

HOW VISITATION AFFECTS THE BEHAVIOR AND WELFARE OF DIFFERENT SPECIES OF CAPTIVE AMAZONIAN PRIMATES?

Liliane Monteiro Leal¹
 Luciane Lopes de Souza²
 Lorena Sarmento dos Santos³

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ABSTRACT: This study had the purpose of understanding the effects of visitation on behavioral patterns and on the well-being of primates in captivity. Five Amazonian primate species were observed using the focal animal method: *Ateles chamek*, *Ateles belzebuth*, *Ateles paniscus*, *Lagothrix cana*, and *Sapajus apella*. Two categories of visitor behavioral observations were adopted - active and passive. From the total number of records, the behavior of primates could be observed in 53.7% of the notes in the presence of visitors. The behavior of the visitors in front of the cages was considered passive in 91.2% of those records. The three species of *Ateles* reacted in different ways in the presence and absence of visitors. The type of visitor behavior had influence on the behavior of the primate (Chi-square=22.9, $p<0.001$). Stress indicating behaviors (CIE) represented 3.3% of the behavioral repertoire of the species (n=253 records). The primates presented a varied number of CIE, which included indexes of reduced well-being levels. *A. belzebuth* was ranked first as the species most affected by visitation. These results show the importance of understanding the stress effects on the behavioral pattern of captive primates in relation to visitation and other factors, leading to alternative actions for the zoo in order to improve the level of their welfare.

KEYWORDS: Amazon. *Ateles*. Captivity. *Lagothrix*. *Sapajus*.

COMO A VISITAÇÃO AFETA O COMPORTAMENTO E O BEM-ESTAR DE DIFERENTES ESPÉCIES DE PRIMATAS CATIVOS DA AMAZÔNIA?

RESUMO: O entendimento dos efeitos da visitação nos padrões comportamentais e no bem-estar dos primatas em cativeiro foi o objetivo deste estudo. Por meio do método animal focal foram realizadas observações de cinco espécies de primatas amazônicos: *Ateles chamek*, *Ateles belzebuth*, *Ateles paniscus*, *Lagothrix cana* e *Sapajus apella*. Para observações comportamentais dos visitantes, foram adotadas duas categorias, ativo e passivo. Do total de registros, encontrou-se que os comportamentos dos primatas foram exibidos em 53,7% das anotações na presença de visitantes. O comportamento dos visitantes diante dos recintos foi em 91,2% considerado passivo. As três espécies de *Ateles* reagiram de formas diferentes na presença e ausência de visitantes. O tipo de comportamento dos visitantes teve influência no comportamento dos primatas (Chi-quadrado=22,9, $p<0,001$). Os comportamentos indicadores de estresse (CIE) representaram 3,3% do repertório comportamental das espécies (n=253 registros). Os primatas apresentaram um número variado de CIE, apresentando indicadores de reduzido grau de bem-estar. *A. belzebuth* esteve em primeiro lugar no ranking das espécies mais afetadas pela visitação. Estes resultados mostraram a importância de compreender os efeitos do estresse no padrão comportamental dos primatas cativos relacionados a visitação e outros fatores, levando ao zoológico alternativas que conduzam a ações para melhorar o grau de bem-estar.

PALAVRAS-CHAVE: Amazônia. *Ateles*. Cativeiro. *Lagothrix*. *Sapajus*.

¿CÓMO VISITAS AFECTAN EL COMPORTAMIENTO Y BIENESTAR DE DIFERENTES ESPECIES DE PRIMATES EN CAUTIVERIO EN AMAZONIA?

RESUMEN: Comprender los efectos de visitas en los estándares comportamentales y en el bienestar de los primates en cautiverio fue el objetivo de este estudio. Mediante el método de animales focales se realizaron observaciones en cinco especies de primates amazónicos: *Ateles chamek*, *Ateles belzebuth*, *Ateles paniscus*, *Lagothrix cana* y *Sapajus apella*. Para observaciones comportamentales de los visitantes, se adoptaron dos categorías, activa y pasiva. Del total de registros, se encontró que los comportamientos de los primates se mostraron en 53,7% de las notas en presencia de visitantes. El comportamiento de los visitantes frente a los recintos fue considerado pasivo en un 91,2%. Las tres especies de *Ateles* reaccionaron de manera diferente a la presencia y ausencia de visitantes. El tipo de comportamiento de los visitantes influyó en el comportamiento de los primates (Chi-cuadrado=22,9, $p<0,001$). Los comportamientos indicadores de estrés (CIE) representaron el 3,3% del repertorio

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¹ Graduada do Curso de Licenciatura em Ciências Biológicas, da Universidade do Estado do Amazonas, Manaus, Amazonas, Brasil. E-mail: liml.bio@uea.edu.br.

² Professora e orientadora do Curso de Licenciatura em Ciências Biológicas, da Universidade do Estado do Amazonas, Manaus, Amazonas, Brasil. E-mail: llopes@uea.edu.br

³ Acadêmica do Curso de Licenciatura em Ciências Biológicas, da Universidade do Estado do Amazonas, Manaus, Amazonas, Brasil. E-mail: lss.bio18@uea.edu.br

conductual de la especie (n=253 registros). Los primates presentaron un número variado de CIE, mostrando indicadores de un reducido grado de bienestar. *A. belzebuth* ocupó el primer lugar en el ranking de las especies más afectadas por las visitas. Estos resultados mostraron la importancia de comprender los efectos del estrés en el estándar comportamental de los primates en cautivos relacionados con las visitas y otros factores, llevando al zoológico alternativas que conduzcan a acciones para mejorar el grado de bienestar.

PALABRAS CLAVE: Amazonia. *Ateles*. Cautiverio. *Lagothrix*. *Sapajus*.

Introduction

Zoos play a fundamental role in ensuring the welfare of captive animals. In addition to being a space for leisure, they are also a space for conservation actions. Broom and Molento (2004) emphasize that even if the dimensions and feeding in the enclosures are ideal for each species, the dynamic nature of the environment, the lack of mental and physical challenges, and intense flow of visitation can influence the decrease in welfare. The demand to provide conditions for animals to exhibit natural behaviors and optimize animal welfare conditions are within the priorities and moral obligations of zoos (LEIRA *et al.*, 2017). The presence, intensity and oscillation of daily visitation flows in zoos are aspects that may be linked to the welfare of captive animals.

Over time, several parameters were considered for evaluating animal welfare (BROOM; MOLENTO, 2004). However, measuring such interconnected aspects in their influence can be a very complex activity. Several factors can affect the natural behavior of animals; one of them is the difference in housing conditions (WECHSLER, 1995). Captive animals are submitted to different conditions when compared to animals living in the wild. Temperature, humidity, social and ecological interaction, diet, space limitation, reduced dynamism, and imposition of human contact are some of the conditions that can pose a stressful effect and provoke different behaviors in individuals, causing important biological costs in clinical, behavioral, and physiological aspects in animals (PIZZUTTO *et al.*, 2013). Therefore, the study of animal behavior plays an essential role in the perception of abnormal, pathological, neurological, and stereotyped behaviors that indicate impaired welfare (ALCOCK, 2011).

Brazil is considered the country with the highest number of known primates; however, approximately 39% of species are threatened with extinction (Auricchio, 2017). A brief survey involving captive primates in Brazilian zoos identified three approaches that may be interconnected: impact of visitation, environmental enrichment, and welfare. Rodrigues *et al.* (2010), Neto *et al.* (2011) and Lessa (2014) state that it is possible to observe the welfare of animals through behavioral study and that the display of stereotyped behaviors are good indicators of stress in captivity. For some authors such as Noga (2010) and Guimarães (2012), the effect of visitation may vary among primate species, since it may have a negative impact for one species, while for another, it can prove to be enriching. In addition, the differences are often shown within the species itself, among individuals (RODRIGUES; AZEVEDO, 2016; POLGAR *et al.* 2017).

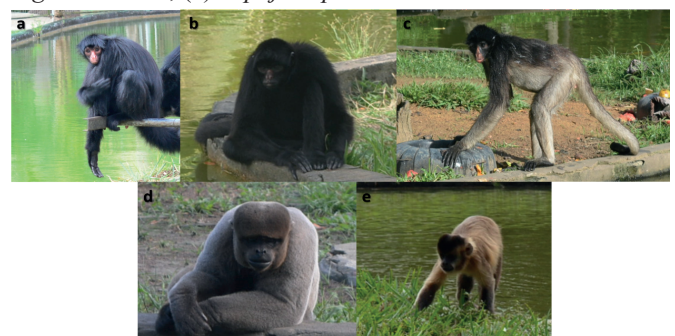
Therefore, the records of species in captivity are very important since they allow better understanding of the behavioral ecology of primates, once making these observations in the wild is much more complex (Guimarães,

2012). Therefore, this study investigates the effects of visitation on the behavior of five species of captive primates, as well as their level of well-being at the Jungle Warfare Training Center in Manaus, Amazonas.

Material and Methods

The zoo at the Jungle Warfare Training Center (CIGS) (3°06'01.9"S 60°02'36.7"W) is located in the urban center of Manaus, in the state of Amazonas. It is open to the public from 9:00 am to 5:00 pm from Tuesday to Sunday. It has 56 different mammal, bird, and reptile individuals (CIGS, 2017). The five species of primates existing in the zoo living in mini-islands created for the welfare of the primates (Fig. 1) were the objects of this study. The primate groups were allocated in a complex of four islands of different sizes, according to the social groups, being one island with the area of 230 m² (*Ateles chamek*, the Peruvian spider monkey, and *Ateles paniscus*, the Guiana spider monkey), with four females and one infant male; one island measuring 107 m² housing the *Ateles belzebuth*, also known as the white-bellied spider monkey, with two adult females, two infant females, and one adult male; a 100-m² island, where the tufted capuchin monkey (*Sapajus apella*) lived with three adult males; and a 125-m² island where the gray woolly monkey (*Lagothrix cana*) lived, with two adult males and one female.

Figure 1: Representatives of the species under study: a) *Ateles paniscus*; b) *Ateles chamek*; c) *Ateles belzebuth*; d) *Lagothrix cana*; e) *Sapajus apella*.



Source: Personal archive (2019)

Through September 2017 to January 2019, systematic observations were made, both during the morning and the afternoon, for one hour per week of each primate species on the islands. Initially, the *ad-libitum* method was used, which consisted in the free recording of the behavior presented by the species with richness of detail, in order to obtain and describe the entire behavioral repertoire of the species (FORTES; BICCA-MARQUES, 2005). The described behaviors were classified into the following categories: locomotion (LOC),

foraging (FOR), feeding (ALI), remaining still (PA), social (SOC), CIE (stress indicator behaviors), which guided the protocol for recording the focal animal methodology, employed at a later stage, which consisted of observations in a pre-defined sample period of 10 minutes of continuous observation of one individual of the group, a five-minute interval, followed by the next sample with another individual, until all individuals were observed in several observation cycles.

The behavioral repertoire of each species under study was related to the presence or absence of visitors, and to the visitor's behavior in front of the primate enclosure, and presented through percentage calculations, and the Chi-square test was used to analyze whether there were significant differences among samples with and without visitors and among visitor categories, in order to assess the effects of visitation on primate behavior. These behaviors were classified into two different categories: active and passive. The behaviors classified as active involved actions such as shouting and making gestures, loud conversations in large groups, and throwing objects into the enclosures. Passive behaviors were represented by direct observation without emitting loud sounds and passing through the enclosure without direct observation. In order to quantify the behavior of visitors, the researchers recorded 1 (presence) and 0 (absence) during the observations of each primate species, also recording the category of the visitor. Therefore, in total, values were obtained for records without visitors, with active visitors, and with passive visitors.

In order to estimate the level of primate welfare, the measures of high and low degree of welfare as proposed by Broom and Johnson (2000) were used. The frequency of behaviors, the duration, and the percentage of social behaviors were also taken into consideration for the evaluation of the stress faced by the species. Based on the evaluation methods proposed by Broom and Johnson (2000), some questions about primates at CIGS can be answered. In addition to a variety of normal behaviors, behavioral indicators of pleasure, adaptation attempts, and behavioral diseases were recorded. A scoring scheme was developed in order to understand how the effect of stress acted on each species, and the resulting ranking could indicate which species were most influenced from the stress perceived through changes in their behavior pattern.

In order to develop such ranking, the varieties of stress indicator behaviors (CIE) displayed by each species, the frequency of these behaviors, and their average duration, and as a counterpoint indicator of adequate welfare, the frequency of social behaviors (SOC) and their average duration, were considered. The scoring system was designed in order to try to provide indicators that could show how the species are affected by stress in the absence and presence of visitors. The values for each category were collected in a table, where the highest CIE values and lowest social behavior values were taken into consideration. The highest CIE value received five points, the second highest three points, and the third highest, one point. In SOC, the reverse scoring was applied, that is, the lowest value received a score of five points, the second lowest, three points, and the third lowest, one point. This difference in order is due to the fact that the existence of social behaviors indicates adequate well-being, and if there is a decrease in them, it may

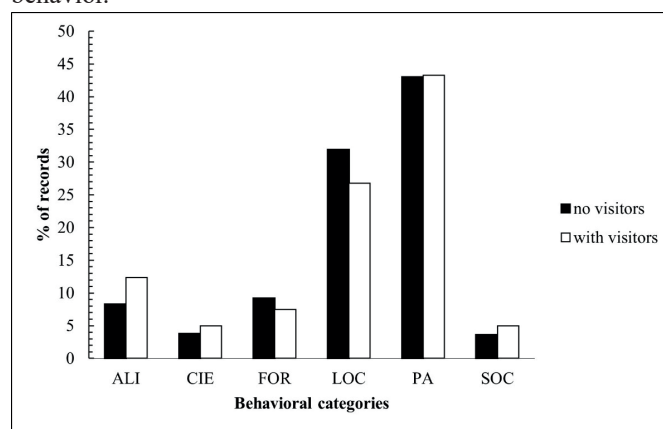
be closely related to stress. At the end, the points were added for each species, and the species that scored the highest was ranked first, followed by the others, according to their rank.

Results

During the study, it could be noted that 53.7% of the focal record primates exhibited different behaviors in the presence of visitors near the enclosure. A total of 91.2% of the visitors presented a passive behavior. Statistical significance was observed for all species, showing that the presence of visitors had significant influence on the behavior of primates. Additionally, the type of visitor behavior also had an influence on the behavior of the primates (Chi-square=22.9, $g=2$, $p<0.001$), that is, visitors with active behavior interfered more in altering the primates' behavior, which were altered by apparently reacting to the visitors' activity, regardless of the species.

A total of 1,444 behavioral records were obtained in 52.5 hours of observation for *Ateles chamek*. The feeding, CIE, and social behaviors of *A. chamek* species were more evident in front of visitors, while the passive behavior remained the same for both categories. This differed from locomotion, which was more present in the absence of visitors, as seen in Fig. 2.

Figure 2: Comparison of behavioral patterns of *Ateles chamek* (n=1,444). ALI= food; CIE= stress indicator behaviors; FOR= foraging; LOC= locomotion; PA=remaining still; SOC= social behavior.

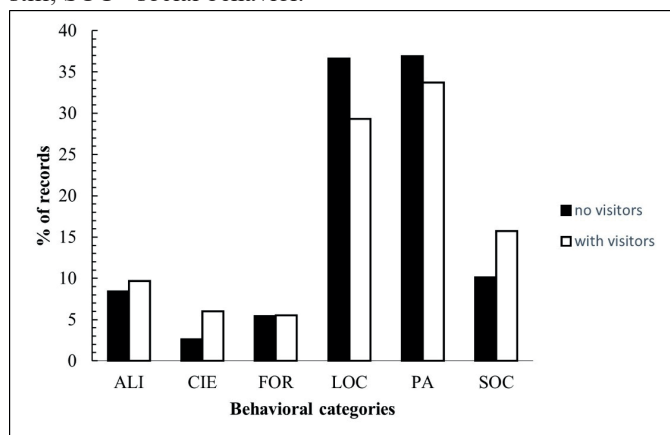


The locomotion and feeding behaviors were more frequently shown in front of active visitors, 30.4% and 24.3%, respectively. It could be observed that the group fed more than two-fold (10.6%) when compared to observations with passive visitors (Figure 3). The other behaviors were more frequently observed in front of passive visitors, with emphasis on remaining still (45.2%), and more social behaviors (5.3%).

A total of 2,061 behavioral records were made in 58 hours of observation for *Ateles belzebuth*. Among all behavioral categories, this species presented a higher frequency of locomotion and remaining still behaviors, both in high percentage in the absence of visitors (Fig. 3). The other behaviors were more present in front of visitors, especially social behaviors, since it is the largest group and has infant individuals. In comparison with the other groups, it has a

higher frequency of social behaviors.

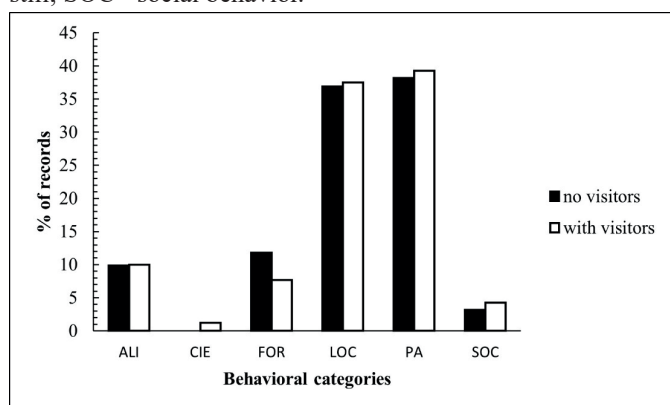
Figure 3: Pattern of behaviors presented by *Ateles belzebuth* related to visitation (n=2061). ALI= food; CIE= stress indicator behaviors; FOR=foraging; LOC= locomotion; PA=remaining still; SOC= social behavior.



In view of the visitors' behavior, it was possible to observe that the group of *A. belzebuth* presented higher percentage behaviors, such as remaining still (34.2%) and social (16.9%) in front of passive visitors. With active visitors, the opposite was observed, with behaviors such as locomotion (33.7%) and CIE (9.6%) being more present.

A total of 1,932 behavioral records were obtained for *A. paniscus* in 49.5 hours of observation. This species was the one with the lowest CIE (in diversity and frequency), but when observed, they were related to the presence of visitors (Figure 4). Foraging behaviors were mostly exhibited when there were no visitors near the enclosure, while the other behaviors occurred in the presence of visitors.

Figure 4: Pattern of behaviors presented by *Ateles paniscus* related to visitation (n=1932). ALI= food; CIE= stress indicator behaviors; FOR=foraging; LOC= locomotion; PA=remaining still; SOC= social behavior.

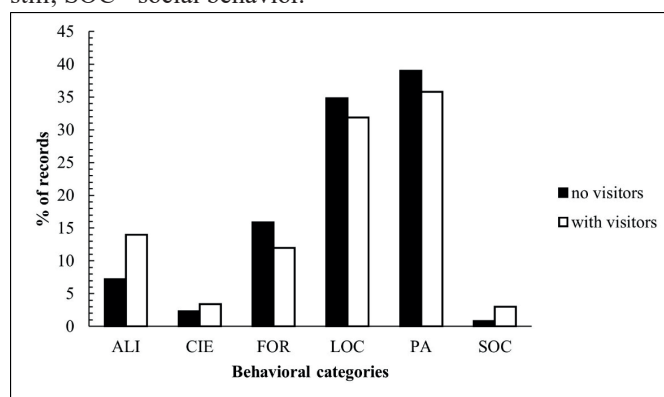


It was possible to observe that the group fed (13.4%) and foraged (10.4%) more in the presence of active visitors, which shows that although there was a direct interaction of the visitors, the group performed their normal activities, without prejudice. With passive visitors, the group moved (39.1%) and socialized (6.2%) more frequently, noticing that the

more passive behavior of visitors was favored more than the active behavior in the sense of exploring the environment and socializing. It is important to point out that the stress indicator behaviors in this species were only of one type, and that they were directed to the distant human being (to researcher), since he remained neutral, but could be visibly noticed.

In *L. cana*, 2,100 behavioral records were made in 48 hours of observation. It was observed that the most frequent activities of the group were also performed in greater percentage in the absence of visitors. However, they fed twice as much, socialized more, and presented more CIE with the presence of visitation, as shown in Figure 5.

Figure 5: Pattern behaviors presented by *Lagothrix cana* related to visitation (n=2100). ALI= food; CIE= stress indicator behaviors; FOR=foraging; LOC= locomotion; PA=remaining still; SOC= social behavior.



Locomotion (34.2%) and remaining still (43.1%) behaviors were most frequently exhibited in front of active visitors, which may indicate that direct interaction, in a certain way, may cause some agitation in some individuals, at the same time it may be causing apathy in others, leading to individuals taking shelter in their home. Different patterns were observed for feeding (15.1%), social (4%) and CIE (4%) behaviors, which were more developed in the presence of passive visitors. This may be an indicator that individuals feel more at ease and that CIEs are not only related to the behavior of visitors.

During the 47.7 hours of observation of *Sapajus apella*, 2,697 behavioral records were made. The most frequent behaviors observed in this species were those of locomotion, followed by remaining still, both reproduced more in the absence of visitors. However, the other behaviors were more present during the presence of visitors in front of the enclosure (Figure 6). It was possible to observe that the group doubled the foraging frequency in the presence of visitors, which may indicate that, despite the presence of people may be considered stressful, it does not affect the development of the natural behavior of the species, since the group also increased the social and feeding behaviors in these conditions. An interesting episode in the feeding behavior of this species in captivity was the act of fishing, which was recorded more than ten times in this study. The individuals would put fruit in the water, wait for some time, trying to attract the fish in order to catch them. On one of the occasions, "fishing" was successfully performed by an adult male in the presence of passive visitors (Figure 7).

Figure 6: Pattern of behaviors presented by *Sapajus apella* related to visitation (n=2,697). ALI= food; CIE= stress indicator behaviors; FOR=foraging; LOC= locomotion; PA=remaining still; SOC= social behavior.

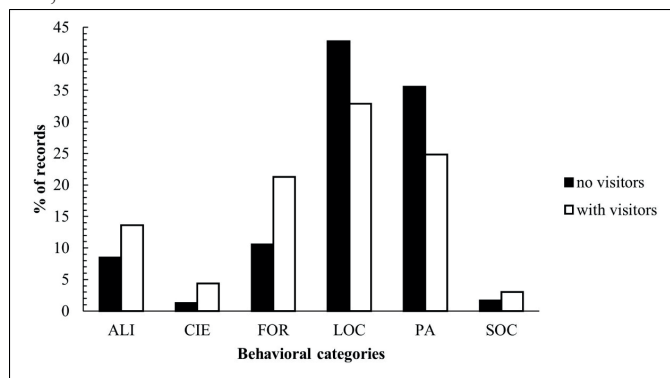
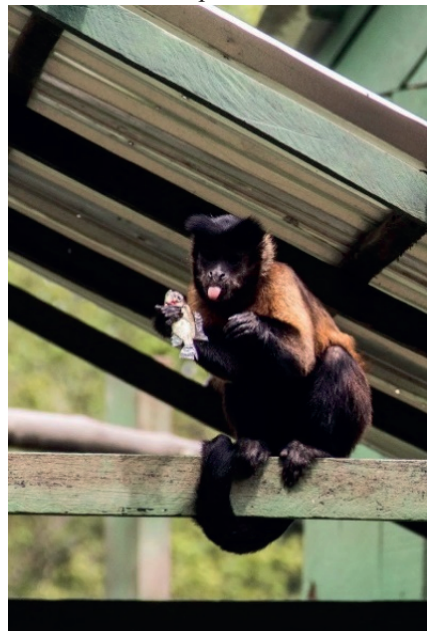


Figure 7: An adult *Sapajus apella* feeding on fish after fishing behavior in the captive environment.



Source: Personal archive (2019)

In front of passive visitors, the group of *S. apella* began to present more feeding (14.1%) and foraging (22.1%) behaviors. With active visitors, there was a slight increase in the frequency of locomotion (39.8%) and CIE (5.2%) behaviors. It could be observed that the direct interaction of visitors had a negative effect on the behavioral pattern of this species.

Stress indicator behaviors represented 3.3% of the species' behavioral repertoire (n=253 records). The species presented a varied number of stress indicator behaviors, *A. paniscus*, *A. chamek*, and *A. belzebuth* exhibited from one to three changes in behaviors. *L. cana* was the species with the highest number of changes, with four altered behaviors, while *S. apella* presented three different types (Table 1).

Table 1: Stress Indicator Behaviors (CIE) observed in each species in the zoo

Stress Indicator Behaviors	<i>Ateles belzebuth</i>	<i>Ateles chamek</i>	<i>Ateles paniscus</i>	<i>Lagothrix cana</i>	<i>Sapajus apella</i>	Total
Repeatedly opening and closing mouth	0.4%	5%	-	4.5%	-	9.9%
Agonistic	1.6%	-	-	12.4%	1.6%	15.6%
Self-link	-	-	-	5.3%	-	5.3%
Rope swinging	-	49.4%	-	-	-	49.4%
Agonistic intragroup	-	-	-	-	0.4%	0.4%
Friction movement	-	-	3.3%	-	-	3.3%
Pacing	2.5%	-	-	1.2%	12.4%	16.1%
Total	4.5%	54.4%	3.3%	23.4%	14.4%	

When related to the measures presented by Broom and Johnson (2004), the parameters described by Paranhos da Costa and Cromberg (1998) and Ferreira *et al.* (2016), this study identified at least three of the indicators of low welfare, such as behavioral and stereotype diseases (FERREIRA *et al.*, 2016), abnormal reactivity, and normal suppression behavior degree (PARANHOS DA COSTA; CROMBERG, 1998), where primates reduce all their activities in the presence of visitors, in addition to the reduced life expectancy for some species (Table 2). In relation to the indicators of high degree of well-being, three parameters were identified: normal behaviors presented by all species, predilection behaviors, and good growth and reproduction rate for one of the species (*Ateles belzebuth*), with a growing infant and a birth observed throughout the study.

Table 2: Evaluation of the primate welfare in the studied zoo

Species	Reduced welfare measures	High welfare measures
<i>A. chamek</i>	Abnormal reactivity Stereotyping	Normal behaviors Behavior of predilection
<i>L. cana</i>	Excessive aggressiveness Abnormal reactivity	Normal behaviors
<i>S. apella</i>	Excessive aggressiveness Stereotypes	Normal behaviors
<i>A. paniscus</i>	Abnormal reactivity	Normal behaviors Behavior of predilection
<i>A. belzebuth</i>	Excessive aggressiveness Stereotypes Self-protection	Normal behaviors Normal growth and reproduction Behavior of predilection

Through these measures, it was possible to identify a reduced degree of welfare for *L. cana* and *S. apella*, and it can be concluded that these species may be facing stress in a more harmful way. On the other hand, the *Ateles* species, despite showing a higher number of behaviors that indicate reduced welfare, also exhibited behaviors that indicate an adequate welfare, which can offset the negative impacts. Despite the stress faced by the *Ateles* species, such behaviors may indicate an attempt to actively confront them.

Tables 3 and 4 show the variation of stress through the ranking in the presence and absence of visitors. It was observed

that not only the presence of visitors caused stress in primates, but that other factors may also be involved. According to the table without visitors, *L. cana* is the species occupying the first place in the ranking, with a total of 20 points. This species presents lower values of social behavior and longer duration of CIE (Table 3). However, the main difference from one table to the other is the decrease in points for visitation, from 20 to 13 for the group of gray woolly monkeys. This may indicate that even if the visitation has an effect on stress in the species, this effect is much smaller than other existing factors (Table 4).

Table 3: Indicators of the effect of stress on primate species without visitation

Ranking	Species	Number of individuals	CIE (%)	Average duration (s)	SOC (%)	Average duration (s)	Score
1	<i>L. cana</i>	4	2.33	67	0.82	69.67	20
2	<i>A. chamek</i>	2	3.79	55.95	3.61	137.14	8
2	<i>A. belzebuth</i>	6	2.59	40.1	10.10	75.79	8
3	<i>S. apella</i>	3	1.27	55.55	1.73	73.20	6
4	<i>A. paniscus</i>	1	0	0	3.11	70.28	4

Table 4: Indicators of the effect of stress on primate species with visitation

Ranking	Species	Number of individuals	CIE (%)	Average duration (s)	SOC (%)	Average duration (s)	Score
1	<i>A. belzebuth</i>	6	5.98	54.30	15.73	68.53	14
2	<i>L. cana</i>	4	3.36	48.63	2.99	46.54	13
3	<i>A. chamek</i>	2	4.98	89.86	4.98	124.72	8
4	<i>A. paniscus</i>	1	1.20	61.33	4.30	70.56	5
4	<i>S. apella</i>	3	4.32	33.92	3.01	99.76	5

As for the second place, this position varied in relation to visitation. With visitation, *A. belzebuth* was ranked first, while *A. chamek* came in third. For *A. belzebuth* the CIE behavior more than doubled in frequency, and its average duration was also longer. This may be linked to the fact of having an alpha male on the island, and the increase may be related to his agonistic behavior directed to visitors. The CIE without visitors is probably related to other factors, as well as to other members of the group. And the increase in social behavior with visitors may be related to the way females cope a little better with stress on busy days. However, it is possible to notice that despite the increased frequency of social activities, there is a decrease in the average duration of these behaviors.

Although *A. chamek* had its pattern changed to an increase in CIE and social behaviors, both in frequency and duration, this increase was not greater than the values for *L. cana*, but were higher than for the other species, scoring 8 points on both tables. This shows that visitation causes a stress effect, but to a lesser extent than related to other species. While *S. apella*, which in the previous table occupied the third place and scored six points, in the presence of visitors, the species went to the fourth position. It can be noticed that there was an increase in CIE in the tufted capuchin monkey, but a decrease in their average duration. On the other hand, social behavior and its average duration increased, showing that although visitation causes a negative effect, it also presented an

enriching effect. With *A. paniscus*, the species did not present CIE without visitation, while its social behaviors had a slight increase in the face of visitation, showing that visitation does not cause a negative effect for this species.

Discussion

The study of primates in captivity can elucidate behavioral aspects and provide subsidies for maintenance and management aimed at animal welfare, in addition to the conservation of species, as well as being important spaces for Environmental Education actions (ALMEIDA; BONORINO, 2018; HOSEY, 2005). The behavioral repertoire of captive primates related to visitation showed changes in all species at the zoo. According to Hosey (2005), these behavior changes in relation to visitation differ depending on the species. In this study, the *A. chamek* and *A. belzebuth* species fed and presented more social and CIE behaviors in the presence of an audience; the same was found for *L. cana*. For *S. apella*, in addition to the previous categories, foraging was also more present in the presence of visitors, which may indicate that this primate is already adapted to the presence of visitors, thus exhibiting more natural behaviors. Farias (2010) observed a low percentage of stress indicator behaviors in the *S. apella* species and related it to other factors besides visitation, since they were also developed in the absence of visitors. Lessa

(2009) found typical stress behaviors in *Cebus apella*; and Montanari *et al.* (2017) in *Sapajus nigritus*, which can be eased by environmental enrichment at the zoo. According to Saad *et al.* (2011), the animals' feelings towards encouragements are closely related to the behaviors they develop in response to circumstances.

For *A. paniscus*, a different pattern was observed, with all categories, except foraging, being performed in front of the audience, a strong indicator that for this species, visitation does not have a negative effect, since there is a greater variety of places to remain in refuge and locomotion. However, in the absence of visitors, the species further explores more the environment in search for food. A similar result was observed in Noga (2010), in which individuals from *Ateles* sp. presented significant differences in their behavioral pattern caused by the effect of visitation, observed by the higher frequency in the repertoire of general activities before the visitors, but lower percentage of hygiene and marking behaviors, which can be understood as something positive, and thus reducing the possibility of the development of neuroses linked to high frequency of certain self-directed behaviors.

In this study, the behavior of the species was directly related to the behavior of visitors. Visitors always seek greater interaction and possible closeness to primates, which in some way ends up taking place in an active way (HOSEY, 2008), unlike the results of this study, with the majority of interactions observed being passive. Farias (2010) also observed a more passive audience and related the low percentage of stereotypes to this factor. However, at the CIGS zoo, the percentage of visitor active behaviors was sufficient to cause an impact on the behavioral repertoire, which can promote a negative and very harmful behavioral response, such as intra- and inter-specific aggressions, self-mutilation, stereotyping, and reduction of social behaviors, which were also mentioned by Hosey (2008). However, the presence of visitors caused different responses in each species (FERNANDEZ *et al.*, 2009).

For *A. chamek* and *L. cana*, it was possible to notice that even with the passive behavior of the visitors, the species presented CIE, which may indicate that there are other factors besides the interaction with the visitors that may be causing stress in these species. In *A. belzebuth* and *S. apella*, the active behavior of visitors caused more CIE and higher frequency of locomotion, which may indicate that the species is under greater stress in face of this type of interaction, which was also observed by Hosey (2005). Similarly, Woods *et al.* (2019) observed that the number of visitors was not the greatest influence of agonistic behaviors directed to the audience, but the most intense/active behavior of visitors, as if primates saw them as a threat. In this study, through direct behaviors (agonistic display scans), *A. belzebuth* showed that the presence and behavior of the visitors caused discomfort and increased the number of CIE, which was very similar to the findings by Woods *et al.* (2019). According to Davey (2007) and Hosey (2008), larger primates tend to respond more offensively to the audience, since they may not associate them as potential predators, but as a threat to their territory.

Broom (2011) states that once there is some kind of stress, the well-being will be compromised, even if temporarily.

In this work, all species presented some type of CIE, and identifying the factors that may be causing this stress is pivotal for any zoo. According to Sanders and Feijó (2007), activities in zoos have been considering the animals' welfare as a priority, aiming at improving the quality of life. Therefore, behavioral monitoring is necessary to identify and work on mitigating the impacts. Any action taken at a zoo to make this happen requires investment, so there is a need to develop actions to identify priorities. The ranking presented herein was created in order to identify the species that were most affected by stress due to visitation. And through it, it was possible to identify that *A. belzebuth* is the species most affected by visitation, while *L. cana* is one of the most affected by stress, but due to other factors. Therefore, it can be concluded that depending on the species and its captivity conditions, there are different ways to ease their stress.

Sherwen and Hemswoth (2019) conducted a literature review on the impacts of visitation on the welfare of captive primates in zoos and reported that there are negative, neutral, and positive impacts depending on the perception of the animal. They also concluded that animal welfare depends on a number of factors, which include intrinsic animal characteristics (previous experiences, genetics, and temperament) and environmental characteristics (social grouping, enclosure structure, and sensory environment). Their findings also revealed that there is a range of responses in the interaction of visitors with zoo primates, which seems to be related to the species studied, the nature and intensity of visitor interaction, the enclosure structure, and the individual characteristics of the animals. These results may shed light on the findings in this study since different responses were also found depending on the species and type of interaction with visitors at the CIGS zoo.

According to findings by Domingues (2018) and validated by this study, educating visitors through the use of signs is a practical way to try to ease the abusive behavior of the audience at zoos, although the presence of staff can more efficiently inhibit inappropriate attitudes from visitors. Another important proposal would be to provide information on the stressful effects of particular auditory and visual incentives on each species, which can be useful to guide the visitors on how to better behave in front of enclosures, seeking everyone's cooperation for better animal welfare.

Conclusions

This study observed the effect of visitation on the behavioral pattern and welfare of primates in captivity. It was observed that the presence of visitors in front of the enclosure changed the behavior pattern of the species, and that the active behavior of the audience was directly related to the stress indicator behaviors and the reduction in the duration of social behaviors developed by some species. Even with the passive behavior of visitors, primates presented CIE, which may lead to the conclusion that the mere presence of visitors, in a certain point, is already a stressful factor, and that besides the visitation, other factors may be also at play. This effect varied among species, and for *Ateles paniscus* there was no negative effect.

The ranking created by this study revealed and highlighted how stress affected the species, identifying the most affected primates. This study showed the importance of understanding the effect of visitation at the zoo in order to develop targeted actions to improve the quality of life of primates in captivity.

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