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Distribution of Two Sympatric Species of Sloths (*Choloepus didactylus* and *Bradypus tridactylus*) along the Sinnamary River, French Guiana[1]

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ABSTRACT

During the filling of the Petit Saut dam in French Guiana, a wildlife rescue operation was conducted for 17 months. Over 900 sloths (*Bradypus tridactylus* and *Choloepus didactylus*) were captured along the Sinnamary River in a primary rain forest that was largely undisturbed at the outset. Raw densities of 1.7 *B. tridactylus*/km^2 and 0.9 *C. didactylus*/km^2 were estimated. The distribution of captures was relatively continuous for both species along the rivers; variations most likely reflected biases due to capture methods. The highest densities of captures were located mainly in marshy areas. During the first months, due to different probabilities of sighting the two species, *B. tridactylus* captures predominated; however, as defoliation advanced, captures of *C. didactylus* reached the same level. In both species, over 73 percent of individuals captured were solitary and another 23–24 percent were females carrying young, accounting for 96 percent of emancipated individuals.

RÉSUMÉ

Dans le cadre de la mise en eau du barrage de Petit Saut en Guyane française, une opération de sauvetage de la faune s'est déroulée pendant 17 mois. Plus de 900 paresseux (*Bradypus tridactylus* et *Choloepus didactylus*) ont été capturés le long du fleuve Sinnamary dans une forêt tropicale primaire peu perturbée au départ. Les densités brutes ont été estimées à 1.7 *B. tridactylus*/km^2 et 0.9 *C. didactylus*/km^2. La distribution des captures le long des fleuves était relativement continue pour les deux espèces: les variations reflètent vraisemblablement des biais liés aux méthodes de capture. Les plus fortes densités de captures se situaient principalement dans des zones marécageuses. Au cours des premiers mois, et dû à des probabilités de repérage différentes entre les deux espèces, les captures de *B. tridactylus* ont prédominé, mais la défoliation progessant, les captures de *C. didactylus* ont atteint le même niveau. Pour les deux espèces, nous avons capturé plus de 73 pourcent d'individus solitaires et 23–24 pourcent de femelles portant un jeune. Ceci amène le pourcentage des animaux capturés solitaires à 96 pourcent des animaux émancipés.

Key words: Bradypus tridactylus; Choloepus didactylus; *density; distribution; French Guiana; habitat loss; rain forest; sloths; wildlife animal rescue.*

THE TWO EXTANT GENERA OF SLOTHS, *Bradypus* and *Choloepus*, comprise five species and are members of two different families that are believed to have diverged at least 40 million years ago (Höss *et al.* 1996). They are slow and silent, cryptic animals and are of little economic interest, which partly explains why their status and habits remain largely unknown. Most field studies on sloths have been conducted in the disturbed and young to medium-age forest of Barro Colorado Island, Panama, and have focused on *B. variegatus* and *C. hoffmanni* (Montgomery & Sunquist 1973, 1975, 1978; Sunquist & Montgomery 1973; Meritt & Meritt 1976; Meritt 1985). The two genera occur in sympatry, and partition of resources allows them to avoid interspecific competition to a great extent (diets, activity rhythms, and use of forest strata). In this study, we examined the local distribution and densities of two other species, *B. tridactylus* and *C. didactylus*, in French Guiana.

Over 5000 animals were captured by the "Faune Sauvage" operation during the flooding of > 365 km^2 of primary tropical rain forest during

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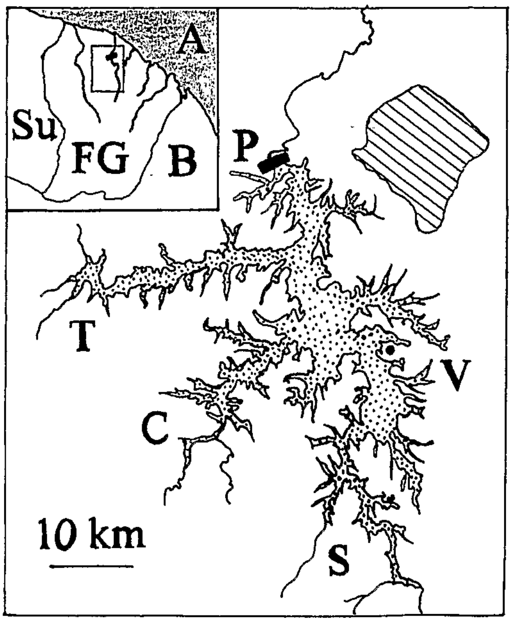

FIGURE 1. Location of study site showing the filled dam reservoir (dotted area), which includes the Sinnamary River (Si), the Courcibo River (c), and the Tigre Stream (T). The nearby release zone (hashed area) is also shown. A: Atlantic Ocean, B: Brazil, FG: French Guiana, P: Petit Saut dam (base camp), Su: Surinam, V: Saut Vata (upriver camp).

the construction of a hydroelectric dam at Petit-Saut, French Guiana. The capture of over 900 *B. tridactylus* and *C. didactylus* during this animal rescue provided an unprecedented occasion to examine the distribution of a large sample of these two species.

MATERIALS AND METHODS

The study area (Fig. 1) lies 4°45′–50°4′N and 52°55′–53°15′W; the dam is located on the Sinnamary River, *ca* 40 km from the Atlantic Ocean. The dominant forest type is dense, primary lowland rain forest on ferralitic ground, with a canopy varying in height from 25 to 35 m (De Granville 1986); some trees, however, reach 50 m. This plant formation is representative of the high floristic diversity of the Guianese forest: over 1080 species of large trees (Sabatier & Prévost 1990, Hoff 1994). Four habitats are more species-rich in the Sinnamary basin than in the rest of French Guiana: sandy and rocky banks, swamp and wetland forests, and cabbage plant forests. As a whole, the Sinnamary basin contains 23 percent of the Guianese flora; this relatively species-poor state is due to the absence of any large relief and open plant formations such as grasslands (Hoff 1994). Average rainfall is 3780–3850 mm/yr, with two rainy seasons and two dry seasons; one is usually marked from July through November and the other is a variable "litte summer" around March (Hoff 1994). The landscape is very hilly although altitudes rarely exceed 200 m.

The rescue operation lasted from January 1994 (beginning of dam filling) to May 1995. Capture operations were divided into two forest sectors and were made by two different groups of capture workers. The division between the two sectors was 5 km downstream from the Courcibo branch (Fig. 1). The flooded area along the Sinnamary River upstream from this division was covered by capture workers based at Saut Vata, a permanent camp 40 km upstream from the dam; the downstream sector was covered by workers based at the Petit-Saut dam. The Tigre Stream was sampled by the downstream workers only, whereas the Courcibo River was sampled by both teams as of November 1994.

After being secured, animals were transported by boat to the base camp situated at the dam, where they were examined by the veterinary staff before being released in a nearby 150 km^2 area (Fig. 1). Similar rescue operations were undertaken at Tucurui, Balbina and Samuel dams in Brazil, and at Brokopondo in Surinam (Collin 1991). An overview of the French Guianan project has been described by Vié (1999).

Bradypus tridactylus were captured manually by climbing trees; *C. didactylus* are more dangerous and had to be captured with a noose pole. The sloth was lowered to the boat and retrieved in a landing net, then transferred to an individual pet transportation box and conveyed to base camp. A clinical examination was performed and biological samples were taken. Adult animals were tattooed and tagged with color- or radio-collars before being released in a nearby 150-km^2 zone.

Each animal was assigned an identification number; the date, time, and location of the capture, as well as capture circumstances such as number of individuals captured simultaneously (*e.g.*, mother and young) or capture method employed, were recorded. Capture locations consisted of 21-ha squares previously plotted on a map of the reservoir area. The number of conspecifics captured simultaneously (groups) and the number of animals captured at the same locality regardless of date (the number of captures/square) were also recorded.

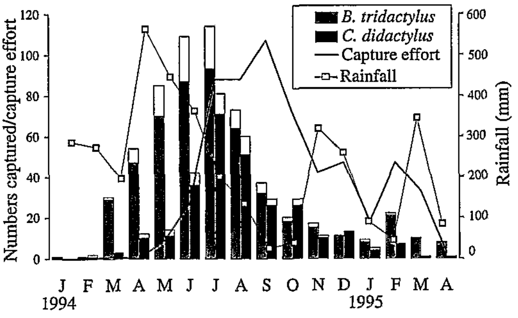

FIGURE 2. Numbers of *Bradypus tridactylus* and *Choloepus didactylus* captured per month (histograms), and capture effort for arboreal animals, expressed as number of boats employed per month (curve). Full bars represent emancipated animals only; clear bars indicate total numbers captured.

Density estimates are based on the total number of individuals captured. Capture dates and spatial distribution, however, deal with emancipated animals (*i.e.*, independent of parents) only; females and their dependent young were necessarily captured together and counted as one. Correlations between capture date and capture effort were tested using a Pearson correlation analysis.

RESULTS

Numbers captured.—A total of 638 *B. tridactylus* and 317 *C. didactylus* were captured during the 17 months (January 199–May 1995) of capture operations. Only 602 *B. tridactylus* (528 emancipated) and 310 *C. didactylus* (273 emancipated), however, were analyzed for capture dates and spatial distribution, because key information was missing for the other animals. The overall species ratio was two *B. tridactylus* to one *C. didactylus*. The monthly distributions of captures (Fig. 2) were normal for both species, as was monthly capture effort ($P > 0.5$, Kolmogorov-Smirnov test). For both species, captures peaked in July 1994 and capture effort was maximum in September.

Densities.—It is difficult to accurately determine the area covered by capture teams during the rescue operation. The size of the entire flooded area itself (365 km^2) provides a rough estimate, since maps are not accurate and satellite images did not fit our purposes. Based on this area, the overall density was 2.6 sloths/km^2 (1.7 *B. tridactylus* and 0.9 *C. didactylus*).

Spatial distribution.—Sloths were captured all along the Sinnamary River and its two major tributaries (Courcibo River and Tigre Stream) as well as along small streams (Fig. 3). Certain spatial discontinuities were identified: *B. tridactylus* and *C. didactylus* were not captured along a portion of the Courcibo River, no *C. didactylus* and few *B. tridactylus* were captured along a portion of the Sinnamary River situated downstream from the Cour-

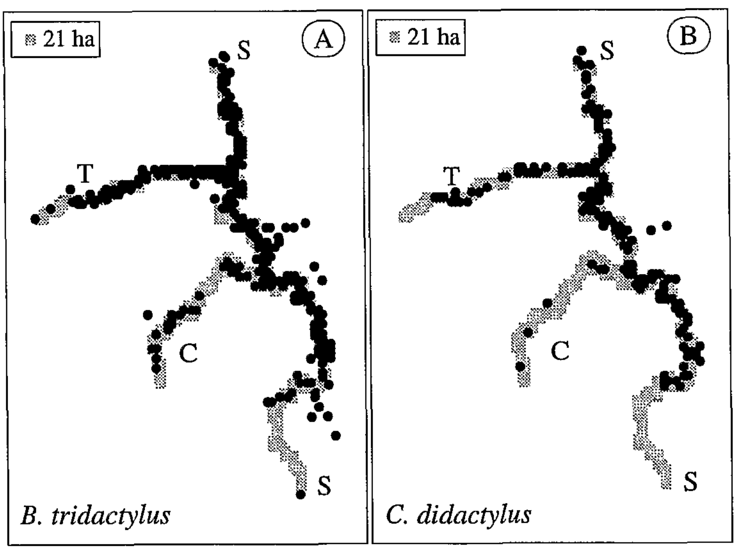

FIGURE 3. Capture locations (dark circles) of *Bradypus tridactylus* (A) and *Choloepus didactylus* (B) in 21-ha squares. Light squares represent the course of the main rivers: S = Sinnamary, C = Courcibo, T = Tigre.

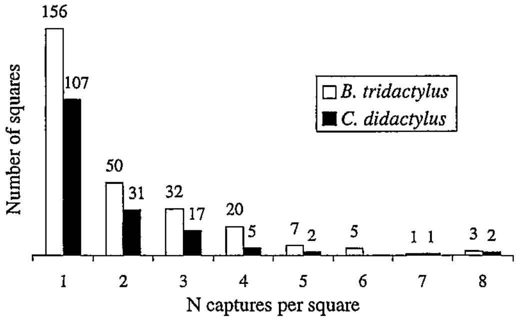

FIGURE 4. Distribution of the number of 21-ha squares having yielded *N* captures of emancipated *Bradypus tridactylus* and *Choloepus didactylus.*

cibo branch, and no *C. didactylus* were captured along two portions of the Tigre Stream.

With respect to location (Fig. 4), the most frequent situation was only one individual of a given species captured per 21-ha square (57% for *B. tridactylus* and 65% for *C. didactylus*). Two to three captures per species and per square made up one-third of the capture situations (30% for *B. tridactylus* and 29% for *C. didactylus*), but four animals or more per square were infrequent. Those locations having yielded more than four emancipated individuals of a given species were scattered along the Sinnamary River, and most coincided with marshy areas.

In both species, > 73 percent of individuals captured were solitary and another 23–24 percent were females carrying young, accounting for 96 percent of emancipated individuals. In *B. tridactylus,* 3.7 percent (22 individuals) were captured in groups. The groups were composed as follows: one pair of adult females, one pair of males (one adult and one juvenile), three heterosexual pairs (two pairs of adults and one pair of an adult male with a juvenile female), and four groups consisting of an adult male with a mother and young. In *C. didactylus,* groups made up 2.6 percent (8 individuals) of the animals captured, and they consisted of one adult heterosexual pair and three pairs of an adult female with a juvenile male.

DISCUSSION

METHODOLOGICAL CONSTRAINTS.—During the first months, capture yield (Fig. 2) was relatively low for various reasons: capture effort was low, as rescue teams focused mainly on trapping terrestrial vertebrates on small islands formed by the rising water and sloths were captured only by chance sightings; the area flooded (= explorable) was limited; trees were still alive and green, making sloths difficult to spot; and capture workers were inexperienced. As of mid-February 1994, however, when exploration of the flooded understory began, and by June 1994, about two-thirds of the final area was flooded (Faune Sauvage 1995). At this point, almost half of the total number of *B. tridactylus,* but less than one third of *C. didactylus,* had been captured. This difference in capture success during the first months between the two species was the result of different probabilities of sighting the sloths: *B. tridactylus* were more often in tree crowns and could thus be spotted even if the trees were still green, given the observer had enough perspective. During daytime, *C. didactylus,* on the other hand, were more frequently hidden in masses of lianas (Montgomery & Sunquist 1978) in lower branches and were masked by the vegetation. During the following months, capture yield was high, because of capturers devoting more time to arboreal vertebrates and the progressing defoliation of dying trees that made sloths more visible. From August/September on, capture yield diminished anew, as the flooded area was thoroughly explored and only few sloths were still to be found.

The "Faune Sauvage" project's primary imperative was to rescue the greatest possible numbers of animals threatened by the rising water. Our results are largely dependent upon the collecting procedure in space and time, and our interpretations must therefore be regarded as tentative.

NUMBERS CAPTURED AND DENSITIES.—Sloths were captured in 337 different squares (*i.e.,* a surface of 71 km^2) which is *ca* one-quarter of the estimated total flooded area. Our raw density estimate is 1.7 *B. tridactylus* and 0.9 *C. didactylus*/km^2, but these figures can be corrected upward to 9 *B. tridactylus* and 4.5 *C. didactylus*/km^2 if we consider only the area having indeed yielded captures instead of the total flooded area. The latter density estimate assumes that sloths were present throughout the study area, but that only one-quarter of the flooded area was actually searched. This estimate thus incorporates spatial variation in capture effort.

In general, sloths appeared to have a continuous distribution along flooded banks of the rivers (Fig. 3). There were several gaps in captures, and conversely, locations that yielded high numbers of captures; but these however, are likely to reflect methodology. Because the filling of the reservoir was progressive, areas far upstream and wide valleys could not be explored by boat until rather late.

TABLE 1. *Comparisons among different rescue operations in South America: total surface of dam reservoirs, capture effort, and numbers of sloths captured. For the sake of comparison, total surfaces of dam reservoirs were used to calculate sloth densities in all cases, including Petit Saut; this is because the areas actually searched for animals are not known for the other dams. Figures for Tucurui, Brokopondo, and Samuel are drawn from Collin (1991).*

Site	Total area flooded (km^2)	Duration of rescue operation (months)	Number of sloths captured	Sloth densities (ind/km^2)	Number of rescue workers ($/km^2$)
Tucurui	2430	7	40,860[a]	16.81	0.29
Brokopondo	1600	15	2944	1.84	0.15
Samuel	645	5	373[b]	0.58	0.10
Petit Saut	365	17	955	2.6	0.08

[a] Figure drawn from ELECTRONORTE (1985).
[b] At the Samuel dam, only captures of *Choloepus* are reported.

Furthermore, as the trees died and lost their leaves, sloths became easier to spot. The important gap in captures of *C. didactylus* along the Courcibo River could have been linked to poor visibility along this hilly part of the forest.

Several capture locations yielded species proportions above or below the overall 2:1 ratio. Since tropical rain forests are very heterogeneous and the two sympatric genera of sloths have different habitat and food requirements (Montgomery & Sunquist 1978), local abundances of each species could be expected to vary. Britton (1941) stated that both genera may range over the same neighborhood together, while in other cases, one genus may occupy an extensive area alone. Habitat quality surely played an important role, but that is beyond the scope of this study.

The other animal rescues in South America (Eletronorte 1985, Collin 1991) yielded lower sloth densities, except Tucurui; that operation, however, lasted only seven months (Table 1). This may have been due to the considerable number of rescue workers on that project.

Glanz (1990) reported sloth densities from different localities: 633 sloths/km^2 in the secondary forest on Barro Colorado Island, Panama, 2/km^2 in a young, broken-canopy forest of Venezuela, and $< 1/km^2$ in a mature forest in Peru. Charles-Dominique *et al.* (1981) estimated densities for *B. tridactylus* as 3–6/ha in a secondary forest in French Guiana, Montgomery & Sunquist (1975) estimated 8.5 *B. variegatus* and 1.1 *C. hoffmanni* per ha by fecal counts or *ca* 5 *B. variegatus* and 2 *C. hoffmanni* (Sunquist & Montgomery 1973) on Barro Colorado Island; Waage & Montgomery (1976) reported 6–10 sloths/ha in several localities in Panama. Emmons (1984) reported 0.1 and 0.4 *B. variegatus*/10-km transect in a mature forest of Peru and 0.7 *C. didactylus*/10-km transect in a logged forest of Ecuador; these low figures seem to suggest that visibility was limited along her transects, as she stated that *Bradypus* and *Choloepus* were underestimated. Glanz (1990) furthermore has remarked that medium and large mammals are unwary and remarkably abundant on Barro Colorado Island, and that this locality is notorious for its high densities of sloths. Density estimates for sloths vary greatly from one study to another, depending on forest type and census method, and it appears difficult to obtain a reliable estimate of sloth densities in primary forest.

Our figures for animals captured in groups are very low compared to total numbers captured, but they can help better our knowledge of the social structure of these animals. Adult heterosexual pairs may have been meeting for mating. This is especially interesting for the four *B. tridactylus* groups, each composed of an adult male with a mother and young, since it has been suggested (Beebe 1926) and observed (Richard-Hansen & Taube 1997) that female *Bradypus* can mate while still carrying young. Three heterosexual pairs in *C. didactylus*, each composed of an adult female with a juvenile male, may have been mother and young. Meritt (1985) has reported that in captivity, *Choloepus* mothers and offspring may remain in close proximity and in behavioral association (rhythms of activity) two years after birth.

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