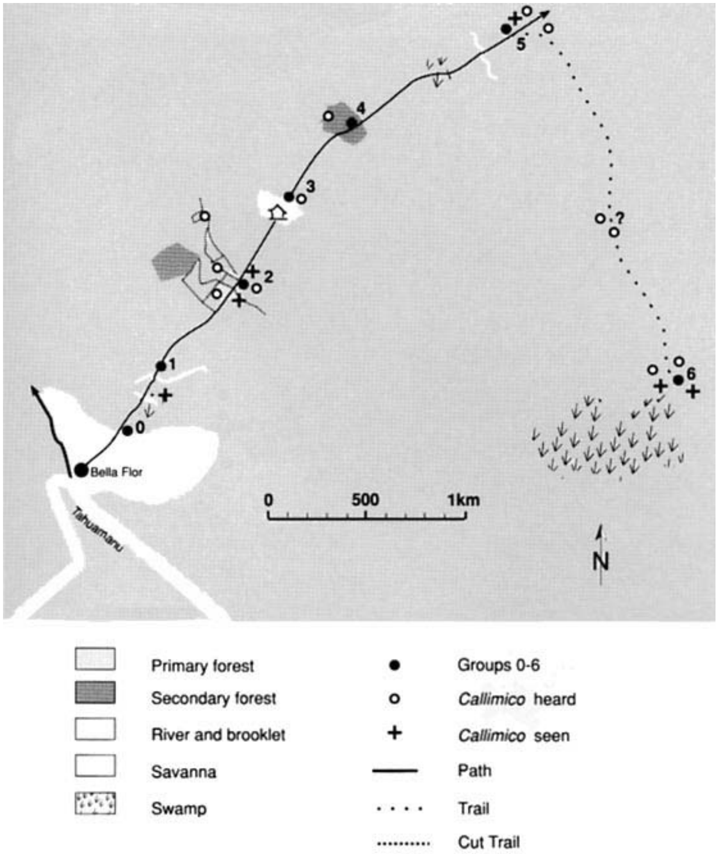

Fig. 4. Map of the study site close to Bella Flor.

could not be reliably identified. In two other polyspecific troops, the number of Goeldi's monkeys was to three (group 5) and about four (group 6).

Home Range

The groups were separated by distances of about 500–700 m, and we do not known whether their ranges overlap (Fig. 4).

The home ranges of each group were situated in primary forest, but six of eight included a small area of secondary forest with fast-growing ambaibo (*Cecropia* sp.) and balsa trees (*Ochroma lagopus*) (Fig. 5a), whose

Fig. 5a. Example of fruit-trees serving as food for callitrichid species: (a) *Ochoma lagopus* (Balsa) on the right and *Cecropia* sp. (Ambaibo) on the left (secondary forest); (b) *Chorisia* sp. (Toborochi) (primary forest); (c) *Hymenaea* sp. (Paquio) (primary forest).

Fig. 5b. Continued

Fig. 5c. Continued

fruit and flowers are eaten by several species of monkeys (*Cebus*, *Pithecia*, *Saguinus*).

Figure 6 shows the area used by the main study group. By connecting the most peripheral sightings of this group, we estimate its home range to be ≥80 ha. There were four small clearings within the home range and one larger area of secondary forest (about 200 m^2) with many ambaibo and balsa trees and fast-growing thickets of bamboo and various shrubs. Centrally placed in the home range, separated by 20–100 m, there were four toborochi trees (*Chorisia* sp.) (Fig. 5b) with flowers and fruit (Table VI). No

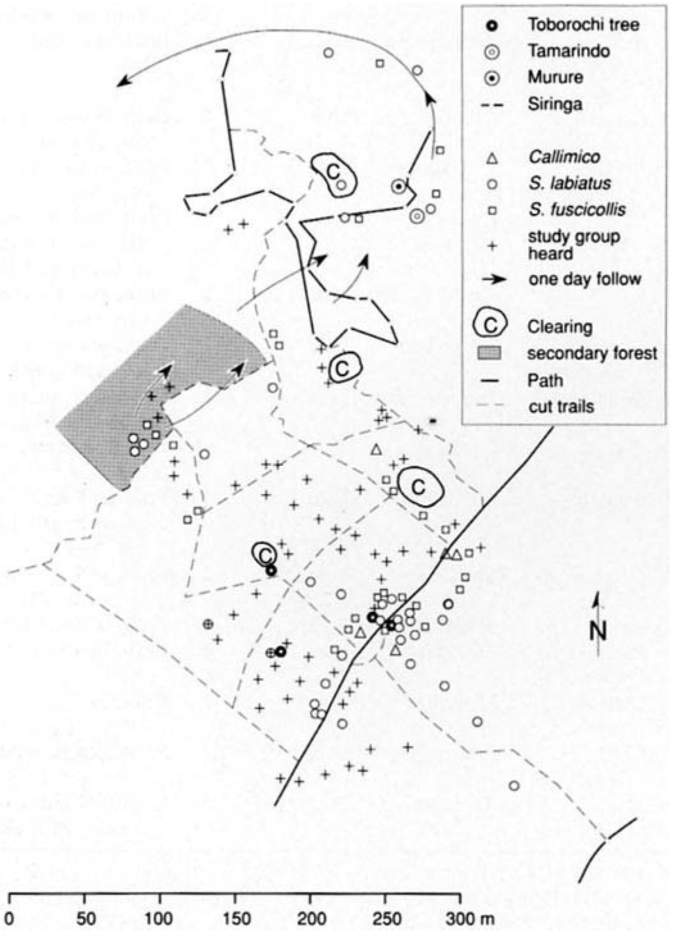

Fig. 6. Home range of main study group at Bella Flor, a polyspecific troop composed of *Callimico goeldii*, *Saguinus fuscicollis* and *S. labiatus*.

Table VI. Plants Reportedly Used as Food by Callitrichids in the Pando Department

Common name	Scientific name	Family	Plant type	Forest type[a]	Part consumed[b]

Uembe	indet.	Aracaceae?	Epiphyte	1	Fruit, yellow-green, sweet, 30 cm, VIII
Balsa[c]	*Ochroma lagopus*	Bombacaceae	Tree	2	Nectar of flowers, white, 10–15 cm, V–VII; and fruit, cream-brown, 7–8 cm, VII
Toborochi[c]	*Chorisia* sp.	Bombacaceae	Tree	1+2	Blossoms, red, length 8.5 cm, IV–VI; and fruit, green, hard, length 8–10 cm, VI-VII
Isigo	*Protium heptaphyllum*	Burseraceae	Tree	1	Fruit, red, size of a fist, VI
Paquio[c]	*Hymenaea* sp.	Cesalpinaceae	Tree	1	Fruit, brown, length 6–7 cm; and seeds, X–XI
Achachairu	*Rheedia achachairu*	Clusiaceae	Tree	1	Fruit, yellow, soft, size of a fist, X
Chijllu (=Uvillio)	*Vallea stypularis*	Elaeocarpaceae	Tree	1	Fruit, dark-brown, grape-like, sweet, small, in bunches, VIII
Micro-bambus[c]		Graminaceae	Shrub/ Tree	2	Fruit, green, oatlike, very small
Murure[c]	*Brosmium alicastrum*	Lauraceae	Tree	1	Fruit, orange, 2–3 cm, in small bunches
Tamarindo silvestre[c]	*Dialium* sp.	Leguminosae	Tree	1	Flowers, small and green, VII; and fruit, chocolate-colored, small, X–XI
Pacay	*Inga* sp.	Mimosaceae	Tree	1	Fruit and seeds, yellow / green, length 10–20 cm,V–VI
Ambaibo[c]	*Cecropia* sp.	Moraceae	Tree	2	Fruit, yellow-chocolate, 8–10 cm, VII
Cauchu	*Castilla ulei*	Moraceae	Tree	1	Fruit, big as a fist, yellow
Nui	*Pseudolmedia* sp.	Moraceae	Tree	1	Fruit, X–IX
Quechu	*Olmedia aspera*	Moraceae	Tree	1	Fruit, X
Chichapi[c]	*Celtis brasiliensis*	Ramnaceae	Liana	1	Fruit, green, small, VI
Cabeza de mono	*Apeiba tibourbou*	Tiliaceae	Tree	1	Fruit big, green with spines, VIII–IX

[a] 1, primary; 2, secondary; 3, riverine.

[b] Roman numerals represent months of ripeness or flowering.

[c] Plants on which *Saguinus* fed.

river flows through the home range, but in the southeast lies a small, swampy area with several palm trees.

Activity

The group used different sleeping places, two of which were situated near the toborochi trees and one in the northeast corner of the home range. The three species in the group did not sleep all together on the same tree; we saw them emerge in the morning from three different trees in close proximity. Each species probably slept by themselves at a height of about 8–10 m. The presumed sleeping trees were overgrown by epyphites and lianas, with dense leaf cover overall. We found no sleeping holes in them, though local people reported that *Saguinus* and *Callimico* generally sleep in tree holes.

Whenever the *Callimico/Saguinus* group did not sleep near the toborochi trees, it appeared to sleep in the north of the home range. In 13 of 19 cases, we saw them moving from north to south in the morning, traveling from the sleeping site to the toborochi region and then slowly moving to the south of the home range.

In the morning, the monkeys started to move at 0705–0715, about 10–15 min after dawn. While emerging from the sleeping sites, they produced soft contact- and long-calls, and once in full movement, the group vocalized loudly for about 15–45 min.

In June and July, the four toborochi trees represented the core of the home range of the main study group. On 19 of 24 days the group spent at least part of the day in their vicinity. The group appeared to rest for a relatively long period in the afternoon, because we never located them after 1300, nor could we follow them to their sleeping tree.

The longest continuous period over which we followed them is 4 hr: at 0720 we first heard them in the northeast part of the home range, and at 0820 we located them together with one *Pithecia* in the secondary growth, all feeding on balsa trees for about an hour. Then they traveled for 200–300 m to other feeding trees – tamarindo silvestre (*Dialium* sp.) and murure (*Brosmium alicastrum*) (Table VI) – and, finally, moved to the northern boundary of their home range, where we last heard them at 1120. During this time we did not see *Callimico* but we heard their long-calls from within the group.

Locomotion

Callimico and the two species of *Saguinus* appear to have different height preferences for traveling and feeding: *S. labiatus* at 17 ±9 m (range, 2–30 m; *n* = 26), *S. fuscicollis* at 16 ± 7 m (range, 0–30 m, *n* = 46), and *Callimico* at 7 ± 7 m (range 0–20 m, *n* = 12). In only 17% of all sightings was *Callimico* at heights >10 m (on a paquio tree; Fig. 5c). When moving quickly, like the two species of *Saguinus*, *Callimico* ran quadrupedally or performed long leaps along horizontal branches and made large leaps from branch to branch or from and to clusters of thin terminal branches. After spotting the observer, *Callimico* always moved downward to hide in the thicket, rather than climbing higher as the tamarins did. On one occasion, a *Callimico* ran across a path on the ground. Goeldi's monkeys also climbed quadrupedally upward and downward – always head first – on thick vertical trunks, using their claws, like tamarins.

Feeding

Table VI is a list of all plants whose flowers, fruits or seeds we saw (or were reported by our guide to be) eaten by callitrichids and other monkeys. Unfortunately, we did not observe *Callimico* feeding. While the two species of *Saguinus* fed high in a tree, the Goeldi's monkeys were near the ground, possibly foraging on insects there.

In June and July, we repeatedly encountered the three species together around the toborochi trees (Fig. 5b). On these trees, *S. labiatus* sucked the green fruit, while *S. fuscicollis* licked or ate something inside the red blossoms – possibly nectar or ants. The tamarins also ate the big white flowers of balsa trees (*Ochroma lagopus*) in secondary growth, the little orange fruit of murure (*Clarisia* sp.), and on the chocolate-colored small fruit of tamarindo silvestre (*Dialium* sp.); the latter two trees occur in primary forest. Once nonfeeding *Callimico* was on a paquio tree (*Hymenaea* sp.), whose fruit and seeds are reportedly eaten by monkeys.

Several times *S. labiatus* fed in an unusual position, hanging upside down by its hind feet from a toborochi branch, probably searching for insects under the leaves and suckling on fruits. *Callimico* feed occasionally in this posture (Pook and Pook, 1981)

Predators

In the morning immediately before the monkeys started to move, large birds of prey glided noiselessly through the crowns of the trees. Because Goeldi's monkeys are so often near the ground, birds may catch them infrequently. The main predator of *Callimico* may be the tayra (*Eira barbara*), a primarily terrestrial carnivore. Nearly always, when we detected *Callimico*, we also heard a tayra, or occasionally a pair of them, roaring and sometimes saw them nearby. A less common potential predator, is the

Jaguarundi, which we once observed climbing down a tree near a group of *Saguinus*.

Long Calls

Although the description of *Callimico* vocalizations was not a main objective of this study, we attended to one of them because it is of great help in locating *Callimico* in the forest.

The vocal repertoires of many callitrichids include a stereotyped phrase, usually referred to as long call. Table VII is a list of callitrichid species whose long calls are described and documented via sonagrams. Names other than long call have also been used by some authors for the

Table VII. Studies Presenting Sonagrams of Callitrichid Long Calls

Species	Name of Vocalization[a]	Reference
Callimico goeldii	—	Epple (1968)
	Long call	Present study
Callithrix jacchus	Phee call	Epple (1968)
	Loud shrilling call	Pook (1977)
	Phee call	Winter (1978)
C. geoffroyi	Phee call	Epple (1968)
Cebuella pygmaea	J-call	Pola and Snowdon (1975)
	Adult J-call	Snowdon and Hodun (1981)
Leontopithecus chrysomelas	Long call	Snowdon *et al.* (1986)
L. chrysopygus	Long call	Snowdon *et al.* (1986)
L. rosalia	—	Epple (1968)
	Long call	Kleiman *et al.* (1988)
	Long call	McLanahan and Green (1977)
	Long call	Snowdon *et al.* (1986)
Saguinus fuscicollis	Long call	Hodun *et al.* (1981)
	Long call	Moody and Menzel (1976)
	Loud shrilling call	Pook (1977)
S. geoffroyi	—	Epple (1968)
	Long whistle	Moynihan (1970)
S. labiatus	Tsee series	Coates and Poole (1983)
	Long call	Maeda and Masataka (1987)
	Long call	Masataka (1988)
S. mystax	Long call	Heymann (1987)
	Long call	Snowdon and Hodun (1985)
S. oedipus	Quiet and normal long call	Cleveland and Snowdon (1982)
	—	Epple (1968)
	Quiet and normal long call	Snowdon *et al.* (1983)

[a] In spite of different names, we suggest that these vocalizations are directly comparable because they resemble each other both in several acoustical characteristics and in the behavioural context.

same apparent vocalizations. In order to facilitate comparison, we list them in Table VII.

In order to describe long calls in *Callimico* in more detail, we made tape recordings at Bella Flor. Tape recordings of 13 *Callimico* long calls are of sufficient quality for sonagraphic analysis. For comparison, we also analyzed 36 long calls of *Saguinus*. As we did not recorded whether the latter were produced by *S. fuscicollis* or by *S. labiatus*, we make no comparison between the long calls of these to species.

We summarize the parameters measured in the sonagrams in Table VIII. An unfiltered sonagram of a typical *Callimico* long call is in Fig. 7. Only the basal frequencies of the vocalization are evident in the sonagram, but harmonics may exist above 11 kHz. The long calls of *Callimico* in Bella Flor have a duration of about 3–4 sec and consist of about 10–17 notes. The notes have a very pure, tonal quality, i.e., they show up as narrow bands in the sonagram (some fuzzyness results from reverberations in the forest). Most of the basal frequency modulation occurs between 7 and 9 kHz.

The long calls of *Callimico* and those of the two sympatric species of *Saguinus* usually have the following structure. The first note frequently differs from the following notes in several respects: It is of lower intensity and a distinctly higher frequency. Subsequent notes are of descending frequency modulation. In all three species, the shape of the individual long-call notes is similar: They begin with a sharp decrease in frequency, usually

Table VIII. Summarized Statistics of Several Parameters that Describe Long Calls of *Callimico goeldii*.

Parameter	Long calls[a]	Mean	SD	Minimum	Maximum
Duration of long call (sec)	13	3.56	0.51	2.82	4.47
Number of notes per long call	13	13.69	2.36	10	17
Duration of shortest note (sec)[b]	12	0.08	0.03	0.03	0.13
Duration of longest note (sec)[c]	13	0.50	0.12	0.31	0.76
Duration of shortest interval (sec)[d]	12	0.06	0.02	0.03	0.10
Duration of longest interval (sec)[e]	13	0.14	0.03	0.08	0.19
Lowest start frequency of a note (kHz)	13	8.49	0.61	7.45	9.69
Highest start frequency of a note (kHz)	12	9.59	0.39	9.07	10.37
Lowest end frequency of a note (kHz)[c]	13	6.09	0.61	4.91	6.89
Highest end frequency of a note (kHz)[b]	12	8.03	0.29	7.58	8.57

[a] Because the first note in one of the long calls was not very distinct on the sonagram, a few parameters were not measured in this long call. For these parameters, *n* is 12, instead of 13.

[b] Usually the first note in a long call.

[c] Usually the last note in a long call.

[d] Usually the first interval in a long call.

[e] Usually the last interval in a long call.

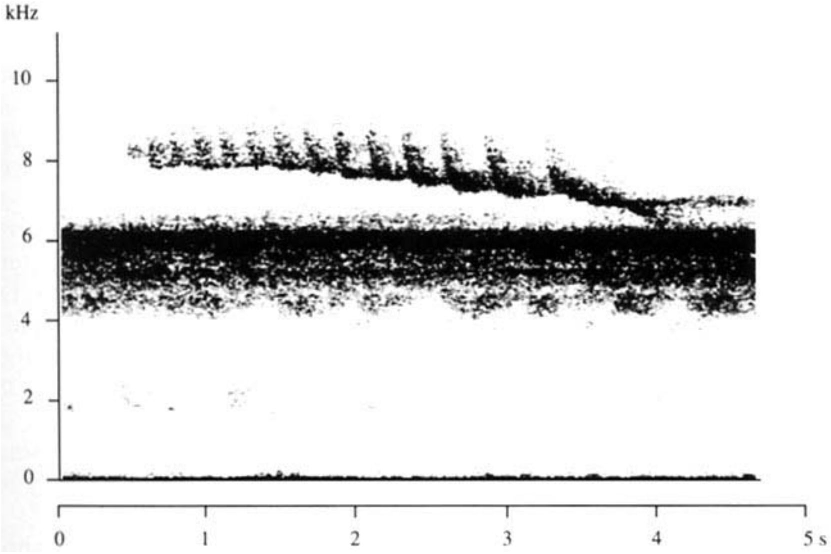

Fig. 7. Unfiltered sonagram of a typical long call by *Callimico*.

followed by a second sequence with a lesser decrease. The end of the notes is more variable: A second sharp decrease or a short increase in frequency may follow. As a rule, the highest frequency usually occurs at or near the beginning of the note, and the lowest frequency at or near the end. Throughout the series, each note and interval is longer than the preceeding one; this is particularly obvious in *Callimico*. In addition, the intensity of the notes increases, and both the start and the end frequencies of the notes become lower. The last note is often often particularly long. When an individual of any of the three species gives a long call, its mouth is opened wide and its teeth are bared.

Saguinus fuscicollis and *S. labiatus* produce long calls that sound very similar to those of *Callimico*. They are at least as loud as those of *Callimico*, they are in about the same frequency range, and the shape of the notes is intriguingly similar. In contrast to the long calls of *Callimico*, those of *Saguinus* are shorter (3.56 ± 0.51 sec, n = 13, for *Callimico* vs 2.42 ± 0.59 sec, n = 36, for *Saguinus*) and contain fewer notes (13.69 ± 2.36 sec, n = 13; vs 10.78 ± 2.32 sec, n = 36). The differences in both parameters are statistically significant (Mann–Whitney U test: U = 33, P = 0.0001, and U = 91.5, P = 0.0013, respectively). In addition, *Callimico* exhibits a very marked slowing-down in the rhythm of note presentation and a decrease in frequency toward the end of its long calls. This was less obvious – and frequently absent – in long calls of *Saguinus*.

Although we conducted no comparison between the long calls of the two smpatric species of *Saguinus*, we had the impression that those of *S. fuscicollis* are longer and exhibit a slightly more pronounced deceleration and decrease in frequency toward the end, while long calls of *S. labiatus* tended to be shorter and more constant in their rhythm and frequency range. Figure 8 shows a sonagram of a long call by *Saguinus*, tentatively attributed to *S. fuscicollis*.

We repeatedly observed at Bella Flor that two individuals of a given species would present their long calls almost in synchrony, resulting in temporal overlap of more than 60%. Among the long calls analyzed here, two such instances occurred in *Callimico* and four in *Saguinus*. An example is shown in Fig. 9. In this sonagram, the two individuals do not end their long calls at exactly the same time, and it can be heard distinctly on the tape recording that two animals are calling. In some other instances, the synchrony of two callers was so perfect that only the analysis of the sonagrams revealed the fact that two individuals were calling concurrently but differing slightly in the frequency of their vocalizations.

Most long calls occur during early morning calling bouts, at about 0700, when the animals emerge from their sleeping trees and come together. Often, we heard long calls of all three species during the same calling bout. Thereafter, long calling bouts decreased in frequency until about midday, sometimes occurreing when the animals arrived at food sources, e.g. the toborochi tree. We rarely heard long calls after 1200, and

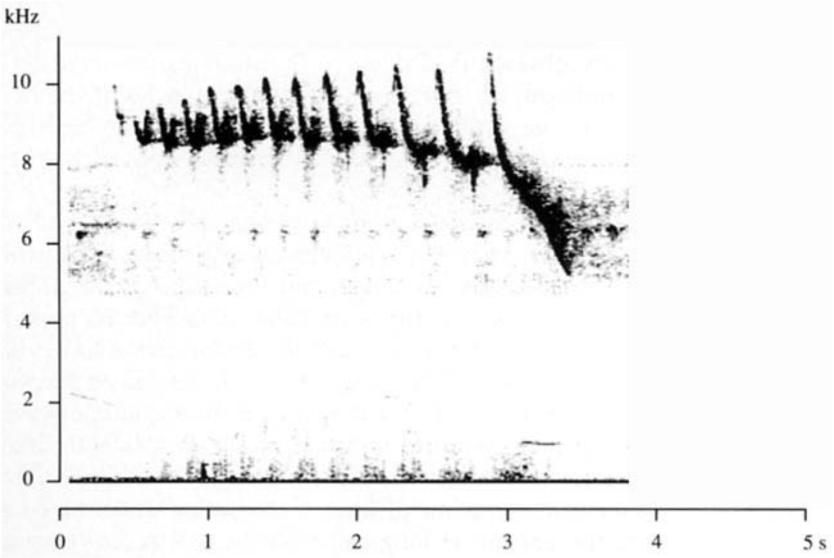

Fig. 8. Unfiltered sonagram of a long call by *Saguinus*, tentatively attributed to *S. fuscicollis*.

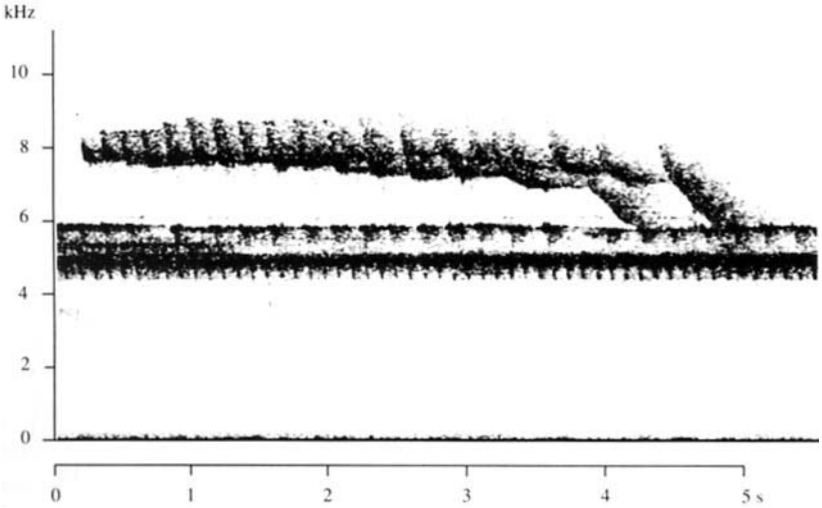

Fig. 9. Unfiltered sonagram of two long calls by *Callimico*, uttered almost in synchrony.

calling was not resumed in the evening when the animals settled down for the night. Figure 10 shows the starting time for calling bouts that we recorded during 26 days. The total number of long calls recorded for *S. fuscicollis* is larger than that in the other two species, probably because *S. fuscicollis* was more abundant.

DISCUSSION

Habitat

Izawa (1979) and Pook and Pook (1981) have described *Callimico* as a habitat specialist, living almost exclusively in a dense bamboo forest, termed shabby forest by Izawa (1979). Izawa (1979) suggested that the natural decline of the shabby forest since the early and middle Quaternary, together with competitive pressure from *S. fuscicollis*, may have been responsible for the low densities of *Callimico* and might eventually lead to its extinction. In contrast to these earlier reports, we never found *Callimico* in bamboo forest, though we searched from them intensively there. Instead, *Callimico* was always located in primary forest, twice on big trees at a height of about 10–20 m and otherwise at a height of about 0–9 m. They usually retreated quickly into the undergrowth as soon as they noticed us.

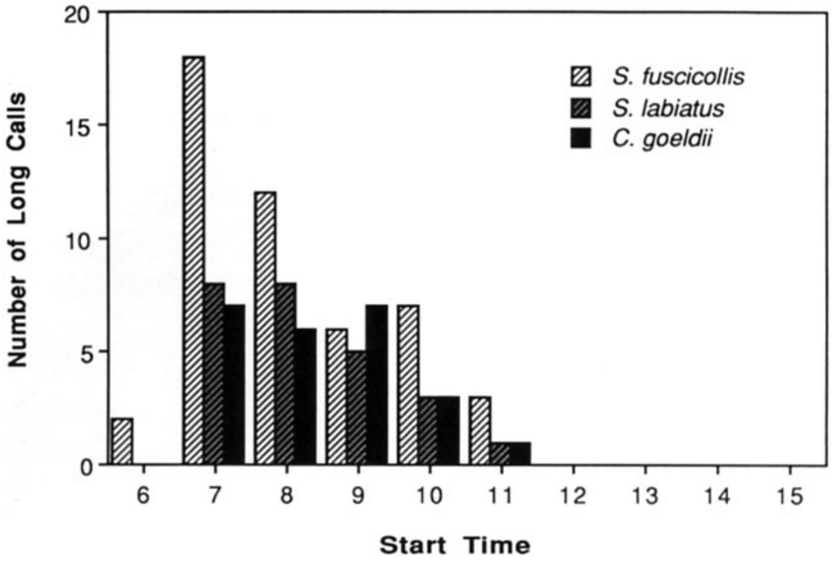

Fig. 10. Start times of long call bouts by callitrichids recorded during 26 days.

We do not know whether, like *Saguinus* spp., *Callimico* might also occasionally occur in secondary growth.

Feeding

Pook and Pook (1981) twice saw a *Callimico* jump to the ground from 0.5–1 m and then immediately jump back with a big grasshopper or cricket in its mouth. Possibly insects that occur under litter on the ground attract *Callimico* to the forest floor. Unfortunately, we never directly observed *Callimico* feeding during this study. But even if feeding on terrestrial insects makes up a substantial part of their diet, it is unclear why *Callimico* tended to flee down from the trees when disturbed by us, and not upward like *Saguinus* do. By often staying close to the ground, *Callimico* may be an easier prey for terrestrial predators – such as large snakes and tayras – than *Saguinus* are.

Locomotion

Izawa (1979), Moynihan (1976), and Pook and Pook (1981) reported that *Callimico* often leap from trunk to trunk with the body and head ver tical. This contrasts with our observations. We saw *Callimico* climbing big trunks via their claws, running over horizontal branches, and jumping *Saguinus*-like over larger distances to and from clusters of thin terminal branches. We never observed *Callimico* vertically clinging and leaping.

When disturbed by us, *Callimico* fled down from the trees, not upward like *Saguinus*. Moynihan (1976) and Pook and Pook (1982) also noted this response. This behaviour is unusual among Neotropical primates and its adaptive value is unknown, especially when taking into consideration the frequent presence of ground-dwelling predators near them.

Social Structure

We observed *Callimico* in groups of two to five animals (mean = 3.3, n = 6, Table V). This contrasts with the larger groups observed in most other recent studies (Buchanan-Smith, 1991a; Masataka, 1981a, b; Pook and Pook, 1981, 1982). It also contrasts with the larger groups of ≤13 *Saguinus* (*S. fuscicollis* mean = 5.1, n = 36; *S. labiatus* mean = 4.8, n = 17; Table V) that we observed.

Izawa (1979) and Pook and Pook (1981) reported that, unlike *Saguinus*, groups of *Callimico* live largely in isolation from each other, separated by distances of up to several kilometers. We found that *Callimico* sometimes occupy adjacent home ranges, e.g., at Bella Flor. Even if one group of *Callimico* associated with two different groups of *Saguinus*, as Pook and Pook (1982) speculated, they would still be surrounded by neighboring groups of *Callimico* in Bella Flor.

The home range of 80 ha that we estimated here for the polyspecific main study troop is much larger than the home range sizes of *Saguinus* in the Pando Department [17–23 ha (Buchanan-Smith 1990, 1991b) and 20–35 ha (Pook and Pook, 1982)] and is closer to, but still smaller than, the home range size of up to 50–60 ha estimated for one group of Goeldi's monkeys by Pook and Pook (1982). In view of the small number of direct observations on *Callimico* within the main study group, the estimate presented here must be regarded with caution and is a minimum estimate.

Polyspecific Associations

Four tamarin species are sympatric, and frequently found in mixed-species troops with *S. fuscicollis*, but are mostly or wholly allopatric to each other: *S. imperator*, *S. labiatus*, *S. mystax*, and *S. nigricollis* (Buchanan-Smith, 1990, Heymann, 1990; Norconk, 1990; Pook and Pook, 1982). At Bella Flor, *Callimico* was usually the third participant in mixed troops of *S. labiatus* and *S. fuscicollis*. Pook and Pook (1981, 1982) and Buchanan-Smith (1991a) noticed that the three species spent more than half of their time in association with each other. Whereas *S. fuscicollis* and *S. labiatus* sometimes feed on the same tree, *Callimico* was usually within 5 to 20 m of them, often down in the shrub layer. Since the three species tend to feed and travel at different heights, feeding competition may not be very pronounced. We saw no evidence of competitive pressure on *Callimico*. *Callimico* never feed on the big toborochi trees, in contrast to *Saguinus*, between which *S. labiatus* appeared to be dominant over *S. fuscicollis*.

It is probably advantageous to at least one of the associating species to be in a large mixed group of 9 to 18 individuums. One frequently suggested advantage may consist in enhanced predator detection; Terborgh (1990) discusses several mechanisms by which this may be achieved. The relatively silent and shy *Callimico*, living closer to the ground than *Saguinus* does, may benefit from being warned of aerial predators by the noisier *S. fuscicollis*. A further hypothesis, which does not exclude the first one, it that *Callimico* warns *Saguinus* of terrestrial predators.

Twice we saw *Pithecia* in association with *Saguinus*, but one instance was of a relatively short duration (about 1 hr). Buchanan-Smith (1990) and Izawa (1978) also observed associations between monkeys of these two genera.

Long Calls

Saguinus and *Callimico* give long calls in three contexts: when the group members come together in the early morning, when one or several individuals becomes isolated from their group, and during inter-troop encounters (see Pook and Pook, 1981, for *Callimico*, and references in Table VII for callitrichids). It is usually assumed that long calls serve several functions; the most frequently suggested of these include long distance territorial advertisement and coordination of movements of group-members. In polyspecific troops, these functions are possibly also apply to inter-species communication (Pook and Pook, 1982).

Most of the basal frequency modulation of *Callimico* great calls occurs between 7 and 9 kHz (in the two sympatric *Saguinus* species this is much similar). During the day there is considerable ambient noise in the forest. On the unfiltered sonagrams (Figs. 7-9), the ambient noise shows up as a grey haze, which is particularly strong between 4 and 7 kHz, where it often takes the form of a dark horizontal band. Above 8 kHz ambient noise is virtually absent. Figure 11 shows the relative intensity of ambient noise at different frequencies. The preferred frequency range of *Callimico* long calls is also indicated and is situated just above the range of the ambient noise. Long calls of

Callimico appear to exploit a frequency window above 7 kHz, possibly in order to avoid competition from other sound sources. Similar findings have previously been reported for other callitrichids such as *Cebuella pygmaea* and *Saguinus mystax* (Heymann, 1987; Snowdon and Hodun, 1981).

Long calls were particularly helpful in locating *Callimico* and *Saguinus* in the forest. They were very loud and we could hear them over a distance >200 m. It is probable that callitrichids can hear the long calls over longer distances, since the auditory sensitivity of New World monkeys for sounds >7 kHz is superior to that found in humans and great apes (Fobes and King, 1982).

Although Masataka (1982, 1983) described and sonagraphically documented the vocal repertoire in *Callimico* in some detail, he did not mention long calls, and none of the sonagrams that he published resembles long calls. In addition, three sonagrams of vocalizations by *Callimico* have been published by Moynihan (1976); his Fig. 43 resembles the end of a long call,

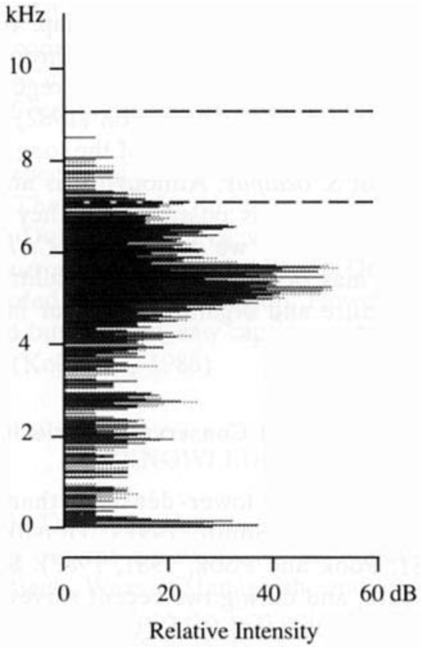

Fig. 11. Relative intensity of ambient noise at different frequencies. No callitrichid vocalizations occurred during this sample. The two dashed lines indicate the upper and lower limits of the preferred range of long calls by *Callimico*.

but it is described as a “faint trill” and may, therefore, differ from the loud long calls that we describe. True Goeldi monkey long calls were described by Epple (1970, p. 34) as “rhythmical calls given in isolation”, and by Pook and Pook (1981, 1982) as “shrilling calls”. Epple’s description includes a drawing of a sonagram (1968, Fig. 44), but it is very different from those of the long calls we recorded.

Epple’s (1968) subjects produced long calls with fewer notes (2-10 vs 10–17) and shorter intervals (about 0.04 s vs 0.03–0.19 sec) than our subjects did. The long call on her sonagram is shorter than those from Bella Flor (ca. 0.8 vs 2.82-4.47 sec), and the individual notes in her sonagram are of the ascending type, except the last note, instead of descending in frequency. The reasons for these differences are unknown. It is possible that *Callimico* from various localities have different long calls, but Epple (1968) did not report the source(s) of her subjects.

The occasional occurrence of long calls uttered in synchrony by two individuals of *Callimico* or *Saguinus* suggests duetting behavior, but the small sample available precludes a statistical comparison of these incidences against randomly occurring long-call overlap. It may be significant that McLanahan and Green (1977) reported synchronized long calls (and some other synchronized vocalizations) to be a regular vocal feature in *Leontopithecus rosalia*. Cleveland and Snowdon (1982) described “antiphonal overlapping Quiet Long Calls,” variants of the long calls discussed here, among group members of *S. oedipus*. Although it is not clear how this antiphonal overlap is organized, it is possible that they were referring to a vocal phenomenon similar to that we describe for *Callimico*. Our observations suggest that duets may occur also in other callitrichid species. Duets with a very similar structure and organization occur in the songs of indris (Thalmann *et al*., 1993).

Distribution and Conservation Priorities

Callimico goeldii occurs at lower densities than most other South American primates (Buchanan-Smith, 1991a; Hershkovitz, 1977; Izawa, 1979; Masataka, 1981; Pook and Pook, 1981, 1982). Sightings by field researchers have been rare, and during two recent surveys *Callimico* was not seen (Freese *et al*., 1982; Kohlhaas, 1988). *Callimico* was not very familiar to most local people whom we interviewed, but sometimes they were able to provide helpful information. The common answer to queries referring to *Callimico* was, “There are Goeldi’s monkeys, but they are extremely rare and shy and therefore very difficult to find.” It became obvious during the fieldwork that *Callimico* clearly exhibits more cryptic behavior toward ob servers than *Saguinus* does. Their fleeing downward and hiding may contribute to the rarity of sightings.

We have shown that *Callimico* persist in areas of nothern Bolivia (Fig. 1). Nevertheless, they are rare in all our survey areas, with the exception of Bella Flor. The survival of the species in Bolivia is probably threatened. This view is supported by the disturbing fact that we failed to find *Callimico* in the vicinity of Mucden and Triunfo (Fig. 1), where Buchanan-Smith (1991a), Izawa (1979), Masataka (1981a, b), and Pook and Pook (1981) had conducted field studies of them. The reasons for their decline and possible disappearance from this area and their rarity elsewhere in the Pando are unknown. In most of our survey areas, there is no reduction of habitat suitable for *Callimico*, which could explain their low density, and insects were abundant there.

Although hunting pressure is especially high on the larger species – *Ateles* and *Alouatta* – *Callimico* and *Saguinus* are also readily eaten. In addition, *Callimico* is apparently regarded as an animal for which foreigners are willing to pay. During our study, local inhabitants suggested that it might be helpful to use a captive young *Callimico* as a calling animal in order to attract conspecifics to the observation site, and they offered to go into the forest to catch one by shooting its parents. It is possible that the study groups of our predecessors were hunted once their locations became known.

A few other species of primates in the study areas may be as rare as *Callimico* are. They include *Ateles paniscus*, *Cebuella pygmaea*, and *Saguinus imperator*. During our survey, we found no evidence that *Lagothrix lagotricha* or *Saguinus mystax* live in the Pando Department. Izawa and Bejarano (1981) recorded them in this region. However, they did not encounter them in the wild but, instead, saw captive animals and registered reports from local people (Kohlhaas, 1988).

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