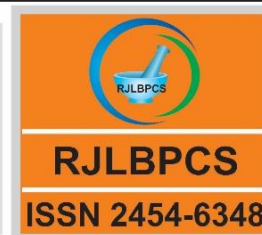




Life Science Informatics Publications

Research Journal of Life Sciences, Bioinformatics,
Pharmaceutical and Chemical SciencesJournal Home page <http://www.rjlbpcs.com/>**Original Research Article****DOI: 10.26479/2018.0405.04****BLACK HOWLER MONKEYS (*ALOUATTA CARAYA*): BEHAVIOUR AND DIET
IN BRAZILIAN SAVANNAH (CERRADO)****Vanessa Katherinne Stavis^{1*}, Maria Rita Marques¹, Marcelo Oscar Bordignon¹, Wanly Pereira², Nara
Inacio Luccas Lazaro², Elias Rodrigues da Cunha², Bruna Gardenal Fina²**

1. Federal University of Mato Grosso do Sul Foundation - UFMS, Institute of Biosciences,
INBIO, Campo Grande, MS, Brazil.
2. Federal University of Mato Grosso do Sul Foundation – UFMS, Campus of Aquidauana,
CPAQ, Aquidauana, MS, Brazil.

ABSTRACT: The activity patterns and diet of a group of *Alouatta caraya* were monitored in a fragment Savannah (Cerrado) forest on Mato Grosso do Sul, Brazil, from June 2012 to March 2013. Quantitative data were collected by scan sampling method. The general activity patterns (n = 6873 records) was 39.9% rest, 26.4% travel, 24.8% feeding, 6.3% for social behaviour. The level of resting was relatively minor to patterns of genus (39.9%). The diet (n = 1707 records) was marked by the consumption of leaves throughout the study (46.5%), fruits (34.8%) and flowers (17.8%). The group consumed items of 72 plant species classified in 30 families. The consumption was higher in the dry season at leaves (58.7%) and fruits in the rainy season (42.8%). The consumption of flowers was high by the standards of southerly populations of the species *Alouatta caraya* feeded significantly more in rainy season, but spent more time in other categories in dry season: travel and social interactions. It is necessary phytochemical studies on the items consumed in Savannah (Cerrado) biome to know which selection criterion the *Alouatta* use, contribute to the development of conservation strategies.

KEYWORDS: black-howler-monkeys; feeding ecology; behavioral ecology; activity patterns

Corresponding Author: Dr. Vanessa Katherinne Stavis* PhD

Federal University of Mato Grosso do Sul Foundation - UFMS, Institute of Biosciences,
INBIO, Campo Grande, MS, Brazil.

Email Address: vanessastavis@hotmail.com

1.INTRODUCTION

The howler monkeys (*Alouatta* spp.) are among the largest platyrrhines and have the widest geographical distribution, ranging from northern Argentina to southern Mexico [29]. The black howler monkey, *Alouatta caraya* (Humboldt 1812) is found mainly in Brazil, and has the largest geographic distribution of any howler, occurring throughout the Savannah (Cerrado) and Pantanal biomes, ranging south to the southern Atlantic Forest [14] and in adjacent areas of Bolivia, Paraguay and Argentina [17]. The behavior of howlers is reasonably well-known [28], [29]. These monkeys have a predominantly folivorous-frugivorous diet [69], low activity rates, and are typically found in polygynous groups of medium to large size [53]. Howlers regularly feed on mature leaves, although softer, less fibrous, young leaves are preferred when they are available [13]. Mature fruit is the other important food item, together leaf petioles, buds, flowers (sometimes seasonally very important), seeds, moss, stems, twigs and bark, and exceptionally, vertebrate prey [14]. The available data also indicate that Amazonian populations are more frugivorous than those of other regions [44], [79], [81], [96], although leaves are a seasonally important resource in all cases. The Savannah (Cerrado), second largest Brazilian biome, originally covered about 20% of the national territory, with an area of approximately two million km² [54]. It is composed of a mosaic of phytogeographies, ranging from forest areas (riparian forests, gallery forests and forest beds) to open areas (clean field, dirty field, cerrado field), passing through areas with intermediate structural characteristics (Cerradão and Cerrado Strict Sensu) [31], [83]. This diversity of environments is associated with a great diversity of animals and plants, the latter presenting a high degree of endemism [65], [67]. The estimates of loss of area of the Brazilian Savannah (Cerrado) are alarming; approximately 2.2 million hectares of this biome are lost annually [54]. Due to the high degree of floristic endemism and the great loss of area presented by the biome, the Savannah (Cerrado) is currently considered a priority conservation area or a hotspot [66], [68]. Habitat loss and fragmentation limit the survival of most mammals living in the forest, particularly strictly arboreal primates. As the size of the fragment directly affects food availability, the survival of primates in small fragments may depend on food flexibility [1], [73]. The Savannah (Cerrado) biome is marked by two well defined climatic seasons, a dry rainy season, the living species of this biome in the course of evolutionary history, were adapting to the seasonality of the region to guarantee survival and diversity, these adaptations occurred at morphological and phenological level of plant species, reproductive and animal feeding [55]. The vegetative cycle of the Savannah (Cerrado) plants occurs under the influence of natural climatic phenomena. At the beginning of the dry season, a great part of the vegetal species enter into vegetative rest, which induces foliar deciduifolism. Some species emit flowers, especially those belonging to the families Bignoniaceae, Bombacaceae during this period, which corresponds to the winter, the flowers of these species will serve as food for many animals, among them the primates. These features (flowers) soften the lack fruits during the dry season. Few fruit species complete the cycle of maturation in

the dry season, this minority is distributed by different environments of Savannah (Cerrado) and play an important role in the feeding of many animal species, among others, we can mention: *Hymenaea courbaril* (Jatobá - da - mata), *Hymenaea stigonocarpa* (jatoba - do - campo), *Didynopanax macrocarpum* (mandioqueiro - do - cerrado), *Inga vera* (Ingazeiro), *Mauritia flexuosa* (Buriti), *Butia purpurascens* (Coconut - jataí) [47], [48], [50]. When the rainy season begins, fruit maturation, the main source of food for a large contingent of fauna, does not occur homogeneously in all Savannah (Cerrado) areas. The great fructification occurs during the months of November, December and January, a season coinciding with the height of the rainy season. The concentration of these resources decreases, accompanying the end of the rainy season [56]. However, except for the months of May and June, which are considered critical when it comes to food supply, the other months that correspond to the dry season, even in a smaller quantity, present some resources, including flowers, roots, resins, some fruits [5], [27]. From July to September, months belonging to the dry season, many species of trees drop their leaves, although evergreen species contribute to an evident semi-deciduous pattern. Annual rainfall is about 1500 mm, most of which occurs from November to March (rainy season). In this period the average temperature is 27 ° C, while in the dry season (April to October) the average temperature is 20 ° C, and in the colder months (June-July) frost may occur [82]. The present study focuses on the behavioral ecology of a group of black howlers, *Alouatta caraya* in a semi-deciduous submontane seasonal forest fragment in Savannah (Cerrado) biome in the state of Mato Grosso do Sul, Brazil. Data on activity states and feeding behavior were collected in scan samples, providing quantitative measures of the activity budget and the composition of the diet of the study group. The analysis of these data was used to test two hypotheses: (i) that the activity pattern of the study group varies significantly between seasons, specifically, through a reduction in movement and an increase in resting and social interactions during the dry season (when resources were least abundant), and (ii) that the composition of the diet changes significantly between seasons, varying in accordance with the availability of different resources. While *Alouatta caraya* is not endangered, its populations are declining throughout most of the species range due to the ongoing expansion of farmland and fragmentation of natural habitats. In addition to evaluating the ecological and behavioral patterns of the species in the Savannah (Cerrado) biome of Mato Grosso do Sul, this study aimed to provide a database for planning conservation initiatives and management for the species and their habitats in this biome and adjacent ecosystems.

2. MATERIALS AND METHODS

2.1 Study Area

This study was conducted in an fragment of 83 hectares inserted in the Savannah (Cerrado) biome, existing in the municipality of Dois Irmãos do Buriti, Mato Grosso do Sul, on the Estância Crioula Farm, at the following geographic coordinates: 55°32'5,778 "W 20°31'13,598" S Zone 21 South,

WGS84). This area is part of the Serra de Maracajú range, which divides the state of Mato Grosso do Sul, separating the high plateau, to the east, from the wetland plains to the west, surrounded by areas of planted pasture (*Brachiaria brizantha* cv. Marandu) and with a connection to the southeast of the fragment, as shown in Fig 1.



Fig 1: High-resolution image of the Geoeye satellite, available in the ArcMap 10 database (ESRI®) (A) Location of the state of Mato Grosso do Sul - Brazil; (B) Representation of the biomes inserted in the state of Mato Grosso do Sul with a spot marking the location of the fragment within the state; (C) Fragment of 83 ha surrounding the pasture area formed by submontane semi-deciduous seasonal forest and gallery forest, inserted in Estância Crioula Farm – Dois Irmãos do Buriti - MS.

In the higher areas predominates arboreal vegetation of semi-deciduous submontane seasonal forest and in the margins of the channels predominates forest of the gallery [41]. The topography of the study area presents smooth undulating and flat relief, with dimensions ranging from 219 m to 316 m (data extracted from the Digital Elevation Model / Shuttle Radar Topography Mission 30 m). The average height of the plant species that make up the area is 20 meters, consisting of species such as jequitibás (*Cariniana estrellensis*), angicos (*Anadenanthera macrocarpa*), jatobás (*Hymenaea courbaril*), copaibas (*Copaifera langsdorffi*) whose leaves are consumed throughout the year, figs (*Ficus* sp), ipês (*Tabebuia* sp), which fruits and flowers are consumed by howler monkeys, among others [50]. The analysis of the seasons was based on rainy season and dry season, the latter being characterized by low rainfall and low temperatures and the rainy season the opposite, abundance of rain and high temperatures [32]. For this analysis the data were grouped considering the months of dry season June to September and rainy season the months of October to March. The phytosociological survey was done by the fixed area sampling method, which takes into account the size of the fragment (83 hectares) and vegetation structure, the plots method was used, and a total of

80 plots of 10 x 10 meters were installed, distributed in blocks of 20 x 50 meters in different altitudes, this measure allowed to sample a representative portion of the floristic structure of the study area [34]. The inclusion criterion was for individuals with a chest height equal to or greater than 10 cm. The botanical material was collected and identified according to APG-III. The calculations of the phytosociological parameters were performed through the program Fitopac 2.1 [94]. Samples were collected from trees with perimeter at breast height (PBH) equal to or greater than 10 cm, which were dried in an oven for identification. The species were identified by the Specialists of Botanical Collection of UFMS (Federal University of Mato Grosso do Sul, PhD Flávio Macedo Alves, PhD Bruna Gardenal Fina and PhD Arnildo Pott). Although they do not get independent measures of availability of resources, howler monkeys seem to consume the items that are part of their diet according to availability for the seasons. The analysis of the seasonal pattern in the diet, increased consumption of new leaves and fruits in the rainy season are in agreement with the productivity of the period, which is characterized by a relative abundance of these items in other studies [35], [46], [79], [101].

2.2 Study Group

The group size varies from 11 to 13 animals: 3 adult males, 3 adult females, 1 subadult female, 3 juveniles males, 1 juvenile female, 1 infant male and 1 infant female. The distinction between sex-age groups was carried out by the parameters: body size, coloration, behavior and genitals [11].

Activity Budgets and Diet

Behavioral data were collected between June 2012 and March 2013, with samples being taken on five days per month, from dawn to dusk, totaling at least ten hours per day. Quantitative data were collected using scan sampling method for 5 minutes with an interval of 10 minutes [6], [56]. The 10 months of observation generated 6873 behavioral records. We used a sampling scheme for 5 minutes with an interval of 10 minutes between scans, similar to other studies with another *Alouatta* spp. The monthly sampling effort was those according to [11], [38], [59], [60], [62], dedicated to five monthly day, with period of 10 hours a day for observation and collecting behavioral data of members of the study group. For the records of the activity budgets and diet was applied a protocol similar to other studies with *A. caraya* [11], [52], [72], [87], [92]. The scan samples, with five-minute scans with 10-minute intervals for each member of the group visible during sampling in a maximum of five minute were recorded: identity; its activity; the group member within a 10 m radius of the subject; its height relative to the soil, your posture (sitting, lying down, grabbed, suspended by the tail and front legs, suspended by the tail and hind legs, or bipedalism or quadrupedalism). The behavioral categories that were used in this study, based on those used in accordance with [11], [38], [59], [62], were: *Moving* - when animals to shifted during the record. *Resting* - subject standing, sitting or lying down, with no apparent activity. *Feeding* - subject eating or chewing food items. *Social Interactions* - any activity that involves peaceful interactions as grooming parasites, hugs, play behavior, or in some

cases characterized by physical aggression or behavior, pushing, biting, throws or by displacement of another individual due to simple arrival at the site of a dominant individual. *Other Behaviors* - activities that do not fit into any of the above categories: solitary play, self-grooming, scratching, drinking water. In each time of recording the behavior of animals, where it was observed feeding behavior was recorded which consumed item (leaves, flowers, fruit) whenever possible, in terms of plant species. When it was not possible in tree that was serving as feed point was marked with a permanent identification to species level and later identified. Data were tabulated in a spreadsheet organized by day, month and season (dry and rainy). For comparisons among animals, the data were grouped by season. The differences between the seasons were analyzed using the binomial z test [76], where as the significance level was $\alpha = 0.05$ [56]. For the analysis of the general activity budgets we used the data gathered during all the months of observation. However, within the context surrounding the general pattern of activities of the study group, a seasonal analysis was based in the rainy and dry period. Thus, for this analysis, data were grouped seasonally, dry season (from June to September 2012) and rainy season (between October 2012 and March 2013). Diet composition was calculated by dividing the number of records of each item by the total number of feeding records collected during the study period. The items consumed were classified as leaves, fruits (mature and immature) and flowers (buds and open).

3. RESULTS AND DISCUSSION

During the period from June/2012 to March/2013 were obtained 510 hours of direct observation of the study group, 200 hours in the dry season and 310 in the rainy season. In total 6873 records of behavior were obtained, and 39.9% (n=2739) records of resting, 26.4% (n=1815) of moving, 24.8% (n=1707) at feeding, 6.3% (n=432) to social interactions and 2.6% (n= 180) in activities that do not fit into any of the above categories. With a predominance of long periods of resting and low levels of social interaction (Fig 2A). Among the seasons of the year, there were differences in the behavioral categories in which a higher frequency in the handling behavior was observed in the dry season, 31%, n = 793 (z = 5.65, p <0.05), social interaction 7.4%, n = 189 (z = 2.78, p <0.05) and other behaviors 3.5%, n = 90 (z = 3.53, p<0.05). In the rainy season, resting behaviors were significant 41%, n = 1767 (z = -1.93, p<0.05) and feeding 27.6%, n = 1189 (z = -5.92, p<0.05) (Fig 2B).

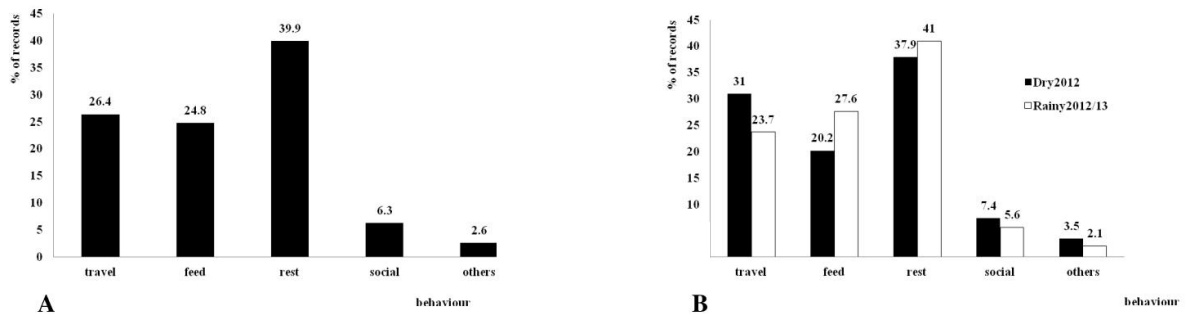


Fig 2: A) Activity budgets and distribution of behavioral categories for *Alouatta caraya* group; B) between seasons (dry and rainy) over the period June/2012 to March/2013 (n=6873 records) in semi-deciduous submontane seasonal forest fragment in Savannah (Cerrado) biome.

In the phytosociological analysis 1396 individuals were sampled, belonging to 35 families and 95 species. The richest families were Fabaceae (21) and Rubiaceae (8), followed by Bignoniaceae, Moraceae, Arecaceae and Sapindaceae with 4 species each. The species with the greatest number of individuals were *Protium heptaphyllum* March (158), *Coussarea hidrangeifolia* (Benth.) Müll.Arg (107), *Casearia gossypiosperma* Briq. (52), *Eugenia* sp. (45) and *Trichilia pallida* Swartz. (38). There are species that are considered rare numerically but of great biological importance such as *Myracrodruon urundeuva* All. (11), *Copaifera langsdorfii* Desf. (6), *Anadenanthera colubrina* (Benth.) Von. Altschul (5), *Cariniana estrellensis* (Raddi) Kuntze (3), *Magonia pubescens* St.Hil. (1), many of these species were part of the diet of the *Alouatta* group of this study over the 10 months of observation. The Shannon index (H') was 3.65 nats / individual and the equability index (J') was 0.80, showing high diversity and good distribution of individuals in the area. The total density was 1745 individuals per hectare and the total basal area was 21.65 m² / ha, being these values considered high, demonstrating the presence of many young individuals, which suggests area in regeneration. In this study the group of *Alouatta caraya* used food items (leaves, flowers and fruits) of 72 plant species classified in 30 families. The families with the highest number of species used by the black howler monkeys were Fabaceae, Rubiaceae and Bignoniaceae. The diet group was of comprised of leaves, fruit (mature and immature) and flowers (flower buds, and open) (Fig 3A). Leaf was the most consumed food item (46.5%, n=794) throughout the study, followed by fruits (34.8%, n=594) and flowers (17.8%, n=319). In the dry season, in spite of a shorter feeding time, there was a significant consumption of flowers, 25.1%, n = 130 ($z = 6.34$, $p < 0.05$) and leaves 58.7%, n = 304 ($z = 4.86$, $p < 0.05$). In the rainy season, fruit consumption was significant 42.8%, n = 510 ($z = - 8.83$, $p < 0.05$) in relation to the dry season, Fig 3B.

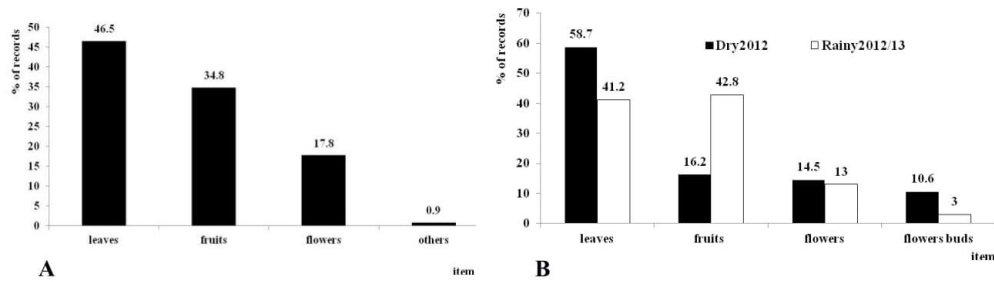


Fig 3: A) Diet of *Alouatta caraya* group and frequency in the consumption of food items in semi-deciduous submontane seasonal forest fragment in Savannah (Cerrado) biome; B) during seasons (dry and rainy) from June 2012 to March 2013 (n = 1707 records).

The results of this study revealed activities patterns and feeding behavior typical of *Alouatta* genus, however points to possible intra and inter specific differences, encouraging the idea of being made more systematic research on the species in Savannah (Cerrado) environment. During the observations of the study group, in the Estância Crioula Farm monkeys spent 39.9% of their time inactive, 24.8% feeding, 26.4% traveling, 6.3% in social activities, and 2.6% involved in other miscellaneous behaviors. The study group maintained the typical pattern recorded for the genus, with inactivity more frequent than other behaviors, usually associated with a highly folivorous diet. For the standard of activity of the studied group of howler monkeys, the behavioral category "resting" was more frequent, but it was smaller when compared to several studies carried out with the same species and in a nearby region such as [72], in the municipality of Terenos - MS within the Savannah (Cerrado) biome, where the "resting" category was 50.9% and the work of [86] in the region of Aquidauana (Savannah (Cerrado)-Pantanal) where rest had a frequency of 64.7% and others of the genus, such as *Alouatta caraya* [106], where the rest recorded 77.4% and we can mention other species as *Alouatta palliata* (57%) observed by [105], *Alouatta belzebul* (58.7%) observed by [75] and *Alouatta guariba* (71.8%) observed by [59]. In most cases, the howlers *Alouatta* spp. spend less than 10% of their time traveling, and rarely more than 20%, although [105] reported a very high value (27.4%) for *Alouatta palliata*. However, the time budget is very similar in terms of time spent in traveling (26,4%), the value is similar of that obtained for *A. caraya* (29.9%) living in gallery forests in Terenos (MS) [72], the highest value recorded for a species of the genus [29], and to the others groups of the *A. caraya* (25.4%) studied in central part of Aquidauana (MS) [68] and in Alegrete (Rio Grande do Sul, Brazil) with 23.4% of their time traveling [80]. In the southern geographic distribution of *A. caraya*, [106] showed a value of only 2.4% while [11] registered 17.1%. We proposed the hypothesis in which the activity budgets of the members of the study group would vary according to the temporal distribution of the main items of their diet, leaves, fruits and flowers. For the study group, it was assumed that variations in the temporal distribution of the major food resources, leaves, fruits and flowers, directly influence their behavioral strategies.

In this context, the basic hypothesis is that the patterns of activities vary systematically between climatic seasons. More specifically, in the period of greatest food short ages, the dry season it was expected that: (a): the animals spend less time in locomotion behavior, and more time to resting and to social interactions; and (b): the composition of the diet would change significantly between seasons. The analysis confirmed this hypothesis in part, the results of the main activities correlated with the seasons indicated that the social behavior and the displacement along the living area were higher during the dry season and that the group members spent significantly more time resting and feeding in the rainy season. The howlers maintain the proportion of time for activities in different seasons, but this does not mean that the total times allocated are the same. They respond to seasonal, generally by altering the activity period. This is evident, for example, at resting and sleep. In the rainy it was higher than the dry season, a difference that may be have to do with the extended temporal dimension of rainy season. The resting tends to be higher in the middle of the day, in periods where temperatures are relatively higher in warmer seasons (rainy seasons) and during longer periods when temperatures are low, in colder seasons (dry seasons). The high rates of resting for *Alouatta* spp may be related to a strategy for minimizing energy expenditure, considering the standard folivory in the diet of these animals, i.e., high rates of inactivity seem to be a compensation (trade-off) for feeding behavior based on poor resources [13], [62], [69]. But it is not the case of the study group since the rest was higher in the rainy season where fruit consumption was significant and is considered a rich resource in energy. The number of 72 plant species classified in 30 families used by *Alouatta caraya* group of this study is higher than that found in other studies with another species, how with *Alouatta guariba* in Atlantic Forest as in the study of [23] reports that 68 species consumed in semi-deciduous forest in Santa Genebra, Campinas, São Paulo state and [2] observed 49 species of plants in the diet of *A. guariba* in northern Paraná state, both in semi-deciduous forest ecosystems. Probably the number found in this study is higher because in addition to having plant species characteristic of semi-deciduous forest, has typical plant species of tropical rainforest environment, so, more humid environment, with large trees around 30 meters in height low loss of leaves in the dry season which has its items used as food by black howler monkeys [57], [59]. To obtain a satisfactory amount of food, primates have to deal in their foraging behavior, with the space-temporal features of the habitats that they occupy. Factors such as the spatial and temporal distribution, quality and abundance of resources are identified as determinants of social organization in primates, both in evolutionary level as at the level of immediate adjustments to the environment [25], [30], [42], [62], [71]. Thus, herbivorous primates select their food resources based on the nutritional return and amount of secondary compounds that each food item offers [70], [100], [104]. In this way they feed on items with low availability, but with a high energy return, and when they become scarce in the environment, they change to a diet of items with less energy and widely distributed [40], [84], [104]. Thus, some primates may spend more time locomotion in periods of low

availability of energy foods, in order to find enough of these resources to compose their diet [21], [89], [103]. Others, in turn, may adopt the opposite strategy and move to shorter distances in times of short age [30] or increase rest time [95] in order to reduce the energy expenditure [35], [63], [90]. The folivory is strongly associated with the animal's body size, which together, influence the sizes groups and in this home range and core areas of these neotropical primates, as is the case in the species of the *Alouatta* genus [2], [12], [16], [20], [23], [25], [36], [60], [61], [62], [69], [105] and the species of *Brachyteles* genus [19], [86], [98], [102]. The diet of howlers is a reflection of basic needs determined by body size, anatomical specializations (size and structure of the gastrointestinal tract) and the ability to switch large periods of resting. These adaptations make the howlers able to draw energy from food theoretically lower energy content, where the leaves [11],[22], [39], [59], [62] in this case leaves reflect of certain basic needs. In general there is a predominance of leaves in the diet, found they eating leaves in a ratio greater than others items. But this characteristic in the diet does not think that the leaves are only the most important goal of the foraging behavior of howlers, fruit, a more energetic item, seems to have a preponderant role in the diet of most species where the fruits were in abundance in rainy seasons (see examples [75] *A. belzebul*, [76], [78] *A. discolor*, [53] *A. caraya*). For the study group, the diet consisted predominantly by plant material, especially leaves, a pattern typical of the genus *Alouatta* spp. [29]. The use of leaves had a relatively similar diet of the study with *A. caraya* in a similar region [72] and close to the other studies related to howler monkeys that average around 56.4%, including *A. caraya* [11], [17], [53], [87], [105], [107]. Fruit and fruit consumption were relatively large, fruit consumption (34.8%) was similar to the group studied in Terenos [72] (35.5%) and superior to the *A. caraya* group studied by [86] in Aquidauana (Savannah (Cerrado)-Pantanal) which was 8.2%. Flowers were resources appreciated in the dry season and their consumption was higher (17.8%) than in other groups of *A. caraya* [106] (2.2%), [11] (2.7%) and slightly above the studies carried out in the region (14.9% [86], 12.9% [72]). In the case of howlers, the analysis of the seasonal pattern in the diet, demonstrated that there was an increased on consumption of the fruits (42.8%) in the rainy season and flowers in dry season (25.1%). The frugivory was marked during the rainy season (42.8%) when compared to dry (16.2%). Despite that not obtain independent measures of resource availability, howlers seem to consume these items according to availability for the seasons. The analysis of the seasonal pattern in the diet, increased consumption of the new leaves in the rainy season is in accordance with the productivity of the period [35], [46], [101], the same can be said of the consumption of fruits, since this period is characterized by a relative abundance of fruit in the majority of the other study sites [79]. A similar pattern can be seen in case of leaves, where folivory predominates in most but not all species of the genus, we can mention *A. belzebul* [16] where it had 13.3% of leaf consumption and 59% of fruits, [76] 24.8% of leaves and 55.6% of fruits. Regarding seasonal differences, howler monkeys are capable of adjusting to the availability of resources, the

consumption of leaves is not balanced between seasons (58.7% and 41.2% in the dry and rainy seasons respectively), leaf consumption was significant in the dry season but flowers and fruits are consumed according to availability station, fruits in rainy and flowers in dry season. The climatic seasons, of course, differ in photoperiod and temperature as both variables are smaller in dry season. Thus, for efficiency, assuming that the animals were defending a minimum consumption of food, they should move in the season more frequently with less time available, in this case, the dry. Thus, animals should be more efficient in dry season. There is a great tendency in this direction, howlers are moving more and engaging in food major shifts. The highest consumption of leaves and reduced folivory of reproductive plant parts such as flowers and partly fruits, recorded for the study group compared to other populations of *A. caraya*, located in southern Brazil (60.9% leaves, 28.9% fruits and 2.7 flowers [11], and northern Argentina (74.2% leaves, 23.6% fruits and 2.2 % flowers [106], [107]), would be consistent with this hypothesis, the intra specific level when the availability of fruits is significant directs their efforts in diet for the consumption of this item [72]. For example, the diet of the red-handed howlers (*A. discolor*) [79] have complements the high frugivory observed in *A. belzebul* [76]. Although intra specific variation in howler diets is high and new studies with highly folivorous species have shown higher frugivory, *A. belzebul* seems to be the most consistently frugivorous howler species [76], in spite of its wide geographic distribution and sympatry with *Ateles chamek*, a highly frugivorous primate [79]. Also, reduced by resting periods would be consistent with a diet frugivorous [26], [57], [59], as observed in other atelidae such as *Ateles* spp. [21], [29] and *Brachyteles* spp. [97], [99], although such behavior patterns for black howler monkeys, *A. caraya* require that these interpretations are made with some caution when considering the possible influence of methodological issues described above. According [78] howler studies evidence great variation of dietary specific richness, mostly due to differences in vegetation richness among habitats and study duration, and confirms high frugivory for several primate species commonly exhibit dietary changes following seasonal variation in fruit availability [62], [73], [87], [97], [99], [103]. Therefore, is expected that howlers would consume less fruit in the dry season in Savannah (Cerrado) biome [10], [35], [46], [101], when there is a shortage of fruit production, the same seems to be the norm in other biomes as Amazon [75], [76], [77], [79], [93], [103], and Atlantic forest [74], [85], [91], [97], [99]. Nevertheless, this analysis indicates clearly that a more systematic approach is needed for the comparative analysis of different studies, one which should include the standardization of sampling procedures, the age-sex composition of study groups, and the study period, all of which may influence recorded values considerably. In *Alouatta*, there is often as much variation within species as there is between species. In addition to possible methodological issues, differences may reflect the influence of site (habitats and biomes, for example) at the population level [4], or even individual factors, making identification almost impossible at inter specific patterns [72]. It seems possible that methodological factors may be less important here, and indeed, there

seems to be much less intra specific variation [72]. Overall, folivory seems to be more pronounced in populations at higher latitudes, especially those of species howler monkeys that *A. guariba* [64] and *A. caraya* [3], compared with species whose populations are located closer to the equator in the Amazon region, such as *A. belzebul* [77], *A. seniculus* [44] and *A. discolor* [78], [79]. This may reflect both productivity levels [3] and, especially, the less pronounced seasonality of the equatorial ecosystems [72]. There is a complex picture on the current understanding of the effects of habitat fragmentation and disturbance on species of the genus *Alouatta* that are among the most studied neotropical primates [29] due to their ability to persist in fragmented and disturbed habitats, including large and small fragments where other primate species cannot survive [24], [33], [51]. According to [8] in a review carried out on populations of *A. caraya*, *A. guariba*, *A. palliata*, *A. pigra* and *A. seniculus* indicate that fragment size is an important factor that negatively affects the presence, the abundance and persistence of populations of howler monkeys in fragmented habitats. Among other factors, the success of howler monkeys to deal with habitat disturbance has been related to their ability to (1) feed on different plant species and adapt their diet to species available in the habitat ex. [78], [88] (2) to increase the amount of leaves in their diet [9], [43], [89], (3) to consume exotic species [12], (4) use small residential areas [33], [51] and (5) use activity budgets of energy saving [63]. Although the pattern of activities is within the expected range for the species, the "resting" behavior is below the rates recorded for the same species and others of the genus, this probably reflects the demand for resources, which justifies feeding and displacement behaviors above found for the howler monkeys, in front of these data it is noticed the necessity of phytochemical studies on the items consumed in submontane semi-deciduous seasonal forest environment inserted in Savannah (Cerrado) biome to know the selection criterion on the items that make up the diet of these primates, since a nutrient balance approach provides a strong framework for large-scale analyzes of foraging decisions and choice of fragments, helping to explain how the spatial distribution of nutrients in the fragment, habitat, and landscape level affect feeding, foraging and travel decisions of individuals and their living standards rupture (for example, [18], [66]).

4. CONCLUSION

In general, we conclude that food choice and nutrient balance and prioritization may be less linked to a specific dietary emphasis, but a response to the specific fragment characteristics such as the nutritional composition of the food available, the presence / absence of basic food species (that is, resources that are available annually, Lambert and Rothman, 2015), and the intensity of fluctuations in resource availability. For example, regardless of primate species, food selection toward protein rich resources is most evident in places where the protein concentration in the environment is low or during periods of protein shortage [37]. The use of a nutritionally explicit model can direct effective conservation by identifying the nutritional requirements of a particular species, and thus properly regenerating, protecting and / or expanding a diverse set of fragments and foods that offer

the opportunity for a balanced nutritional diet. Finally, we highlight that the Savannah (Cerrado) biome is a domain which has been deforested at a very high rate and may be extinct soon [54] that is the reason why the conservation of the species which inhabit it is so important.

ACKNOWLEDGEMENT

We are grateful to Coordination of Improvement of Higher Level Personnel (CAPES), for an Master's scholar ship between 2012-2013 and PhD scholarship between 2014-2018 to MSc. Vanessa Katherinne Stavis.

CONFLICT OF INTEREST

The authors wish to state that there is no conflict of interest associated with the study.

REFERENCES

1. Agostini I, Holzmann I, Di Bitetti MS. Influence of seasonality, group size, and presence of a congener on activity patterns of howler monkeys. *J. Mammal.* 2012; 93(3):645–657.
2. Aguiar LM, Ludwig G, Reis NR, Rocha VJ. Dieta, área de vida, vocalizações e estimativas populacionais de *Alouatta guariba* em um remanescente florestal no norte do Estado do Paraná. *Neotrop. Primates.* 2003; 11(2):78-86.
3. Aguiar LM, Pie MR, Passos FC. Wild mixed groups of howler species (*Alouatta caraya* and *Alouatta clamitans*) and new evidence for their hybridization. *Primates.* 2008; 49:149-152.
4. Aguiar LM, Ludwig G, Passos FC. Group size and composition of black-and-gold howler monkeys (*Alouatta caraya*) on the Upper Paraná River, Southern Brazil. *Primates.* 2009; 50:74-77.
5. Alberts CC. Perigo de vida: predadores e presas: um equilíbrio ameaçado. São Paulo: Atual. 1989; 74 p.
6. Altmann J. Observational study of behavior sampling methods. *Behavior.* 1974; 49:227-267.
7. APG III - Angiosperm Phylogeny Group. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG III. *Bot. J. Linn. Soc. London.* 2009; 161:105-121.
8. Arroyo-Rodríguez V, Dias PAD. Effects of Habitat Fragmentation and Disturbance on Howler Monkeys: A Review. *Am. J. Primatol.* 2010; 72:1–16.
9. Asensio N, Cristóbal-Azkarate J, Dias PAD, Vέα JJ, Rodríguez-Luna E. Foraging habits of *Alouatta palliata* mexicana in three forest fragments. *Folia Primatol.* 2007b; 78:141–153.
10. Barbosa-Filho GB, Araújo AC. Fenologia de floração e síndromes de polinização na Serra de Maracaju, Mato Grosso do Sul. *Anais do Encontro de Iniciação Científica.* 2009; ENIC, 1: n°1(5).
11. Bicca-Marques JC. Ecologia e comportamento de um grupo de bugios-pretos *Alouatta caraya* (Primates, Cebidae) em Alegrete, RS, Brasil. Dissertação de Mestrado, Universidade de Brasília, Departamento de Ecologia. 1991.
12. Bicca-Marques JC, Calegari-Marques C. Feeding behavior of the black howler monkey

- (*Alouatta caraya*) in a seminatural Forest. Acta Biol. Leopold. 1994; 16:69-84.
13. Bicca-Marques JC. How do howler monkeys cope with habitat fragmentation? In: Primates in Fragments: Ecology and Conservation (L.K. Marsh, Ed.), Kluwer Academic/Plenum Publishers, New York. 2003; pp. 283-303.
 14. Bicca-Marques JC, Muhle CB, Prates HM, Oliveira SG, Calegario-Marques C. Habitat impoverishment and egg predation by *Alouatta caraya*. Int. J. Primatol. 2009; 30(5):743-748.
 15. Boinski S. Habitat use by squirrel monkeys (*Saimirio erstedii*) in Costa Rica. Folia Primatol. 1987; 49:151-167.
 16. Bonvicinno CR. Ecologia e comportamento de *Alouatta belzebul* (Primates: Atelidae) na mata atlântica. Rev. Nord. Biol. 1989; Joao Pessoa, 6 (2):149-179.
 17. Bravo SP, Sallenave A. Foraging Behavior and Activity Patterns of *Alouatta caraya* in the Northeastern Argentinean Flooded Forest. Int. J. Primatol. 2003; 24:825- 846.
 18. Busia L, Schaffner CM, Rothman JM, Aureli F. Do fruit nutrients affect subgrouping patterns in wild spider monkeys (*Ateles geoffroyi*). Int. J. Primatol. 2016; 37:738-751.
 19. Carvalho Jr O, Ferrari SF, Strier KB. Diet of a miquiqui group (*Brachyteles arachnoides*) in continuous primary forest. Primates. 2004; 45:201-204.
 20. Chapman CA. Flexibility in diets of three species of Costa Rican primates. Folia Primatol. 1987; 49:90-105.
 21. Chapman C. Patterns of foraging and range use by three species of neotropical primates. Primates. 1988; 29:177-194.
 22. Chiarello AG. Home range of the brown howler monkey, *Alouatta fusca*, in a forest fragment of south eastern Brazil. Folia Primatol. 1993; 60:173-5.
 23. Chiarello AG. Diet of the Brown Howler Monkey *Alouatta fusca* in a semi-deciduous Forest fragment of South eastern Brazil, Tokyo. Primates. 1994; 35(1):25-34.
 24. Chiarello AG. Primates of the Brazilian Atlantic forest: the influence of forest fragmentation on survival. In: Marsh LK, editor. Primates in fragments: ecology and conservation, New York: Kluwer Academic/Plenum Publishers. 2003; pp. 99-121.
 25. Clutton-Brock TH, Harvey PH. Species differences in feeding and ranging behavior. In Primate Ecology, TH. Clutton - Brock (ed.). New York, Academic Press. 1977; pp. 557-579.
 26. Coelho AM, Bramblett CA, Quick LB, Bramblett SS. Resource availability and population density in primates: a socio-bioenergetic analysis of the energy budgets of Guatemalan howler and spider monkeys. Primates. 1976; 17:63-80.
 27. Costa Lima B. Frutos, mamíferos, répteis, peixes, aves e abelhas melíferas do centro-sul de Goiás: uma tentativa de sistematização dos recursos de subsistência. In: Anuário de Divulgação Científica, Goiânia: UCG. 1976; 36 p.
 28. Crockett CM, Eisenberg JF. Howlers: variations in group size and demography. In: Primate

- Societies, (Smuts BB, Cheney DL, Seyfarth RM, Wrangham RW, Struhsaker TT, Eds.) University of Chicago Press, Chicago.1987; pp. 54-68.
29. Di Fiore A, Campbell CJ. The Atelines: variation in ecology, behavior, and social organization. In: Campbell CJ, Fuentes A, MacKinnon KC, Panger M, Bearder SK (eds.). *Primates in Perspective*, Oxford University Press, New York. 2007; pp. 155-185.
30. Dunbar RIM. *Primate Social Systems*. Croom Helm Ltda., London, England.1988; 373 p.
31. Eiten G. Formas fisionômicas do Cerrado. *Rev. Bras. Bot.* 1979; 2:139-148.
32. Embrapa. Empresa Brasileira de Pesquisa Agropecuária. Unidade Gado de Corte. Relatório Anual das temperaturas máximas e mínimas e dados pluviométricos. Relatório não publicado. Campo Grande, MS, Brasil. 2010; 60 p.
33. Estrada A, Solano SJ, Martinez TO, Estrada RC. Feeding and general activity patterns of a howler monkey (*Alouatta palliata*) troop living in a forest fragment in Los Tuxtlas, Mexico. *Am. J. Primatol.* 1999; 48:167-183.
34. Felton AM, Felton A, Lindenmayer DB, Foley WJ. Nutritional goals of wild primates. *Functional Ecology.* 2009; 23:70–78.
35. Ferreira KR, Fina BG, Kusano DM. Comportamento Fenológico de *Erythroxylum suberosum* ST. Hil. (Erythroxylaceae) em uma área de Cerrado stricto sensu em Aquidauana, Mato Grosso do Sul. *Anais do Encontro de Iniciação Científica, ENIC.* 2010; 1(3).
36. Fuentes E et al. Reporte preliminar sobre el uso de recursos alimenticios por una tropa de monos aulladores, *Alouatta palliata*, en el Parque La Venta, Tabasco, México. *Neotrop. Primates*, Washington. 2003; 11(1):24-29.
37. Ganzhorn JU et al. The importance of protein in leaf selection of folivorous primates. *American J. Primatol.* 2017.
38. Glander KE. Reproduction and population growth in free-ranging howling monkeys. *American J. Primatol.* 1980; 53:25-36.
39. Glander KE. Feeding Patterns in Mantled Howling Monkeys. In Kamil, Alan C, Sargent, Theodore D. Editors. *Foraging Behavior: Ecological, Ethological, and Psychological Approaches*. New York: Garland STPM Press, 1981.
40. Hladik CM. A comparative study of the feeding strategies of two sympatric species of leaf monkeys: *Presbytissenex* and *Presbytis entellus*. In Clutton-Brock TH. (ed.), *Primate Ecology*, Academic Press, New York. 1977; 324–353.
41. Instituto Brasileiro de Geografia e Estatística– IBGE. *Manual Técnico da Vegetação Brasileira*. 2ªed. Revista e Ampliada. Rio de Janeiro. 2012; 271.
42. Jolly A. *Evolution of Primate Behavior*. Macmillan Publishing Company, New York. 1985; 416.
43. Juan S, Estrada A, Coates-Estrada R. Contrastes y similitudes en el uso de recursos y patrón

- diarios de actividades en tropas de monos aulladores (*Alouatta palliata*) en fragmentos de selva en Los Tuxtlas, México. *Neotrop. Primates*. 2000; 8:131–135.
44. Julliot C, Sabatier D. Diet of red howler monkey (*Alouatta seniculus*) in French Guiana. *Int. J. Primatol.* 1993; 14:527–550.
45. Lambert JE, Rothman JM. Fallback foods, optimal diets, and nutritional targets: Primate responses to varying food availability and quality. *Annual Review of Anthropology*. 2015; 44:493–512.
46. Lehn CR. Aspectos estruturais e fenológicos de uma população de *Danaea sellowiana* C.Presl (Marattiaceae) em uma floresta estacional semidecidual no Brasil Central. Dissertação de Mestrado. Universidade Federal de Mato Grosso do Sul. Campo Grande, MS, Brasil, 2008.
47. Lorenzi H. Árvores brasileiras: manual de identificação e cultivo de plantas arbóreas nativas do Brasil. São Paulo: Plantarum. 1992; 352 p.
48. Lorenzi H. Palmeiras no Brasil: nativas e exóticas. São Paulo: Plantarum. 1996; 303 p.
49. Lorenzi H. Árvores brasileiras: manual de identificação e cultivo de plantas arbóreas nativas do Brasil. São Paulo: Plantarum. 2002; 2:368.
50. Lorenzi H. Árvores brasileiras: manual de identificação e cultivo de plantas arbóreas nativas do Brasil, Instituto Plantarum de Estudos da Flora, Nova Odessa. 2008; vol 1.
51. Lovejoy TE et al..Edge and other effects of isolation on Amazon forest fragments. In: Soule' ME, editor. *Conservation biology. The science of scarcity and diversity*. Sunderland, Massachusetts: Sinauer Associates. 1986; pp. 257–285.
52. Luccas-Lazaro NI. Cuidado parental e relações sociais entre fêmeas adultas e seus filhotes de bugios-pretos-e-dourados (*Alouatta caraya*; Primates, Atelidae) em fragmentos urbanos de Cerrado-Pantanal em Aquidauana, Mato Grosso do Sul. Dissertação de Mestrado (Biologia Animal). Fundação Universidade Federal de Mato Grosso do Sul, Mato Grosso do Sul, 2013.
53. Ludwig G et al. Comparação da dieta de *Alouatta caraya* (Primates: Atelidae) em mata ciliar insular e continental na região do Alto rio Paraná, Sul do Brasil. *Rev. Bras. Zool.* 2008; 25: 419-426.
54. Machado RB et al. Estimativas de perda da área do Cerrado brasileiro. Relatório Técnico. Conservação Internacional, Brasília, DF. 2004.
55. Malheiros R. A Influência da sazonalidade na dinâmica da vida no bioma cerrado. *Rev. Bras. Climat.* 2016; 19:2237-8642.
56. Martin P, Bateson R. *Measuring Behavior*. Cambridge University Press. 1993.
57. McNab BK. Energetics of arboreal folivores: Physiological problems and ecological consequences of feeding on an ubiquitous food supply. In *The Ecology of Arboreal Folivores*. G. G. Montgomery (ed.). Smithsonian Press: Washington. 1978.

58. McNab BK. Foods habitats, energetics and the population biology of mammals. *Am. Nat.* 1980; 116:106-124.
59. Mendes SL. Ecologia e Comportamento do barbado (*Alouatta fusca*) da Estação Biológica de Caratinga (MG). Dissertação de Mestrado. Departamento de Ecologia da Universidade de Brasília, 1985.
60. Mendes SL. Estudo ecológico de *Alouatta fusca* (Primates: Cebidae) na Estação Biológica de Caratinga, MG. *Rev. Nord. Biol.* 1989; 6 (2):71-104.
61. Milton K, May ML. Body weight, diet and home range area in primates. *Nature*. 1976; London: 259:459-462.
62. Milton K. The foraging Strategy of Howler Monkeys, a study in primate economics. Columbia University Press, New York. 1980; 165 p.
63. Milton K. Physiological ecology of howlers (*Alouatta*): energetic and digestive considerations and comparisons with the Colobinae. *Int. J. Primatol.* 1998; 19:513–548.
64. Miranda JMD, Passos FC. Composição e dinâmica de *Alouatta guariba clamitans* Cabrera (Primates, Atelidae) em floresta ombrófila mista no Estado do Paraná, Brasil. *Rev. Bras. Zool.* 2005; 22:99-106.
65. Mittermeier RA et al. Hotspots revisited. Earth's biologically richest and most endangered terrestrial ecoregions. Eds: Agrupación de Sierra Madre. 2005.
66. Moore BD, Lawler IR, Wallis IR, Beale CM, Foley WJ. Palatability mapping: A koala's eye view of spatial variation in habitat quality. *Ecology*. 2010; 91:3165–3176.
67. Myers N, Mittermeier RA, Mittermeier CG, Fonseca GAB, Kent J. Biodiversity hot spots for conservation priorities. *Nature*. 2000; 403:853–858.
68. Nantes RS, Rímoli J. Ecologia e comportamento de bugios-pretos (*Alouatta caraya*, Primates, Atelidae) em fragmentos florestais em Aquidauana, Mato Grosso do Sul. Relatório Final, PIBIC/UFMS/CNPq. 2008.
69. Neville MK, Glander KE, Braza F, Rylands AB. The Howling Monkeys, Genus *Alouatta*. In *Ecology and Behavior of Neotropical Primate*, Mittermeier RA, Rylands AB, Coimbra-Filho AF, Fonseca GAB. (editors). Littera Maciel Ltda, Brasil. 1988; 2:349-453.
70. Norscia I, Carrai V, Borgognini-Tarli S. Influence of dry season and food quality on behavior and feeding strategy of *Propithecus verreauxi* in Kirindy, Madagascar. *Int. J. Primatol.* 2006; 27: 1001–1022
71. Oates JF. Food distribution and foraging behavior. In: Smuts BB, Cheney DL, Seyfarth RM, Wrangham RW, Struhsaker TT (eds.). *Primate Societies*. University of Chicago Press, Chicago, IL. 1987; 585p.
72. Odalia-Rímoli A, Valdivino EM, Rímoli J, Ferrari SF. Padrão geral comportamental de um grupo de bugios-pretos (*Alouatta caraya*, Humboldt, 1812) em um fragmento de floresta em Terenos

- (MS): uma análise sazonal in S.F. Ferrari , J. Rímoli (Eds). A Primatologia no Brasil – 9; Sociedade Brasileira de Primatologia, Aracaju (Biologia Geral e Experimental – UFS). 2008; pp. 179-191.
73. Passos FC. Hábito alimentar do mico-leão-preto *Leontopithecus chrysopygus* (Mikan, 1823) (Callitrichidae, Primates) na Estação Ecológica de Caetetus, município de Gália, SP. Dissertação de Mestrado. Universidade Estadual de Campinas. Campinas, SP, Brasil. 1992.
74. Peres CA. Primate responses to phenological changes in an Amazonian terra firme forest. *Biotropica*. 1994; 26:98–112.
75. Pina ALCB. Dinâmica socio-ecológica em uma população de Guaribas-das-mãos-vermelhas (*Alouatta belzebul*) na Estação Científica Ferreira Penna, PA. Dissertação de Mestrado, Universidade Federal do Pará, PA. 1999.
76. Pinto LP. Dieta, padrão de atividades e área de vida de *Alouatta belzebul discolor* (Primates, Ateleidae) em Paranaita, norte de Mato Grosso. Dissertação de Mestrado. Campinas: Universidade Estadual de Campinas, São Paulo. 2002.
77. Pinto ACB, Azevedo-Ramos C, Carvalho Jr O. Activity patterns and diet of the howler monkey *Alouatta belzebul* in areas of logged and unlogged forest in Eastern Amazonia. *Anim. Biodiv. Conserv.* 2003; 26:39–49.
78. Pinto LP, Setz EZF. Diet of *Alouatta belzebul discolor* in an Amazonian Rain Forest of Northern Mato Grosso State, Brazil. *Int. J. Primatol.* 2004; 25:1197-1211.
79. Prates HM, Bicca-Marques JC. Age-Sex Analysis of Activity Budget, Diet and Positional Behaviour in *Alouatta caraya* in an Orchard Forest. *Int. J. Primatol.* 2008; 29:703-715.
80. Queiroz HL. Preguiças e guaribas. Os mamíferos folívoros arborícolas do Mamirauá. Rio de Janeiro, Sociedade Civil Mamirauá, MCT, CNPq. 1995.
81. Ragusa-Netto J. Chaco Chachalaca (*Ortalis canicollis*, Wagler, 1830) feeding ecology in a gallery forest in the South Pantanal (Brazil) - *Brazilian Journal Biology*. 2015; 75:49-57.
82. Redford KH, Fonseca GAB. The role of gallery forests in the zoogeography of the Cerrado's non-volant mammalian fauna. *Biotropica*. 1986; 18:126-135.
83. Richard AF. *Primates in Nature*. W. H. Freeman and Company, New York. 1985; 586 p.
84. Rímoli J. Ecologia de macacos-pregos-pretos (*Cebus apella nigrinus*, Goldfuss, 1809) na Estação Biológica de Caratinga (MG): implicações para a conservação de fragmentos de Floresta Atlântica. Tese Doutorado. Universidade Federal do Pará. Belém, PA, Brasil. 2001.
85. Rímoli J, Ades C. Estratégia de forrageamento de um grupo de muriquis (*Brachyteles arachonides*, Primates, Cebidae) da Estação Biológica de Caratinga-MG. In *A Primatologia no Brasil*, Ferrari SF. , Schneider. H. (Eds.). Sociedade Brasileira de Primatologia. Belém, PA. 1997; vol. 5:39-57.
86. Rímoli J, Nantes RS, Lázaro-Junior AE. Diet and activity patterns of black howler monkeys

- Alouatta caraya* (Humboldt, 1812, Primates, Atelidae) in ecotone Cerrado-Pantanal in the left bank of Aquidauana river, Mato Grosso do Sul, Brazil. *Oecol. Aust.* 2012; 16(4):933-948.
87. Rivera A, Calmé S. Forest fragmentation and its effects on the feeding ecology of black howlers (*Alouatta pigra*) from the Calakmul area in Mexico. In: Estrada A, Garber PA, Pavelka M, Luecke L, editors. *New perspectives in the study of Mesoamerican primates: distribution, ecology, behavior and conservation*. New York: Kluwer Academic/Plenum Publishers. 2006; pp. 189–213.
88. Rodríguez-Luna E, Domínguez-Domínguez LE, Morales-Mavil J, Martínez-Morales M. Foraging strategy changes in *Alouatta palliata* Mexicana trop released on an island. In: Marsh LK, editor. *Primates in fragments: ecology and conservation*. New York: Kluwer Academic/Plenum Publishers. 2003; pp. 229–250.
89. Rothman JM, Raubenheimer D, Chapman CA. Nutritional geometry: gorillas prioritize non-protein energy while consuming surplus protein. *Biology Letters*. 2011; 7:847–849.
90. Rylands AB. Exudate-eating and tree-gouging by marmoset sets (Callitrichidae, Primates). In: Chadwick AC, Sutton SL (eds.). *Tropical Rain Forest: The Leeds Symposium*, Leeds Philosophical Society, Leeds, UK. 1984; pp. 155-168.
91. Santini MEL. Alimentação e padrões de atividade de *Alouatta caraya* (Primates, Cebidae), reintroduzido no Parque Nacional de Brasília – DF. Dissertação de Mestrado, Universidade de Brasília, Brasília. 1985.
92. Setz EZF. Ecologia alimentar de um grupo de parauacus (*Pithecia pithecia chrysocephala*) em um fragmento florestal na Amazônia Central, Dissertação Doutorado. Universidade Estadual de Campinas, Campinas, Brasil. 1993.
93. Shepherd GJ. FITOPAC 2.1.2. Software. Campinas: Departamento de Botânica, Unicamp. 2010.
94. Silver SC, Marsh LK. Dietary flexibility, behavioral plasticity, and survival in fragments: lessons from translocated howlers. In Marsh, L.K. (ed.), *Primates in fragments: ecology and conservation*; Kluwer Academic/Plenum Publishers, New York. 2003; pp. 251-265.
95. Souza LL, Ferrari SF, Marcondes LC, Kern DC. Geophagy as a correlate of folivory in red-handed howler monkeys (*Alouatta belzebul*) from eastern Brazilian amazonia. *J. Chem. Ecol.* 2002a; 28, 8.
96. Strier KB. Activity budgets of woolly spidermonkeys, or muriquis (*Brachyteles arachnoides*). *Am. J. Primatol.* 1987; 13:385-395.
97. Strier KB. Diet in one group of woolly spider monkeys, or muriquis (*Brachyteles arachnoides*). *Am. J. Primatol.* 1991; 23:113-126.
98. Strier KB. Atelinae adaptations: behavioral strategies and ecological constraints. *Am. J. Phys. Anthropol.* 1992; 88:515-524.
99. Strier KB. Food, Foraging and Females. In: Strier KB, editor. *Primate Behavioral Ecology*, New Jersey Pearson. 2011; pp. 145-167.

100. Takahashi A, Fina BG. Síndromes de dispersão de sementes de uma área do Morro do Paxixi. In: Livro de Resumos do IV Simpósio sobre Recursos Naturais e Socio-Econômicos do Pantanal, Corumba, MS. 2004.
101. Talebi M, Bastos A, Lee PC. Diet of southern muriquis in continuous Brazilian Atlantic forest. *Int. J. Primatol.* 2005; 26:1175–1187.
102. Terborgh J. *Five New World Primates: A Study in Comparative Ecology.* Princeton University Press, Princeton. 1983.
103. Tutin CEG, Ham RM, White LJT, Harrison MJS. The primate community of the Lopé Reserve, Gabon: diets, responses to fruit scarcity, and effects on biomass. *Am. J. Primatol.* 1997; 42:1–24.
104. Valle YG, Muñoz D, Magaña-Alejandro M, Estrada A, Franco B. Uso de plantas como alimento por monos aulladores, *Alouatta palliata*, en el Parque Yumka, Tabasco, Mexico. *Neotrop. Primates*, Washington. 2001; 9(3):112-118.
105. Williams-Guillén K. The behavioral Ecology of mantled howling Monkeys (*Alouatta palliata*) living in a Nicaraguan shade Coffee Plantation. PhD thesis, New York University, New York. 2003.
106. Zunino GE. Algunos aspectos de la ecología y etología del mono aullador negro (*Alouatta caraya*) en habitat fragmentado. Tese de Doutorado. Universidad de Buenos Aires, Buenos Aires, BA, Argentina. 1986.
107. Zunino GE. Nutricion em primates folivoros: la dieta de *Alouatta caraya* en vida silvestre. *Bol. Primatol.* 1987; 5:78-87.