

Towards a standard framework to describe behaviours in the common-sloth (*Bradypus variegatus* Schinz, 1825): novel interactions data observed in distinct fragments of the Atlantic forest, Brazil

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(With 3 figures)

Abstract

The common three-toed sloth is a widespread species, but the location and the observation of its individuals are greatly hindered by its biological features. Their camouflaged pelage, its slow and quiet movements, and the strictly arboreal habits resulted in the publication of sparse, fragmented and not patterned information on the common sloth behaviour. Thus, herein we propose an updated standardized behavioural categories' framework to the study of the species. Furthermore we describe two never reported interaction behaviours: a probable mating / courtship ritual between male and female; and apparent recognition behaviour between two males. Finally we highlight the contribution of small-duration field works in this elusive species ethological study.

Keywords: common three-toed sloth, recognition behaviour, male-female interactions.

Contribuição para a padronização da descrição de comportamentos de preguiça-comum (*Bradypus variegatus* Schinz, 1825): novos dados de interação observados em distintos fragmentos de Mata Atlântica, Brasil

Resumo

A preguiça-de-três-dedos comum é uma espécie amplamente distribuída. No entanto, a biologia da espécie dificulta a sua detecção e observação na natureza. A camuflagem da sua pelagem, seus movimentos lentos e silenciosos e seus hábitos estritamente arbóreos resultaram na publicação de dados comportamentais esparsos, fragmentados e não padronizados. Assim, no presente trabalho propomos uma tabela atualizada e padronizada de comportamentos de preguiça-comum. Além disso, descrevemos dois novos comportamentos de interação para a espécie: um provável evento de corte ou acasalamento entre macho e fêmea e um aparente comportamento de reconhecimento entre dois machos. Finalmente, discutimos a contribuição de trabalhos de campo de curta-duração no estudo etológico desta espécie tão elusiva.

Palavras-chave: Preguiça-de-três-dedos-comum, comportamento de reconhecimento, interação macho-fêmea.

1. Introduction

The common three-toed sloth, *Bradypus variegatus* (Schinz, 1825), is an obligatory arboreal mammal. Life in the trees' canopy, their slow and silent movements, together with a camouflaged pelage makes sloths extremely difficult to be observed in nature. Consequently, although the common sloth's widespread distribution (Moraes-Barros et al., 2010), few ecological studies were made so far (Ballesteros et al., 2009; Consentino, 2004; Queiroz, 1995; Soares and Carneiro, 2002; Urbani and Bosque, 2006; Vaughan et al., 2007), and basic ethological data are barely understood. For instance, reproductive

means were only reported once (Bezerra et al., 2008), more descriptive parental care three times (Bezerra et al., 2008; Soares and Carneiro, 2002; Pinheiro, 2008), and territorial occupancy is unclear (Bezerra et al., 2008; Hayssen, 2010; Lara-Ruiz and Srbeck-Araujo, 2006). Even this mammal's social system is controversial. Although it is mostly described as being solitary (reviewed by Hayssen, 2010), and interactions between adult common sloth individuals have been only occasionally reported (Ballesteros et al., 2009; Bezerra et al., 2008; Consentino, 2004; Greene, 1989; Lara-Ruiz and Srbeck-Araujo, 2006; Vaughan et al., 2007), these animals can be

quite gregarious (Ballesteros et al., 2009; Vaughan et al., 2007). Also they were reported to occur in several small confined areas, such as public gardens and municipal squares (Consentino, 2004; Manchester and Jorge, 2009; Pinheiro, 2008; Ramos et al., 2007), and even share trees with other sloth's species (Sunquist and Montgomery, 1973; Vaughan et al., 2007).

According to Greene (1989), only long-term animal observation studies could witness less usual common sloth behaviours. Nevertheless such studies were not able to fully describe this species' ecology, so far (e.g. Consentino, 2004; Queiroz, 1995). However, the same author also claimed that small carefully designed studies could be important contributions to the common sloth study (Greene, 1989).

In this context, we intended to address the contribution of opportunistic and small duration field studies on the behaviour of the common sloth. As a result, i) we suggest an updated standardised behavioural categories' framework to describe common sloth behaviour. And ii) report novel behaviour data for the species, in two Brazilian Atlantic forest localities. We describe male-male and male-female interactions, disentangling new insights on common sloths ethology.

2. Materials and Methods

2.1. Study areas

We visited two preserved areas within the Brazilian Atlantic forest: i) at the Serra dos Órgãos National Park (PARNASO, 22°29' S/43°00' W; Figure 1), located in the state of Rio de Janeiro, south-eastern Brazil, between 14 and 19 August 2010; and ii) the Botanic Garden Benjamin Maranhão (BGBM, 07°08'44" S/34°51'42" W; Figure 1), located at the state of Paraíba, north-eastern

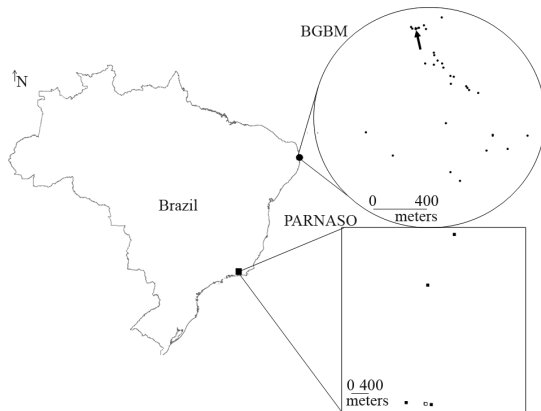


Figure 1 - Total geographical records of common-sloths, *Bradypus variegatus*, obtained during field work in the two distinct Atlantic forest regions. Circles represent records in BGBM (Botanical Garden Benjamin Maranhão) and squares in PARNASO (Serra dos Órgãos National Park). In PARNASO the location of the male-female interaction is depicted as an open square. As for BGBM, all the interactions' location is indicated by an arrow.

Brazil, between 19 to 22 July 2011. The topography of the first area visited is complex and the altitude ranges from 350 to 1.100 m. As for the second area, it ranges between 0 to 250 m. The approximate temperature during the sampling days in PARNASO ranged from 7 °C and 21 °C, and average insolation hours per day was 4.4 h, while the thermic amplitude for the sampling days in BGBM was 21 °C - 29 °C and 6.3 h of average insolation per day (INMET, 2011). PARNASO's area is surrounded by forest and visits are restricted, while BGBM is a forested fragment located within an urban area.

2.2. Methodology

The initial purpose of the expeditions to the selected forest fragments was collecting biological material for population genetic studies. Given that our main goal was observing the maximum individuals as possible, and when possible capture them for sampling, we inspected all roads, tracks and open sections within both areas at least once a day. However, during all the period we observed and recorded sloth's behaviour, no individual was captured.

Common sloth adult males were recognized by the presence of a dorsal speculum, and adult females by its absence (Hayssen, 2010). An animal was considered to be the same individual in different days of field work if it was found in the same tree or at least in the adjacent ones and no ambiguity was detected (Urbani and Bosque, 2006).

Also, every time a common sloth was found we did a simple record of their posture and behaviour, according to Urbani and Bosque (2006). Few studies had made an exhaustive description of common sloth behaviours (Consentino, 2004; Queiroz, 1995; Urbani and Bosque, 2006). Thus we have chosen to follow Urbani and Bosque (2006) description because the authors based their categories both in their own field experience and in previous works. We kept observing the same individual until no changes occurred both in posture and in behaviour. Whenever possible, pictures and videos were taken and GPS point recorded. DIVA-GIS 7.1.7 (Hijmans et al., 2005) was used to plot the geographical records.

Field work was performed under Instituto Brasileiro do Meio Ambiente (IBAMA) permission (no. 19267-3/14597869).

3. Results

3.1. Updated standardised behavioural categories' framework

We have completed 36.3 h of field work at PARNASO and 19.6 h at BGBM. In PARNASO we saw an average of three individuals/day, and in BGBM 17.25 individuals/day. The observations of all individuals resulted in 93 behaviour records, discriminated in Figure 2 and Appendix I (available on request).

Although the limited time of observation, we have recorded two events of interaction among common sloth adults.

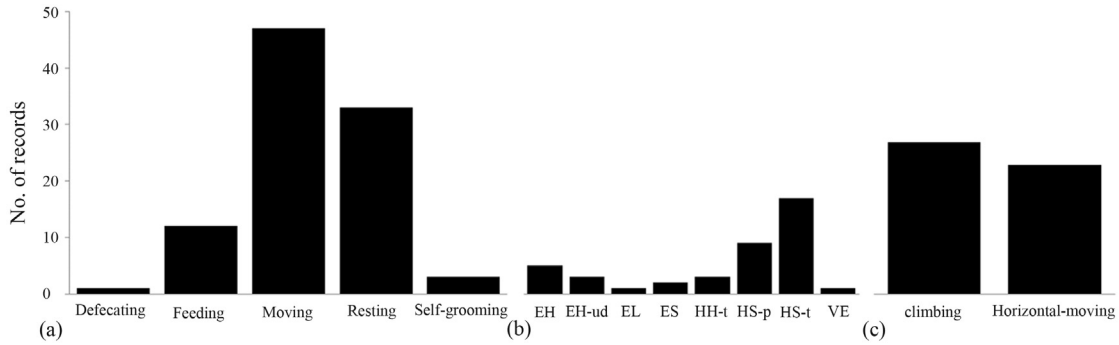


Figure 2 - Frequency of observed behaviour (a), posture (b), and locomotor (c) categories of the common-sloth *Bradypus variegatus* in two areas of the Brazilian Atlantic forest (Serra dos Órgãos National Park and Botanic Garden Benjamin Maranhão). “EH” represents the extended hanging, category; “EH-ud” represents the extended hanging upside down category; “L” represents the extended lying category; “ES” represents the extended sitting category; “HH-t” represents the huddle hanging-total category; “HS-p” represents the huddle sitting-partial category; “HS-t” represents the huddle sitting-total category; “VE” represents the vertically extended category.

3.2. Novel behaviour data

In PARNASO, at 14 August 2010, around 3:00 p.m., a female common sloth (sloth *I*) was observed for the first time. It was a rainy day, and the individual was huddle sitting-total (Hs-t). Days became progressively less cloudy across field-work, but foggy particularly at dawn and dusk. Sloth *I* was seen alone in the next two days. But at 18 August, around 9:00 a.m., a male (sloth *II*) was feeding and sharing the tree with the sloth *I*, although in different branches. At 19 August, around 3:00 p.m., *II* climbed the tree towards *I*, which was feeding. At some point, *II* stopped, stretched its head towards the sloth *I* and then climbed closer to it. Then, *II* outstretched its foreleg and *I* followed it, outstretching both its forelegs,

one at a time. Then *II* struck vigorously the tree trunk twice, and climbed the tree (Figure 3a). The sloth *I* returned feeding. The whole encounter lasted for less than two minutes. One hour and a half later, *II* was seen about 40 m away from that tree, where *I* kept resting, and it moved at least 10 m more, when it was out of sight.

In BGBM, at 19 July 2011, we first spotted a female common sloth at an Hs-t posture, around 8:30 a.m. (sloth *III*). Ten minutes later, a male climbed that same tree (sloth *IV*), and kept Hs-t very close to *III* (Figure 3b). That day, we were only able to work during the morning because it rained heavily all afternoon. All other days were sunny. At 20 July, we arrived at the same spot around the same hour. There we observed four individu-



Figure 3 - Interactions between the common-sloth *Bradypus variegatus* individuals. a) Representation of the last event of interaction recorded in PARNASO, between female *I* (at right) and male *II* (at left). b) In BGBM, female *III* (at left) and male *IV* (at right) sharing the same tree. c) Male *V* (at right) often grabbed, smelled and impeded the movements of the male *VI* (at left). d) *V* chased *VI* before they separate.

als in two adjacent trees. Two sloths were in opposite sides of the canopies at about 20 m from each other. And in the middle, we saw the other two animals in contact (Figure 3c, d). These were both males and we named them as sloths *V* and *VI*, although one of them could be the male seen the day before (sloth *IV*), but we were not able to distinguish it, given we have just considered the geographical position as aforementioned. *VI* seemed to smell *V*, and grabbed it, when *V* tried to move. *V* looked to and probably also smelled *VI*. For five minutes more *VI* reached and smelled *V*, while *V* kept moving (Figure 3c, d). Then they separated and *V* huddle sitting-partial (Hs-p), while *VI* self-groomed in an extended hanging (EH) posture.

4. Discussion

4.1. Updated standardised behavioural categories' framework

Currently, the few common sloth behaviour studies published do not use the same terminology to address the same posture and locomotion events on common sloth (e.g. Ballesteros et al., 2009; Consentino, 2004; Mendel, 1985; Queiroz, 1995; Urbani and Bosque, 2006; Vaughan et al., 2007). So, as stated in the *Methodology* section, we have chosen a list of behaviour categories that had considered previous behaviour description on common sloth (Urbani and Bosque, 2006). Yet, in our opinion, Urbani and Bosque's (2006) categorization was not able to fully describe the common sloth behaviours. For all this, we propose two more postural categories, given their distinctiveness: the extended lying posture (EL, description: stationary; supported by all limbs, ventral surfaces against the tree trunk), and the vertically extended posture (VE, description: stationary; supported by all limbs, ventral surfaces against the tree trunk in a vertical position). Also, we have discriminated the extended hanging upside down (EH-ud) posture, because we observed common sloths not only resting and grooming in that posture, but also feeding. Furthermore, we have considered defecating as a behavioural category, and we suggest that future studies should consider sun-bathing as a sub-resting category, once it was a recurrent behaviour in common sloths.

4.2. Novel behaviour data

Previously reported interactions between common sloth individuals only concerned antagonistic behaviour between males (Ballesteros et al., 2009; Consentino, 2004; Greene, 1989); reproductive means (Bezerra et al., 2008) and tree sharing between individuals of different genders (Ballesteros et al., 2009; Vaughan et al., 2007) or females (Consentino, 2004). The common sloth *II* initially stretched its head towards the sloth *I* suggesting that scent was used to recognize the other individual. Scent has already been proposed to be used by a male when searching a receptive female (Lara-Ruiz and Srbeck-Araujo, 2006). Furthermore, the interaction observed in PARNASO did not involve physical contact as in an an-

tagonistic encounter (Consentino, 2004; Greene, 1989). Therefore, we infer that we witnessed a strength display in a mating or courtship ritual by the male *II* towards the female *I*, although no vocalization was heard in the days or hours before the events described (Bezerra et al., 2008; Lara-Ruiz and Srbeck-Araujo, 2006).

Scent also seems to be involved in the interaction between the two BGBM males (*V* and *VI*). The same arguments and data described in the preceding paragraph lead us to conclude that this second interaction was a recognition behaviour, rather than an antagonistic one. Furthermore the adjacent tree where *V* and *VI* interacted was shared by *III* and *IV*, and in its surroundings, we found an average of 26 individuals/ha/day, so a pacific coexistence is likely to happen.

This density is far higher than the ones previously estimated in large forested areas (from 2.12 ind/ha [Queiroz, 1995] to 8.5 ind/ha [Montgomery and Sunquist, 1975]), and probably higher than in PARNASO. The higher density in BGBM, probably is due to the fact that this area is a forested patch surrounded by urbanizations. Although these records indicate a gregarious social system, probably it is not optional, but mandatory due to the confinement of animals to small forested patches. Gregarious behaviours, both in Costa Rica and Colombia, were recorded in humanized habitats (Ballesteros et al., 2009; Vaughan et al., 2007), and densities up to 17 ind/ha can be inferred from previous observations in public gardens and municipal squares (Manchester and Jorge, 2009; Moraes-Barros, pers. obs.).

5. Conclusion

Our updated framework (Urbani and Bosque, 2006; plus our proposed categories) will be a useful tool in the standardise description of common sloth behaviour in natural environments. It enables the comparison between different studies, both qualitatively (it assures that exactly the same posture and locomotion events are being named when different people are observing the common-sloth individuals), as quantitatively (allows the correct behavioural categories' frequency comparison).

Furthermore, we add evidences that scent is one of the most important senses for the common-sloth day-to-day, and we further support the species ability to live gregariously, opposed to its commonly accepted solitary habits.

Finally, irrespectively of weather conditions, altitude and population density, we were able to describe more postural and locomotion categories than long-duration field studies and report novel interaction data on this species. These facts emphasize and confirm Greene's (1989) statement that small carefully designed studies can effectively contribute to the common-sloth behaviour study.

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Appendix I: Records taken during the field-works reported both in PARNASO (Serra dos Órgãos National Park) and BGBM (Botanical Garden Benjamin Maranhão).

Date	Time*	Sex **	Behavioural category	Postural / Locomotor category	Other	Location
14-8-10	14:24	Female (IX)	Resting	Huddle sitting-total	<i>Cecropia sp.</i>	PARNASO
15-8-10	13:03	Female (IX)	Feeding		<i>Cecropia sp.</i>	PARNASO
15-8-10	14:56	Male (VII)	Feeding		<i>Cecropia sp.</i>	PARNASO
16-8-10	10:23	Male (VII)	Moving	Horizontal-moving	First in <i>Cecropia sp.</i> (moved at least 50m)	PARNASO
16-8-10	12:01	Female (IX)	Moving	Climbing	<i>Cecropia sp.</i>	PARNASO
17-8-10	9:46	Undetermined	Resting	Huddle hanging-total		PARNASO
17-8-10	12:14	Male (VII)	Moving	Horizontal-moving and Climbing		PARNASO
17-8-10	14:20	Undetermined	Feeding		<i>Cecropia sp.</i>	PARNASO
18-8-10	9:19	Female (IX) and Male (II)	Feeding		<i>Cecropia sp.</i>	PARNASO
18-8-10	9:58	Male (VII)	Moving	Climbing and Horizontal-moving		PARNASO
18-8-10	14:36	Female (IX)	Resting	Huddle sitting-total	<i>Cecropia sp.</i>	PARNASO
18-8-10	14:36	Male (II)	Resting / Self-grooming	Huddle sitting-total / Huddle sitting-partial / Extended hanging	<i>Cecropia sp.</i>	PARNASO
18-8-10	15:19	Female (IX)	Resting	Huddle sitting-partial	<i>Cecropia sp.</i>	PARNASO
18-8-10	16:36	Female with an offspring (VIII)	Resting	Huddle sitting-total (offspring not visible)	<i>Cecropia sp.</i>	PARNASO
19-8-10	9:20	Male (IX)	Feeding		<i>Cecropia sp.</i>	PARNASO
19-8-10	9:30	Female (IX)	Feeding	Extended hanging upside down	<i>Cecropia sp.</i>	PARNASO
19-8-10	9:30	Male (II)	Moving	Climbing	<i>Cecropia sp.</i>	PARNASO
19-8-10	11:00	Female with an offspring (VIII)	Resting	Huddle sitting-partial (offspring grabbed the female's ventral region)	<i>Cecropia sp.</i>	PARNASO
19-8-10	15:59	Male (IX)	Feeding		<i>Cecropia sp.</i>	PARNASO
19-7-11	8:33	Undetermined	Resting	Huddle sitting-total	<i>Cecropia sp.</i>	BGBM
19-7-11	8:39	Female (III)	Resting	Huddle sitting-total	<i>Cecropia sp.</i>	BGBM
19-7-11	8:41	Male	Moving	Horizontal-moving		BGBM

Date	Time*	Sex **	Behavioural category	Postural / Locomotor category	Other	Location
19-7-11	8:43	Undetermined	Resting	Huddle sitting-total		BGBM
19-7-11	8:50	Male (IV)	Moving/Resting	Climbing / Huddle sitting-total	<i>Cecropia sp.</i>	BGBM
19-7-11	9:22	Undetermined	Resting	Huddle hanging-total	<i>Cecropia sp.</i>	BGBM
19-7-11	9:28	Undetermined	Moving	Climbing		BGBM
19-7-11	9:36	Undetermined	Resting	Huddle sitting-total		BGBM
20-7-11	8:30	Male	Resting	Huddle sitting-partial / Extended sitting		BGBM
20-7-11	8:30	Undetermined	Resting	Huddle sitting-total	<i>Cecropia sp.</i>	BGBM
20-7-11	8:32	Two males (V and VI)	Moving	Horizontal-moving		BGBM
20-7-11	8:43	Female	Moving	Climbing / Extended hanging		BGBM
20-7-11	8:43	Female	Moving	Climbing		BGBM
20-7-11	8:44	Juvenile	Moving	Horizontal-moving		BGBM
20-7-11	8:46	Undetermined	Moving	Climbing / Extended hanging		BGBM
20-7-11	8:47	Undetermined	Moving	Climbing		BGBM
20-7-11	8:59	Undetermined	Moving	Horizontal moving		BGBM
20-7-11	9:30	Undetermined	Moving	Climbing		BGBM
20-7-11	9:39	Female with an offspring	Moving	Horizontal-moving (offspring grabbed the female's ventre)		BGBM
20-7-11	9:43	Female	Moving	Climbing		BGBM
20-7-11	10:06	Male	Moving	Horizontal moving / Huddle hanging-total		BGBM
20-7-11	10:23	Undetermined	Resting	Huddle sitting-partial		BGBM
20-7-11	10:32	Undetermined	Moving	Climbing		BGBM
20-7-11	10:43	Female with an offspring	Resting/Feeding	Female huddle sitting-partial (offspring grabbed both female's ventre and the food item)	<i>Cecropia sp.</i>	BGBM
20-7-11	14:45	Undetermined	Resting	Extended lying ²		BGBM
20-7-11	14:52	Undetermined	Moving	Climbing		BGBM
20-7-11	15:07	Undetermined	Moving	Horizontal-moving		BGBM
21-7-11	8:00	Undetermined	Resting	Huddle sitting-total		BGBM

Date	Time*	Sex **	Behavioural category	Postural / Locomotor category	Other	Location
21-7-11	8:06	Female	Resting	Huddle sitting-partial (sharing tree with the previous male)	<i>Cecropia sp.</i>	BGBM
21-7-11	8:06	Male	Moving	Horizontal-moving	<i>Cecropia sp.</i>	BGBM
21-7-11	8:27	Male	Resting	Huddle sitting-partial		BGBM
21-7-11	8:30	Juvenil	Moving	Horizontal-moving		BGBM
21-7-11	8:47	Undetermined	Moving/Self-grooming	Horizontal-moving / Extended hanging	<i>Cecropia sp.</i>	BGBM
21-7-11	8:47	Female	Resting/Self-grooming	Extended hanging upside down	<i>Cecropia sp.</i>	BGBM
21-7-11	8:47	Undetermined	Resting	Huddle sitting-total		BGBM
21-7-11	8:47	Undetermined	Resting	Huddle sitting-total		BGBM
21-7-11	8:59	Undetermined	Feeding	Extended hanging upside down		BGBM
21-7-11	9:23	Undetermined	Resting	Extended hanging		BGBM
21-7-11	10:09	Juvenile male	Moving	Horizontal-moving		BGBM
21-7-11	10:15	Male	Feeding / Resting	Huddle sitting-partial	<i>Cecropia sp.</i>	BGBM
21-7-11	10:15	Female	Moving	Horizontal moving		BGBM
21-7-11	10:15	Male	Moving	Climbing		BGBM
21-7-11	10:15	Male	Feeding		<i>Cecropia sp.</i>	BGBM
21-7-11	10:34	Undetermined	Moving	Climbing	Bamboo	BGBM
21-7-11	10:34	Male	Resting	Huddle sitting-total	<i>Cecropia sp.</i>	BGBM
22-7-11	8:20	Female	Moving	Climbing	<i>Cecropia sp.</i>	BGBM
22-7-11	8:20	Undetermined	Moving	Climbing		BGBM
22-7-11	8:21	Male	Moving	Climbing		BGBM
22-7-11	8:37	Female	Moving	Climbing	Bamboo	BGBM
22-7-11	8:44	Female	Resting	Huddle sitting-total	High in spite of the wind. <i>Cecropia sp.</i>	BGBM
22-7-11	8:51	Female	Moving	Horizontal-moving	<i>Cecropia sp.</i>	BGBM
22-7-11	8:52	Female	Moving	Horizontal-moving	<i>Cecropia sp.</i>	BGBM
22-7-11	8:52	Undetermined	Resting	Huddle sitting-total	<i>Cecropia sp.</i>	BGBM

Date	Time*	Sex **	Behavioural category	Postural / Locomotor category	Other	Location
22-7-11	8:52	Female	Moving	Horizontal-moving	<i>Cecropia sp.</i>	BGBM
22-7-11	9:10	Male	Defecating ¹	Climbing		BGBM
22-7-11	9:10	Undetermined	Moving	Horizontal-moving	Bamboo	BGBM
22-7-11	9:28	Male	Moving	Climbing		BGBM
22-7-11	9:28	Male	Moving	Climbing		BGBM
22-7-11	9:28	Juvenile Male	Moving	Horizontal-moving		BGBM
22-7-11	9:28	Female	Moving	Horizontal-moving		BGBM
22-7-11	10:05	Female	Moving	Horizontal-moving	<i>Cecropia sp.</i>	BGBM
22-7-11	10:05	Undetermined	Resting	Extended sitting		BGBM
22-7-11	10:33	Undetermined	Moving	Climbing	Bamboo	BGBM
22-7-11	11:10	Undetermined	Resting	Huddle sitting-total	High in spite of the wind.	BGBM
22-7-11	11:46	Female with an offspring	Resting	Vertically extended ³		BGBM
22-7-11	14:07	Male	Feeding		Bindweed	BGBM
22-7-11	14:41	Undetermined	Moving	Horizontal-moving		BGBM
22-7-11	14:46	Undetermined	Moving	Climbing		BGBM
22-7-11	15:16	Male	Moving	Climbing		BGBM
22-7-11	15:55	Female	Moving	Climbing		BGBM

*Time of the first record

** In brackets are the codes given for some animals that could be identified has being the same individual across the text.

¹ Behavioural category not considered by Urbani & Bosque (2006). Staying stationary in the base of the tree trunk touching the ground.

² Postural category not described by Urbani and Bosque (2006). Stationary; supported by all limbs, ventral surfaces against the tree trunk

³ Postural category not described by Urbani & Bosque (2006). Stationary; supported by all limbs, ventral surfaces against the tree trunk in a vertical position. In this particular casa the offspring was positioned between the ventral region and the tree trunk