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Source: Edentata, 11(1) : 62-69

Published By: IUCN/SSC Anteater, Sloth and Armadillo Specialist Group

URL: https://doi.org/10.1896/020.011.0111

Activity Patterns, Preference and Use of Floristic Resources by *Bradypus variegatus* in a Tropical Dry Forest Fragment, Santa Catalina, Bolívar, Colombia

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Abstract

Monthly field surveys were carried out from February to September 2004 to study behavioral and ecological aspects of *Bradypus variegatus* in a tropical dry forest fragment on "El Ceibal", Santa Catalina, Bolívar, Colombia. The study included samples collected during the dry and wet seasons. Scan sampling was used to record *B. variegatus* activities (feeding, resting, moving, grooming, and surveillance). Plant species utilized for these activities were identified. Sloths spent most of their time resting (56%), followed by moving (23%), surveillance (10%), grooming (8%), and feeding (3%). Generally, sloths were found on trees with heights from 9 to 32 m, with canopy coverage of 9 to 364 m^2 and diameter at chest height from 10 to 44.2 cm. Individuals were usually found in the tree canopy. *Cavanillesia platanifolia* (Bombacaceae), *Guazuma umbilifolia* and *G. tomentosa* (Sterculiaceae) were used as food sources.

Keywords: *Bradypus variegatus,* activity patterns, tropical dry forest, floristic resources

Introduction

The three-toed sloth (*Bradypus variegatus*) is a species associated to the New World tropical forests (Eisenberg and Thorington, 1973). It is found on high tree strata in varied ecosystems, such as dry forests, rain forests, riparian forests and secondary forests (Eisenberg, 1989; Elizondo, 1999). Today, as the distribution and abundance of sloths tend to diminish together with their natural environment, there is a growing interest in the scientific community to learn more about them and use this knowledge in conservation efforts. Numerous studies have been carried out on this species, but there is still much ignorance and controversy about its ecology.

Bradypus variegatus is highly susceptible to habitat alteration. Its limited mobility, reduced home range and shy nature make it highly vulnerable and account for the disappearance of this species from much of its historical range. The distribution of *B. variegatus* once encompassed almost the entire Colombian territory (Wetzel, 1982; Janzen, 1988; Morales-Jiménez *et al.*, 2004). Today, it is limited to a few coastal areas, some inter-Andean lowland localities, and the Pacific Chocó region and Amazon (Moreno and Plese, 2006).

Its long-term survival is threatened by wildlife trade, habitat destruction, and forest fragmentation. Moved by the expansion of farming and urban frontiers, 101,000 ha of natural forest are destroyed in Colombia each year (Chaves and Arango, 1998; IDEAM, 2004) with the direct consequence of the disappearance of its wildlife. One of the most threatened ecosystems is the tropical dry forest (Janzen, 1988). Less than 1% of its original area remains intact in Colombia (Chaves and Arango, 1998; IDEAM, 2004).

Most sloth studies have been carried out in tropical rain forests, such as Barro Colorado Island in Panama (Montgomery and Sunquist, 1978). The few existing studies on Colombian three-toed sloths focused on aspects related to the behavior, rehabilitation and relocation of individuals rescued from illegal trade (Moreno and Plese, 2006) and on wild sloths inhabiting a swamp forest in Puerto Nariño, in the Colombian Amazon region (Kendall *et al.,* 2006).

The goals of the present study were to determine behavioral and ecological aspects of *B. variegatus* in a tropical dry forest fragment. The research focused on activity patterns, use of plant species, tree stratum, and preferred forest area. Results were compared by gender, age class, season, and time of day.

Materials and Methods

Study area, climate and vegetation

"El Ceibal" is a 2,500 ha cattle ranch located in the northern region of Colombia, Department of Bolivar, municipality of Santa Catalina (10°37'36"N, 75°14'50"W; maximum elevation 34 m asl; Fig. 1). Natural forests cover 300 ha of the ranch (Rodríguez, 2001).

Minimum and maximum medium monthly temperatures in the area of "El Ceibal" were 24°C and 35°C, respectively, in 2002 and 2003. Minimum and maximum medium monthly humidity during the same period were 51% and 90%, respectively. Average yearly rainfall was 925 mm (Proyecto Titi-Colombia, 2002, 2003). The climate is bimodal; the mild rainy

season starts in mid-April and continues on to May and June. There is a transitional dry period (locally called "veranillo de San Juan") during July and August, followed by a strong rainy season lasting from September to the end of November. The dry season starts in December and ends in March. During this time, most trees lose their foliage and some bloom. The region is classified as Tropical Dry Forest (Holdridge, 1996; Chaves and Arango, 1998).

Two well-defined seasons occurred during the sampling period. The dry season encompassed a period of 57 days from February 3 to March 31. No rain was recorded during this period. The rainy season lasted from April to September. Normally, this season is differentiated in three periods: mild rainy, "veranillo de San Juan", and strong rainy. However, during our sampling year the "veranillo de San Juan" did not occur; instead, it rained throughout.

The forested areas of "El Ceibal" are fragments within pastures with deforestation pressure on fine wood species. Some fragments are connected through lower vegetation corridors, characterized by the presence of spiny plants with small foliage and a great number of leguminous plants (Rodríguez, 2001). The angiosperm flora of "El Ceibal" is composed of 412 species. Trees are the most representative plant life form, accounting for 33% of all species. Flowering and fructification seasons of most species correspond to the rainy season (Ramírez and Tesillo, 2001).

Data collection

Two preliminary recognition field trips were carried out in December 2003 and January 2004. Two sampling areas were chosen based on vegetation type and presence of *B. variegatus*.

A total of 16 field trips of four days duration, with a time interval of 10 days between them, were carried out between February and September 2004. A total of 64 days and 594 hours of observations were recorded, partially covering the dry and rainy periods.

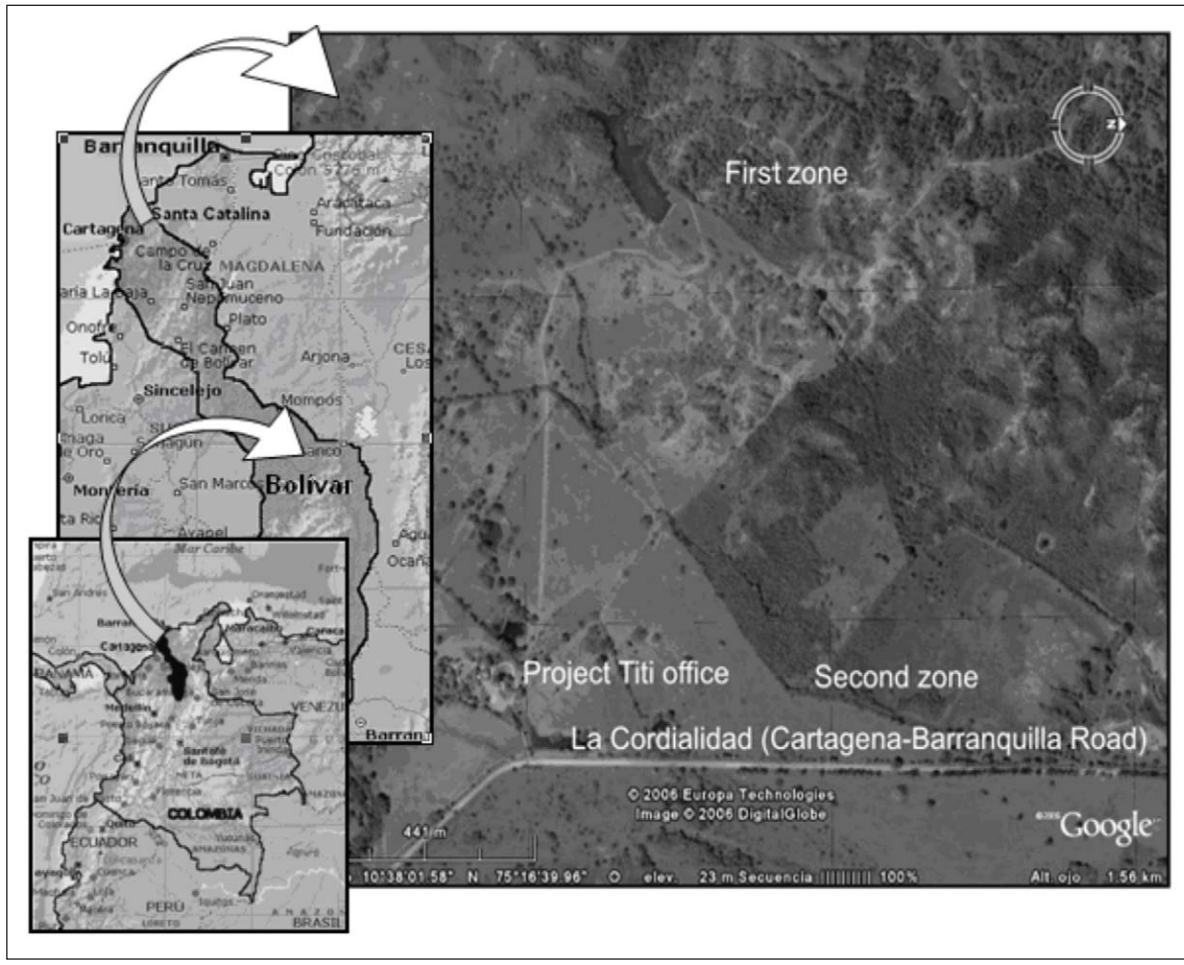

Figure 1. Study Area: Hacienda El Ceibal, Santa Catalina, Bolivar, Colombia.

Three daily observation journeys were done; morning sampling from 07:00 to 11:00 (total: 256 hours); afternoon sampling from 14:00 to 18:00 (total: 256 hours); and nocturnal sampling from 18:30 to 22:30 (total: 24 hours). Nocturnal samplings were done only on individuals that had already been observed during the day; this facilitated locating individuals in the dark. For this reason, evening observations were scarce in relation to the morning and afternoon samplings.

Two observation areas were chosen for the study: one in the forest interior and the other on the forest border. A transect of 3,000 m length was selected in the forest interior for search of *B. variegatus*. This area is characterized by the dominance of the botanical families Fabaceae, followed by Sapindaceae, Euphorbiaceae and Bignoniaceae (Rodríguez, 2001). Most trees are approximately 15 years old (L. Soto, pers. comm.). The most diverse genera in this habitat are *Trichilia*, *Coccoloba, Paullinia*, *Capparis, Bunchosia*, and *Eugenia* (Rodriguez, 2001). The forest interior presents a tree level stratification: the canopy, represented by 10 to 25 m high trees such as *Albizzia niopoides* ("guacamayo"), *Bursera simarouba* ("indio en cuero"), *Spondias mombin* ("jobo"), and *Triplaris americana* ("vara santa"). Some emergent trees, such as *Cavanillesia platanifolia* ("macondo"), may reach 35 m height. The middle stratum is formed by juvenile trees that grow in patches and consists of *Trichilia acuminata* ("negrito"), *Mayna grandifolia* ("puerco espín"), and *Stylogyne turbacensis* ("patica de paloma"). Some shrubs with thin stems, such as *Capparis baducca*, are also present. The lower stratum is herbaceous with plants smaller than one meter, such as *Loira latifolia* and *Rivinia humilis* (Rodríguez, 2001). We recorded the presence of lianas and climbing plants dominated by Fabaceae, such as *Bauhinia glabra* and *Dalbergia brownei*; Bignoniaceae, such as *Anemopaegma inundatum* and *Pithecoctenium crucigerum;* and Sapindaceae, such as *Paulinia cururu.* Epiphytic plants are scarce in this area.

A transect of 2,500 m was selected in the forest border. Most of the trees in this area are found on the edge of a lagoon and are 7 to 8 years old (L. Soto, pers. comm.). Common tree species in this area are *Guazuma ulmifolia* and *Cecropia peltata.* Tree diversity is greater in the interior of the forest (83 tree species) than in the forest border (30 species). In turn, herbaceous climbing plants are more abundant in the borders than in the interior. Similar percentages of shrubs and woody lianas occur in the interior and on the border (Rodríguez, 2001).

Behavior categories were selected following Zerda (2004). They were clearly delineated to facilitate fieldwork. Schedules were designed in order to register activities and collect vegetation data. Sampling times were determined based on the behavior observed during *ad libitum* sampling (Altmann, 1974).

Scan Sampling (Altmann, 1974) was used to record three-toed sloth activities. The behavioral conduct of individuals located while sampling was recorded during five minute periods with intervals of ten minutes between observations (Zerda, 2004). The activities were classified as follows:

- ***Feeding:*** ingesting part of a plant
- ***Resting:*** immobile on a tree or liana
- ***Moving:*** moving on a tree or between trees
- ***Grooming:*** scratching itself
- ***Surveillance:*** observing for potential predators and/or watching juveniles during the independence process
- ***Other:*** engaged in an activity different from the previous ones

The individuals were classified by age based on their size and body weight (Emmons and Feer, 1990; Plese and Moreno, 2005):

- ***Adult:*** individuals with 400–750 mm body length and 2.3–5.5 kg weight
- ***Juvenile:*** individuals that are independent from their mother but do not reach adult measurements, with approximate weight of 1.2–2.3 kg
- ***Infant:*** individuals that are found permanently or semi-permanently on the mothers' abdomen, with weights <1.2 kg.

In both sampling areas, trees on which sloths had been observed were marked with a consecutive number in aluminum tags, as well as marking tape with the same number, to facilitate their tracing and identification. Height, Diameter at Chest Height (DCH), and Crop Coverage (see Rangel and Velásquez, 1997) were registered for all marked trees.

For the purposes of this study, trees were divided vertically in *Lower Part* (from ground to top of the first branch), *Middle Part* (from the first branch to the beginning of the canopy), and *Higher Part* (canopy

of the tree) in order to know which of these parts was most commonly used by *B. variegatus.*

Results and Discussion

B. variegatus *activities by season and by age group*

During the dry season, infants spent most of their time resting and grooming. Adults and juveniles were also resting most of their time, followed by surveillance and moving, likely looking for food sources and for shelters from the sun (Fig. 2).

During the mild rainy season, adults and juveniles were resting most of the time, followed by surveillance in adults and moving in juveniles. For adults, surveillance activity increased during the dry season. Most individuals were females with offspring. Lactating females dedicate a good part of their time to supervision while their offspring explore and move through the tree branches to acquire the necessary skills to survive on high trees and become independent. These observations coincide with Soares and Carneiro (2002), who state that the infants start exploring their surroundings by themselves to know their environment in case of falling or getting lost.

In all age groups, resting activity was higher during the strong rainy season than during the mild rainy season (Fig. 2). Surveillance on the infants also increased because the latter were more independent in their activities. The percentage of surveillance activity in adults continued being predominant after resting activity. During this season, observation of infants decreased and that of adult males increased.

B. variegatus *activities by season and by gender*

During the dry season, feeding activity was best represented by the females who invested 2.3% of the total observation time in this activity (Fig. 3). This may be related to the high energy demand of maintaining offspring that were born mostly in November, December, and January. Males spent more time feeding during the mild rainy season (8.3%). Similarly, this may be related to a greater sexual activity during the months of June and July. Feeding was not observed in either gender during the strong rainy season (Fig. 3). Due to the fact that sloths were observed most of the time in the canopy and that the foliage becomes dense during the strong rainy season, it is very difficult to watch the feeding activity of *B. variegatus* in this period.

Seasonal variation was also observed in moving activity and may be tied to offspring care and sexual activity. Males and females showed little moving activity during the dry season, when infants are dependent and vulnerable, while moving activity increased during the rainy season (Fig. 3). Males move more during the mild rainy season, likely because they are looking for potential mates. Females are more actively moving during the strong rainy season, likely because they are looking for appropriate places to give birth and care for their newborn.

B. variegatus *activities by period of day*

All individuals (adults, juveniles, infants, males, and females) were active during the day and at night (Fig. 4). Resting was more frequent during the day, while feeding activities were more common during the night hours. Inactivity of *B. variegatus* during the day is probably related to stomach satiation after feeding (Sunquist and Montgomery, 1973).

Use of plant species by B. variegatus

Montgomery and Sunquist (1975) mentioned that trees should have specific attributes with regard to species, architecture, associated plants (mainly lianas),

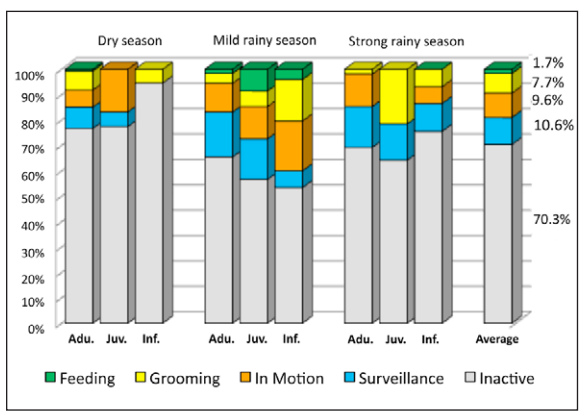

Figure 2. Activities of *B. variegatus* by season and by age group.

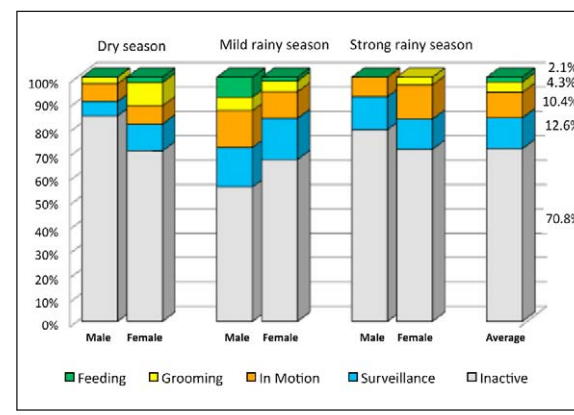

Figure 3. Activities of *B. variegatus* by season and by gender.

and local spacing and distribution to be potentially selected by a sloth. Some of these attributes were observed for the trees selected by *B. variegatus* in this study.

Tree species: The utilization of plant species by *B. variegatus* is shown in Table 1. There is an apparent preference of *B. variegatus* for *C. platanifolia*, *G. ulmifolia, P. septenatum*, and *C. peltata*.

During the dry season, the animals mainly fed on *C. platanifolia* in the interior of the forest, while they foraged on *G. ulmifolia, G. tomentosa* and *P. septenatum* on the forest edge during the rainy season. We did not observe sloths feeding upon *C. peltata* although it was present on the forest border. This agrees with Montgomery and Sunquist (1975) who report that three-toed sloths feed on a great variety of trees, and is in contrast to Goffart (1971) who states that sloths depend on the genus *Cecropia* for feeding.

In accordance with Sunquist and Montgomery (1973), this study indicates that sloths basically feed upon the species of trees on which they remain during different seasons (Table 2). *Guazuma ulmifolia* and *P. septenatum* were the most frequently used forest border trees. They were also used as a food source. *Cecropia peltata* is very common in forest borders. It is therefore likely that sloths use it not only for shelter, but also for feeding (Fig. 5).

Tree architecture: a positive correlation was found between tree height and diameter at chest height (DCH) and the permanence time of individuals on the trees ($y = 55.82x + 30.35$, $R^2 = 0.09$ and $y = 0.21x + 3.31$, $R^2 = 0.04$ for height and DCH,

TABLE 1. Utilization of plant species by *B. variegatus.*

Species	Family	Common name	Forest localization	N	Avg. Height (m)	Avg. DAP (cm)	Avg. Coverage (m^2)	Use	Part
Anacardium excelsum	Anacardiaceae	Caracolí	Border	1	21	92.3	364	Resting	
Bravaisia integerrima	Acanthaceae	Palo de agua	Border	1	18	144.2	36.5	Resting	
Cavanillesia platanifolia	Bombacaceae	Macondo	Interior and border	2	31.5	110	97.1	Resting, Mobilization, Feeding, (mainly dry season)	Flower bud
Cecropia peltata	Cecropiaceae	Guarumo Yarumo	Border	2	13	31.7	43.4	Resting	
Ceiba pentandra	Bombacaceae	Ceiba Bonga	Interior and border	1	23	45.5	10.8	Resting	
Crataeva tapia	Capparidaceae	Naranjuelo	Interior and border	1	9	34	54.9	Resting, Mobilization	
Guazuma tomentosa	Sterculiaceae	Guásimo	Border	2	10	27.5	54.2	Resting, Mobilization, Feeding	Leaves
Guazuma ulmifolia	Sterculiaceae	Guásimo	Interior and border	3	13	47.4	76	Resting, Feeding	Leaves
Lecythis minor	Lecythidaceae	Olla de mono	Interior and border	1	15	23.2	22	Resting	
Pithecellobium saman	Fabaceae – Mimosoideae	Campáno	Interior and border	2	20	55.8	220.4	Resting, Mobilization	
Pseudobombax septenatum	Bombacaceae	Majagua Colorá	Interior and border	3	18.5	81.1	100.8	Resting, Mobilization, Feeding	Leaves
Sapium acuparium	Euphorbiaceae	Ñipi ñipi	Border	2	19.5	58.55	52	Resting, Mobilization, Surveillance (rainy season)	
Tabebuia billbergii	Bignonaceae	Polvillo	Interior and border	1	15	24.2	41	Resting	
Trichanthera gigantea	Acanthaceae	Palo de Agua	Border	1	18	60.5	47.8	Resting, Mobilization	
Average:					**17.5**	**64.7**	**90.6**		

respectively). The correlation was slightly negative for canopy coverage ($y = -1.094x + 1.055$, $R^2 = 0.004$).

Trees more commonly used by sloths showed highly varying characteristics. Sloths selected tree heights from 9 m in *C. tapia*, to 32 m in *C. platanifolia*, with an average of 17.5 m height for all species. DCH varied from 10 cm in *G. tomentosa* to 144.2 cm in *B. integerrima*, with an average of 64.7 cm for all species. Selected canopy coverage was wide-ranging from 9 m^2 in *G. tomentosa* to 364 m^2 in *A. excelsum*, with an average of 90.6 m^2 for all species.

Similar to reports by Montgomery and Sunquist (1978), *B. variegatus* was more commonly observed on trees with a canopy coverage of <200 m^2, corresponding with 91.3% of all sampled trees. The remaining 8.7% of utilized trees had canopy coverages between 200 and 400 m^2. Trees with greater canopy coverage were not utilized by the sloths in the study area.

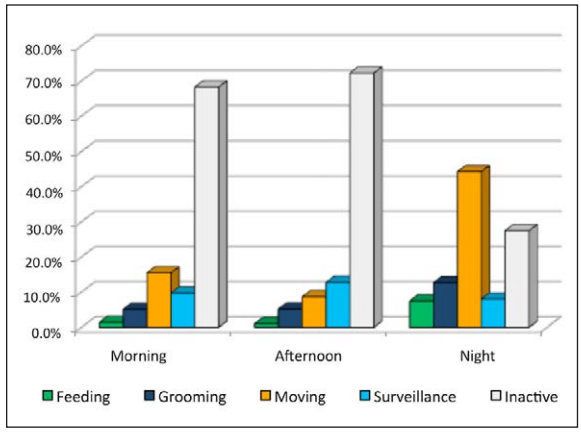

Figure 4. Activities of *B. variegatus* by period of day.

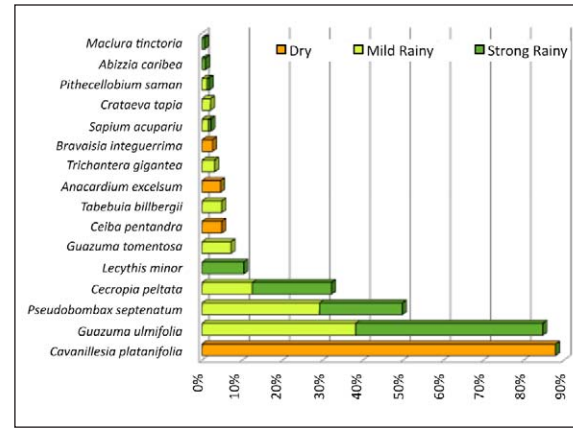

Figure 5. Tree Species Utilization by *B. variegatus* by season.

TABLE 2. Permanence time of *B. variegatus* by season and tree species.

Tree species	Dry season		Mild rainy season		Strong rainy season	
	Hours	%	Hours	%	Hours	%
Maclura tinctoria	0.0	0.0	0.5	0.4	0.00	0.0
Abizzia caribea	0.0	0.0	0.0	0.0	0.62	1.0
Pithecellobium saman	0.0	0.0	1.5	1.2	0.37	0.6
Crataeva tapia	0.0	0.0	2.5	2.0	0.00	0.0
Sapium acuparium	0.0	0.0	2.0	1.6	0.37	0.6
Bravaisia integuerrima	2.4	2.6	0.0	0.0	0.00	0.0
Trichantera gigantea	0.0	0.0	3.9	3.1	0.00	0.0
Anacardium excelsum	4.2	4.6	0.0	0.0	0.00	0.0
Tabebuiia billbergii	0.0	0.0	6.0	4.8	0.00	0.0
Ceiba pentandra	4.5	4.9	0.0	0.0	0.00	0.0
*Guazuma tomentosa**	0.0	0.0	9.0	7.2	0.00	0.0
Lecythis minor	0.0	0.0	0.0	0.0	6.54	10.5
Cecropia peltata	0.0	0.0	15.7	12.5	12.34	19.8
*Pseudobombax septenatum**	0.0	0.0	36.4	29.1	12.90	20.7
*Guazuma ulmifolia**	0.0	0.0	47.7	38.1	29.16	46.8
*Cavanillesia platanifolia**	81.1	88.0	0.0	0.0	0.00	0.0
Total:	**92.2**	**100.0**	**125.2**	**100.0**	**62.3**	**100.0**

* Tree species on which *B. variegatus* was observed feeding.

Feeding was more commonly observed in trees with greater coverage, both in the forest border and in the forest interior. Possibly, greater trees provide more abundant feeding sources and shelter.

Plants associated with the utilized trees: most trees utilized by sloths were characterized by a great number of climbing plants (Table 3), particularly on the forest border. These plants likely facilitate access to the canopy and provide camouflage and shelter from the sun.

Part of the tree preferred by B. variegatus

In most cases (81.7%), sloths were found in the canopy. Displacements from tree to tree were preferably carried out using the interception of the upper canopy branches. Sloths were observed on the middle part of the trees in 17.7% of the observations, and the remaining 0.6% on the lower part of trees.

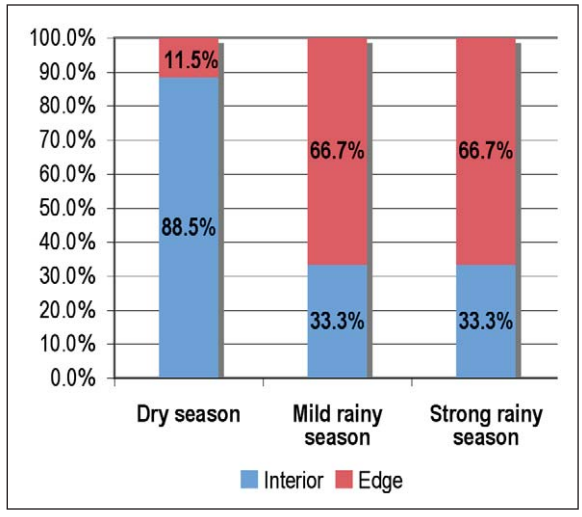

Figure 6. Relative forest location of *B. variegatus.*

TABLE 3. Climbing plants utilized by *B. variegatus.*

Species	Family	Common name
Bauhinia glabra	Caesalpiniaceae	Bejuco cadena
Byttnenia sp.	Sterculiaceae	
Chamisoa altisima	Amaranthaceae	Pintabollo
Cissus sicyoides	Vitaceae	Bejuco de agua
Dioclea sp.	Fabaceae	
Indigofera jamaicensis	Fabaceae - Papilionoideae	Arroz con coco
Macfadyena unguis-cati	Bignoniaceae	Bejuco uñita
Momordica charantia	Leguminosae - Papilionoideae	Platanito
Paullinia sp.	Sapindacea	

Part of the forest preferred by B. variegatus

During the dry season, when most tropical dry forest trees partially or totally lose their foliage, sloths were mainly found in the forest interior and almost exclusively on *C. platanifolia* (Fig. 6). The latter initiates blooming during this season, and sloths mainly fed on its flower buds. During the rainy season, trees renew their foliage and sloths are generally found on the forest border. In this period, they mainly feed on the new leaves and buds of *G. ulmifolia* and *P. septenatum* (Fig. 5). Our observations thus confirm the factors determining habitat selection described by Eisenberg and Thorington (1973) for arboreal mammals and by Montgomery and Sunquist (1978) for sloths in Barro Colorado.

Acknowledgements: To Octavio Gálvis for his scientific advice and valuable academic collaboration in the development of this study. To the biologists Fred Ávila, Orlando Padilla and Álvaro Acosta for their great contribution to enrich this investigation. To the Tamarin Project (Proyecto Titί), especially Luís Soto, Francisco García, and Jaime Causado for their scientific advice and for allowing us to use bibliographical material, equipments and facilities. To Félix Medina and Lino Olivares for their great collaboration in the field. To Hermes Cuadros and Jorge Ferrer for their help with identifying plant material. To the residents and workers at the farm "El Ceibal" for providing lodging and for making the development of this research a pleasant experience.

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