INTRODUCTION

Alouatta guariba clamitans Cabrera, 1940 is an endemic primate species of the Atlantic Forest (Kinsey 1982, Horwich 1998, Mendes et al. 2008), occurring in the region of Misiones, Argentina (Di Bitetti et al. 1994), and in Brazil, from the extreme south, in the region of Canto Galo, state of Rio Grande do Sul (Printes et al. 2001) to the mouth of the Jequitinhonha river, southern Bahia state (Rylands et al. 1996). Individuals may be sexually defined by dichromatism in their pelage as the adult male has a reddish color due to the secretion of exocrine glands (Hirano et al. 2003) and the adult females have a darker pelage with the dorsal coat and the pelage of the members varying from brown blackish to reddish brown (Gregorin 2006).

In the Rio de Janeiro state, A. g. clamitans occurs throughout the coast (Gregorin 2006) and although it has been found in fragmented areas (Chaves and Bicca-Marques 2013) it has been considered threatened and classified as Vulnerable (Bergallo et al. 2000, Bicca-Marques et al. 2015, ICMBio 2018), pointing to a higher conservationist attention for the taxon (Bergallo et al. 2000). Poaching and habitat destruction are the main factors that negatively affect the populations of A. g. clamitans.

ABSTRACT. Alouatta guariba clamitans Cabrera, 1940 is an endemic species of the Atlantic Forest that occurs from south Bahia, Brazil, extending south to the province of Misiones, Argentina. In Rio de Janeiro state, the species was classified as threatened, indicating that attention is needed for the conservation of this taxon. Additionally, an outbreak of yellow fever spread throughout the southeastern states of Brazil from January 2017 until March 2018 seriously threatening Rio de Janeiro populations of the species. Herein, we aimed to provide the first estimates of A. g. clamitans encounter rate, density, and population size in the Ilha Grande State Park (PEIG), which is part of the Atlantic Forest biome of Brazil. Data were collected in two different periods, the first between December 2003 and May 2005, and the second from August 2009 to May 2010, and information on encounter rates and behavior was collected to better understand aspects of species’ ecology. The estimated encounter rate in the first period through the distance sampling method was 0.04 ± 0.01 individuals per kilometer. Nine groups were recorded in the second period of the study, with 47 individuals along 3 km. Our estimates of encounter rate, density and population size were low and reinforces the need to initiate species monitoring and assess the impact that yellow fever outbreaks may have on PEIG populations. The results presented here can be a starting point to support future strategic actions for the species, to measure impacts and to the management of the species, and for a conservation program.

KEY WORDS. Distance sampling, linear transect, primates, scan-sampling, Southern brown howler monkey.
However, the contemporary outbreaks of yellow fever is another factor threatening the populations of *A. g. clamitans* and other South American primates that reinforcing the need for studies on their ecology and behavior (Bicca-Marques 2009). In January 2017, an outbreak of yellow fever began to spread through the southeastern states of Brazil (Fernandes et al. 2017). Yellow fever is a disease caused by a virus of the family Flaviviridae, carried by mosquito vectors *Haemagogus* Linnaeus, 1758 and *Sabethes* Sabethes Robineau-Desvoidy, 1827 (sylvatic cycle) and *Aedes aegypti* Linnaeus, 1762 (urban cycle) (Barrett and Monath 2003). Humans and non-human primate species show different levels of susceptibility to the disease (Kumm and Laemmert 1950, Hervé and Travassos da Rosa 1983, Thoisy et al. 2004). For non-human primates in the Atlantic Forest, yellow fever was diagnosed in 150 of 1000 primate individuals tested (15% occurrence) from January to July 2017 (Fernandes et al. 2017).

Among South American primates, the genus *Alouatta* Lacépède, 1799 (howler monkeys) appears to be the most susceptible (Araújo et al. 2011). For this reason, howler monkeys are considered sentinel species for the early detection of yellow fever epidemics (Araújo et al. 2011).

Information for *A. g. clamitans* on the island named Ilha Grande is restricted to its occurrence and there are no systematized works on the ecology and behavior of the species (Alho et al. 2002, Pereira et al. 2017). Estimates of population size indicators are critical to any effort to conserve endangered species. These estimates allow the assessment of anthropogenic impacts on natural populations, such as habitat loss, identify priority areas for conservation, assess the viability of isolated populations, determine the conservation status of the species, and serve as a basis for other ecological studies as well as important tool for decision makers (Cunha and Loyola 2011, Buckland et al. 2016, IUCN 2018).

In the Ilha Grande State Park (PEIG in Portuguese, Parque Estadual da Ilha Grande), at least 28 individuals of *A. g. clamitans* were found dead in trails in 2017 (personal communication, T. Barradas – Head of Ilha Grande State Park at the time). This number is probably underestimated, because possibly individuals who died inside the forest, away from tracks, were not accounted for. In this context, we aimed to perform the first estimate of the encounter rate and information about the behavior of the species in PEIG.

**MATERIAL AND METHODS**

We conducted the study in the Ilha Grande State Park (PEIG hereafter), located in the Ilha Grande island, southwestern coast of Rio de Janeiro state, Brazil (Fig. 1). The island is isolated from the mainland for about 2 km, with some mountains reaching 1000 m in altitude (Callado et al. 2009, INEA 2010). PEIG is the second largest insular biological park in Brazil and covers 120 km², over half (62%) of the island, which has 19.3 km² (INEA 2010). The climate is hot humid tropical without a dry season. Ilha Grande is the top of a submerged mountain and has two dominant types of topography, mountain and coastal plain (INEA 2010). Almost half of the area (47%) is covered by dense, relatively pristine Atlantic rainforest. Disturbed forests, in an advanced successional stage, are the second major habitat type (43%). The remaining areas comprise rocky outcrops with herbaceous vegetation (7%), salt marshes, mangroves and beaches (2%), and human settlements representing 1% of the island (Alho et al. 2002, Oliveira 2002, Callado et al. 2009). Human settlements are mainly concentrated around the northern coastline of Ilha Grande Bay and in Abraão village.

**Encounter rate, density and population size**

We collected data between December 2003 and May 2005, using 127 samplings, totaling 397.3 km walked in 382 hours of effort. We performed samplings on five existing trails in Ilha Grande to minimize the impact of opening new trails (Fig. 1, Table 1). These five trails covered all types of vegetation found on the Ilha Grande and crossed several streams. Two of these trails are located in the northern part, linking the island’s largest settlement, Abraão Village, to the beaches of Palmas (length 2.1 km) and Feiticeira (2.3 km) (T01 and T02, respectively). The other three trails are on the south side of the island, connecting Dois Rios Village to the beaches of Caxadaço (2.7 km) and Parmaíoca (6.7 km), and to the place locally known as Jataraca (2.1 km), T03, T04 and T05, respectively. We walked the transects early in the morning (5:30 am) and afternoon (3:30 pm), lasting an average of three hours, and walked on average 25.6 times ranging from 23 to 27 times, with an average speed of 1.1 km/h (± 0.5).

For each observation of *A. g. clamitans*, we recorded the perpendicular distance of the first animal sighted from the transect using a measure tape, the length of the transect walked to that point where the animal was observed, date and time of the observation. Encounter rate, density and population size were estimated using the total number of individuals observed within the PEIG (120.52 km²) using the DISTANCE software version 7 (Buckland et al. 2001). This software uses the perpendicular distances to observed animals to estimate the Effective Strip Width (ESW) in the study area and to model the detection function that best fits the probability of detection of an animal at a given distance (Buckland et al. 2001). The best detection model was selected by the Akaike Information Criterion (AIC, Akaike 1973).

**Group composition and behavior**

We collected data from August 2009 to May 2010. We used the first 3 km of the T04 transect (Fig. 1) to characterize the following aspects: group characterization and composition, activity and main behaviors. In total, the groups were followed up for 37 days, with 141 hours of field effort.

We performed groups identification according to their gender-age composition, based on Mendes’s (1989) adapted classification, as well as on the individual characteristics of the
animals, such as coat color, size and scars. For this, we determined that the time of contact with the animals should not be less than 30 minutes and that all individuals detected in the group were described (Mendes 1989). Groups that did not have all the members described, due to poor visualization or withdrawal of individuals during identification, were not included in the results. The observation sessions started at 7:00 am and were finished at 05:00 pm. For the distinction between morning and afternoon shifts, it was considered “morning” from 7:00 am to 12:00 pm, and “afternoon”, from 12:01 pm to 5:00 pm.

We performed behavioral records with direct observation and using Bushnell™ 10 x 50 mm binoculars. Observations consisted of records for each group found, characterizing an observation session, which consisted of the first visualization of any group or individual, until it was no longer within the reach of the observer, thus characterizing the end of the session. Therefore, we recorded behaviors of distinct groups that used the area close to the trail walked.

Table 1. Characteristics of transects (length and coordinates), number of times each transect was walked (N of samples) and total kilometers walked. The coordinates refer to a central point of the tracks. The study was conducted from December 2003 to May 2005, Ilha Grande, Rio de Janeiro, Brazil.

| Transect | T01 | T02 | T03 | T04 | T05 | Total |
|----------|-----|-----|-----|-----|-----|-------|
| Coordinates | 23°07'37.4", 44°10'47.3"W | 23°08'43.3", 44°08'53.5"W | 23°10'07.9", 44°10'24.9"W | 23°11'26.2", 44°13'43.5"W | 23°09'25.4", 44°14'19.6"W |
| Length (km) | 2.1 | 2.3 | 2.7 | 6.7 | 2.1 | 15.9 |
| N of samples | 27 | 23 | 27 | 24 | 27 | 128 |
| Total effort walked (km) | 56.7 | 52.9 | 72.9 | 160.8 | 56.7 | 401 |
| Observed groups | 0 | 0 | 1 | 6 | 9 | 16 |

Figure 1. Map of the study area, showing the area covered by the Ilha Grande State Park, in Ilha Grande, located in the southwest part of the Rio de Janeiro, Brazil. The black lines indicate the transects.
We used the method of scan-sampling (Altmann 1974), where the whole group is quickly examined at regular intervals, generating individual records, with observations every 15 minutes, with 5 minutes for scanning and 10 minutes for interval (Bravo and Sallenave 2003, Ludwig et al. 2008, Prates and Bicca-Marques 2008) to reduce statistical dependence (Setz 1991). The sampled categories of activity were resting, feeding, movement and social behavior (Table 2). We recorded social behaviors and described through the sampling of “all occurrences”, which characterize opportunistic observations used to develop ethograms and for observations of rare but important behaviors (Lehner 1996). For the quantification of social behaviors, we grouped the categories in vocalization, grooming, agonistic behavior, marking, playing and sexual behavior.

Table 2. Behavior categories of *Alouatta guariba clamitans* sampled using the scan-sampling method in the Ilha Grande State Park, Rio de Janeiro state, Brazil.

| Category             | Description                                                                 |
|----------------------|-----------------------------------------------------------------------------|
| Resting              | Individual inactive, standing, sitting, lying, quadruped or hanging by tail |
| Feeding/Foraging     | The act of selecting and picking up the food, chewing it and swallowing it  |
| Movement             | Displacement in the same tree or between trees                               |
| Social behavior      | Behaviors that involve some type of interaction between animals, such as the categories of grooming, playing, agonistic behaviors, sexual behaviors and vocalization |

We grouped the data from each scan by the number of individual in the group who were performing a certain activity at a given time. Then, we analyzed these records obtained by scan-sampling of each behavioral category for the total period of study. For calculating the percentage of each category i, we consider: \( p_i = \frac{n_i}{N} \times 100 \), where \( p_i \): percentage of category i, \( n_i \): the number of records of category i during the period under analysis, and \( N \): the total number of records of all categories during the same period. Where: i = resting, feeding, movement or social behavior.

We performed Spearman correlations between pairs of activity variables to determine possible relationships between activities (Zar 1996). To compare the categories of social behaviors sampled, we used the chi-square test. We performed the analyses in the statistical environment R (R Development Core Team 2010).

**RESULTS**

**Encounter rate, density and population size**

We obtained 16 observations of groups of *A. g. clamitans* in the 397.3 km covered. The effective strip width (ESW) was 8.42 ± 2.14 m with records obtained from 0 to 18.5 m from the transect line. The data were best fitted to a half normal curve with cosine adjustment and a correction following the Poisson distribution. The estimated density was 1.09 ± 0.39 groups/km\(^2\) (Confidence Interval – CI 0.7–1.48), with an estimated group size of 4.21 ± 1.76 individuals (CI 2.45–5.97) and total estimated density was 4.58 ± 1.58 individuals/km\(^2\) (CI 3.00–6.16). The estimated population size for the whole PEIG was 505 ± 211 individuals, with a confidence interval of 294 to 716 individuals. However, the coefficient of variation for density, size of groups and population size was 36.17%. In cases where the coefficient of variation was above 20%, which is considered the limit for a reliable estimate we used the encounter rate. The encounter rate in the PEIG was 0.04 ± 0.01 groups per km traveled (CI 0.03–0.05).

**Group composition and behavior**

We obtained 2,268 individual records in 698 scan-samplings. Using the “all occurrences Method”, we obtained 190 records of social behaviors distributed over 31 days. We identified 47 individuals, distributed in nine distinct groups and two solitary male individuals. All nine groups observed were composed of individuals of both sexes. The mean groups size (± standard deviation) was 5 ± 1.7 individuals (ranging from 2 to 7 individuals). Social composition per group was represented by one to two adult males (1.1 ± 0.3 individuals), one to three adult females (1.9 ± 0.6 individuals) and from zero to four immatures of different age (2 ± 1.3 individuals). Only one observed group consisted of two adult males. The groups were composed of 22% of adult males, 38% of adult females, 4% of subadult males, 27% of juveniles, and 9% of infants. Only one group of adults was observed. The sex ratio between males and females was 1: 1.7. Considering infants, juveniles and subadults as immature, the immature-to-female ratio (IFR) was 1.06 and immature-to-adult ratio (IAR) was 0.67.

The most common behavior observed was resting (45.2%), followed by feeding (28%), movement (21.7%) and social behavior, which occurred in a small fraction of the day (5.1%). Significant negative correlations were found between the percentages allocated for resting and feeding (rs = -0.77, p = 0.021, df = 7, n = 9), as well as for the combination between resting and movement (rs = -0.9, p = 0.002, df = 7, n = 9). The correlation analyzes between the other activities did not present statistically significant correlations (Table 3). In total observations, within the sampled period, individuals exhibited resting.

**Table 3.** Spearman Correlation values (upper right) and level of significance (lower left) among the percentages displayed for each activity of *Alouatta guariba clamitans* behavior in Ilha Grande State Park, Rio de Janeiro state, Brazil. Bold values were statistically significant.

| Behavior          | Resting | Feeding/Foraging | Movement | Social |
|-------------------|---------|------------------|----------|--------|
| Resting           | –       | -0.77            | -0.90    | -0.37  |
| Feeding/Foraging  | 0.021   | –                | 0.52     | 0.60   |
| Movement          | 0.002   | 0.162            | –        | -0.02  |
| Social            | 0.336   | 0.097            | 0.982    | –      |
behavior predominantly in the range of 8:00 to 10:00 am. The feeding activity was more present in the afternoon shift, with a peak between 02:00 and 05:00 pm. The social behavior was more displayed in the morning (07:00–08:00 am) and in the middle of the day (11:00 am–12:00 pm) (Fig. 2).

Feeding was characterized predominantly by the consumption of leaves (young or mature), besides sprouts, fruits and flowers. We were able to identify in field three plant species used as food resources: flowers and fruits of *Miconia prasina* (Sw.) DC. (*Melastomataceae*), embauába leaves (*Cecropia glaziovii* Snethl.: *Urticaceae*) and, most commonly, fig leaves and fruits (*Ficus vermiculata* (Miq.) Miq.: *Moraceae*).

There was a significant difference in the display of categories of social behavior. The most common social behavior was vocalization, with 45.8% of the records, followed by grooming (33.7%), agonistic (7.9%), playing (5.8%), marking (4.2%) and sexual behavior (2.6%) ($\chi^2 = 192.10, p < 0.001, df = 5$).

**DISCUSSION**

To compare densities among studies, it is very important that the studies be conducted following the same methodologies. Therefore, estimated density of individuals of *A. g. clamitans* for the PEIG using the distance sampling (average of 5 ind./km$^2$) can be considered low compared to other studies with this taxon (Table 4). Higher values of density in other areas of the Atlantic Forest has been estimated, such as, for example, 81 ind./km$^2$ in the Cantareira State Park in São Paulo state (Silva-Junior 1981), 15 ind./km$^2$ (Chiarello 1999) and 60 ind./km$^2$ (Ferrereguetti et al. 2016) in the Vale Natural Reserve, located in the north of Espírito Santo state. In Rio de Janeiro state, Araújo et al. (2008) estimated 44.1 ind./km$^2$ in the Poço das Antas Biological Reserve and 42.1 ind./km$^2$ in the União Biological Reserve, both estimates are much higher than the present study estimate. However, the estimated encounter rate fits within the confidence interval of previous studies. Encounter rates of the species is variable in the literature (0.01–2.3 individuals per km walked, Table 4) and here, we estimated 0.4 individuals per km walked. The mean group size was similar in the two study periods using two different methods (4 and 5 individuals, respectively). Previous studies have argued that the size of *A. g. clamitans* groups ranges from 2 (Silva-Junior 1981, Chiarello 1992, Pinto et al. 1993) to 13 individuals (Jardim 2005), and the mean size of 3.7 (Pinto et al. 1993) to 8.23 (Jardim 2005) individuals per group. Therefore, the groups size found in the PEIG fits within the range of these studies.

The occurrence of solitary male individuals in this study is consistent with the predominance of disappearances of young males, subadult and adult observed by Jardim (2005). According to the author, this disappearance is related to the intra-sexual competition and *Alouatta’s* polygynous social system, in which the group is generally composed of one to two adult males and two to three adult females (Silva-Junior 1981, Mendes 1989). The entry into other groups is possibly related to the physical capacity of adult males and the ability to form alliances and coalitions with related individuals to define the hierarchy in the group (Jardim 2005). The formation of most groups of *A. guariba* with one male in its composition was observed by several authors (Table 5). Thus, groups identified in the PEIG followed the trend presented for the species (Table 5).

The ratio between the sex-age classes of the individuals, such as the ratio between males and females, the proportion of IFR and the proportion of IAR are relevant factors to be considered in the composition of the groups, which are used as indicators of population status (Rumiz 1990, Clarke et al. 2002). In fact, adult females generally correspond to the highest proportion of adult individuals (Crockett and Eisenberg 1987, Rudran and Fernandez-Duque 2003, Aguiar et al. 2009). The male/female sex ratios (1:1.7), as well as the calculated values for the IFR (1.1) and IAR (0.7) parameters confirm what has been observed in studies developed in other areas for the genus (Table 5). Lower values of these indices indicate that the population faces difficulties or is declining, while higher values indicate more viable groups or populations (Zucker and Clarke 2003). Although Heltne et al. (1975) have suggested that an IFR below 1.5 is critical for the survival of a population, lower values have been reported for *Alouatta palliata* (Gray, 1849), with no evidence of decline (0.75: Clarke et al. 2002, 0.62: Zucker and Clarke 2003). Therefore, the results may suggest a relative stability between the groups studied in the PEIG at the time.

In general, the activity pattern of the groups observed was similar with most results obtained in other studies for the species and for the genus, because higher frequency activity was resting, followed by feeding activities, movement and social behaviors (Mendes 1989, Chiarello 1992, Oliveira and Ades 1993, Martins 2008). This high inactivity of the howler monkeys can be explained by the low energy value of their folivorous diet and
strategic conservation of energy (Milton 1998). The percentage displayed for resting behavior, when compared to other studies, where ranges from 53.1% (Marcos de Souza Fialho, unpublished data) to 74.1% (Limeira 2000), was lower (45.2%). However, Flávia Koch (unpublished data) found similar movement values to this study in an Atlantic Forest fragment located in the municipality of Barra do Ribeiro, Rio Grande do Sul state, Brazil. One factor that may have influenced this lower proportion of resting behavior was the observation period. We did not conducted sampling in the late afternoon nor early evening, where activities are reduced, allowing for an underestimation of resting behavior. However, Oliveira and Ades (1993) began their observations at 8:00 am and this did not result in a reduction in resting time observed, when compared to other studies. Vocalization was the most frequent social behavior (45.8%), as well as observed by Moro-Rios et al. (2006) (53.4%). In the study by Marcos de Souza Fialho (unpublished data), vocalization and playing were characterized as predominant social behaviors (45.6% and 43.6% in winter and 26.5% and 30.1% in summer, respectively). Oliveira and Ades (1993) and Martins (2008) found a higher percentage of grooming and playing behaviors (1.9% and 1.1%, 1.2% and 1.6%, respectively, relative frequency of records of all activities) than vocalization (0.4% and 0.6%, respectively, of all activities). However, these percentages may present variations according to the composition of the observed groups, such as the presence of immatures, which can increase the playing records. Another factor that may interfere with the number of vocalization records is the distribution and density of the groups present in the study.

Table 4. Estimates of population density and encounter rate for Alouatta guariba clamitans in different areas of the Atlantic Forest

| Locality                              | Density (ind/km²) | Encounter rate | Study                  |
|---------------------------------------|-------------------|----------------|------------------------|
| Ilha Grande State Park, RJ            | 4.58              | 0.04           | Present study          |
| Vale Natural Reserve, ES              | 60                | –              | Ferreguetti et al. (2016) |
| Ilha do Cardoso State Park, SP        | 10.6              | –              | Ingberman et al. (2009) |
| União Biological Reserve, RJ          | 44.1              | 0.07           | Araújo et al. (2008)   |
| Poço das Antas Biological Reserve, RJ | 42.1              | 0.11           | Araújo et al. (2008)   |
| Viraieto/Fatatingüera, SP             | 27.1              | 0.14           | Martins (2005)         |
| Sara, SP                              | 34.6              | 0.22           | Martins (2005)         |
| Água Sumida, SP                       | 10.42             | 0.01           | Martins (2005)         |
| Monal, SP                             | 8.32              | 0.006          | Martins (2005)         |
| Morro do Diabo, SP                    | 15.6              | 0.07           | Cullen et al. (2001)   |
| Tucano Farm, SP                       | 10.9              | 0.07           | Cullen et al. (2001)   |
| Mosquito Farm, SP                     | 36.3              | 0.07           | Cullen et al. (2001)   |
| Caetetus Ecological Station, SP       | 0.6               | 0.07           | Cullen et al. (2001)   |
| Rio Claro Farm, SP                    | 16.3              | 0.07           | Cullen et al. (2001)   |
| Paranacicaba, SP                      | 0.8               | 0.07           | González-Solís et al. (2001) |
| Vale Natural Reserve, ES              | 15                | 0.07           | Chiarello (1999)       |
| Serra do Brigadeiro, MG               | 7.5               | –              | Cosenza and Melo (1998) |
| Caratinga, MG                         | 149               | –              | Hirsch (1995)          |
| Rio Doce State Park, MG               | 49                | –              | Hirsch (1995)          |
| Augusto Ruschi Biological Reserve, ES | 10.1              | 0.18           | Pinto et al. (1993)    |
| Cantareira State Park, SP             | 81                | –              | Silva-Junior (1981)    |

Table 5. Studies developed with Alouatta guariba and A. guariba clamitans in other localities that evaluated the same behavioral parameters of the present study at Ilha Grande State Park, Rio de Janeiro state, Brazil.

| Locality                              | Groups with one adult male (%) | Sex ratio (M/F) | Immature to female ratio (IFR) | Immature to adult ratio (IAR) | Study                  |
|---------------------------------------|--------------------------------|----------------|--------------------------------|------------------------------|------------------------|
| Ilha Grande State Park, RJ            | 90                             | 1 : 1.7        | 1.06                           | 0.67                         | Current study          |
| Cantareira Reserve, SP                | 64                             | 1 : 1.31       |                                |                              | Silva-Junior (1981)    |
| Caratinga Biological Station, MG      | 84                             | 1 : 1.2        | 1.3                            | 0.9                          | Mendes (1989)         |
| Intervales State Park, SP             | 83                             | 1 : 1.85       | 1.2                            | 0.8                          | Steinmetz (2001)      |
| Morro da Extrema, RS                  | 60–90                          | 1 : 2.25       |                                |                              | Jardim (2005)         |
| Fragmento Mata do Lami, RS            |                                | 1 : 3          |                                |                              | Jardim (2005)         |
| Parque Estadual de Itapuã, RS         |                                | 1 : 2.6        |                                |                              | Jardim (2005)         |
| Chácaras Payquêdu Bugre, PR           |                                | 1 : 2.64       | 1.4                            | 0.8                          | Miranda and Passos (2005) |
| Parque Estadual da Ilha do Cardoso, SP| 80                             | 1 : 1.58       |                                |                              | Ingberman et al. (2009) |
area, because vocalization can be associated with territoriality behavior in vocal confrontations (Horwich and Gebhard 1983, Bonvicino 1989). On the other hand, some authors affirm that individuals of *A. g. clamitans* are not territorial, but only antagonistic to those that are not part of their groups, and that defend the place where they are (Neville et al. 1988).

Our estimates of the encounter rate, density and population size of *A. g. clamitans* in the PEIG were low and reinforce the need to initiate a monitoring of the species to assess the impact that outbreaks of yellow fever may have on PEIG populations. The PEIG is an important area for the conservation of the species in the Rio de Janeiro state, and it should be noted that some individuals were victims of yellow fever in 2017. The risk of the species being locally extinct may be higher if new outbreaks of yellow fever reach the Ilha Grande, because it is an island population isolated without immigration from mainland individuals. Therefore, the results presented here can be a starting point to support future action plans for the species *A. g. clamitans*. Population estimates and behavioral information presented here could help to understand species relationships within the PEIG and may be important for assist management measures for the conservation of this species.

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**LITERATURE CITED**

Aguirar LM, Ludwig G, Passos FC (2009) Group size and composition of black-and-gold howler monkeys (*Alouatta caraya*) on the Upper Paraná River, Southern Brazil. Primates 50(1): 74–77. https://doi.org/10.1007/s10329-008-0115-0

Akaike H (1973) Maximum likelihood identification of Gaussian autoregressive moving average models. Biometrika 60(2): 255–265. https://doi.org/10.1093/biomet/60.2.255

Alho CJR, Schneider M, Vasconcellos LA (2002) Degree of threat to the biological diversity in the Ilha Grande State Park (RJ) and guidelines for conservation. Brazilian Journal of Biology 62(3): 375–385. https://doi.org/10.1590/S1519-69842002000300001

Altmann J (1974) Observational study of behavior: sampling methods. Behaviour 49(3): 227–266. https://doi.org/10.1163/156853974X00534

Araújo RMD, Souza MBD, Ruiz-Miranda CR (2008) Densidade e tamanho populacional de mamíferos cinegéticos em duas Unidades de Conservação do Estado do Rio de Janeiro, Brasil. Iheringia, Série Zoologia 98(3): 391–396.

Araújo FAA, Ramos DG, Santos AL, Passos PHDO, Elkhoury ANSM, Costa ZGA, Leal SG, Romano APM (2011) Epizootias in primatas não humanos durante reemergência do vírus da febre amarela no Brasil, 2007 a 2009. Epidemiologia e Serviços de Saúde 20(4): 527–536. https://doi.org/10.5123/S1679-49742011000400012

Barrett AD, Monath TP (2003) Epidemiology and ecology of yellow fever virus. Advances in Virus Research 61: 291–317.

Bergallo HG, Geise L, Bonvicino CR, Cerqueira R, D’Andrea PS, Esberárd CE, Vaz SM (2000). Mamíferos. A fauna ameaçada de extinção do Estado do Rio de Janeiro. Editora da Universidade do Estado do Rio de Janeiro, Rio de Janeiro, 125–130.

Bergallo HG, Esberárd CE, Geise L, Grelle CEV, Vieira MV, Gonçalves PR, Paglia A, Attias N (2009) Mamíferos endêmicos e ameaçados de extinção do Estado do Rio de Janeiro: diagnóstico e estratégias para a conservação. In: Bergallo HG, Fidalgo ECC, Rocha CFJD, Uzêda MC, Costa MB, Alves MAS, Van Sluys M, Santos MA, Costa TCC, Cozzolino ACR (Eds) Estratégias e ações para a conservação da biodiversidade no Estado do Rio de Janeiro. Instituto Biomas, Rio de Janeiro, 209–220.

Bicca-Marques JC (2009) Outbreak of yellow fever affects howler monkeys in southern Brazil. Oryx 43(2): 173. https://doi.org/10.1017/S0030605309432046

Bicca-Marques JC, Alves SL, Ingberman B, Buss G, Fries BG, Alonso A, Cunha RTG, Miranda JMD (2015) Avaliação do Risco de Extinção de *Alouatta guariba clamitans* Cabrera, 1940 no Brasil. Processo de avaliação do risco de extinção da fauna brasileira. ICMBio. Available online at: http://www.icmbio.gov.br/portal/biodiversidade/fauna-brasileira/lista-de-especies/7179-mamiferos-alouatta-guariba-clamitans-guariba-ruivo.html [Accessed: 26/03/2019]

Bonvicino CR (1989) Ecologia e comportamento de *Alouatta belzebul* (Primates: Cebidae) na Mata Atlântica. Revista Nordestina de Biologia 6(2): 149–179.

Bravo SP, Sallenave A (2003) Foraging behavior and activity patterns of *Alouatta caraya* in the northeastern Argentinean flooded forest. International Journal of Primatology 24(4): 825–846. https://doi.org/10.1023/A:1024680806342

Buckland ST, Anderson DR, Burnham KP, Laake JL, Borchers DL, Thomas L (2001) Introduction to distance sampling: estimating abundance of biological populations. Oxford University Press, Oxford, 432 pp.
Buckland ST, Rexstad E, Thomas L, Borchers DL (2016) Distance sampling surveys of population size: enabling better decision-making by wildlife managers. In: Buckland ST (Ed.) UK success stories in industrial mathematics. Springer International Publishing, 45–51. https://doi.org/10.1007/978-3-319-25454-8_6

Callado CH, Barros AAM, Ribas LA, Albarello N, Gagliardi R, Jascone CES (2009) Flora e cobertura vegetal. In: Bastos M, Callado CH (Orgs) O ambiente da Ilha Grande. UERJ/CEADS, Rio de Janeiro, 91–162.

Chaves OM, Bicca-Marques JC (2013) Dietary flexibility of the brown howler monkey throughout its geographic distribution. American Journal of Primatology 75(1): 16–29. https://doi.org/10.1002/ajp.22075

Chiarello AG (1992) Activity pattern of the brown howler monkey Alouatta fusca, Geoffroy 1812, in a forest fragment of southeastern Brazil. Primates 34(3): 289–293.

Chiarello AG (1999) Effects of fragmentation of the Atlantic forest on mammal communities in south-eastern Brazil. Biological Conservation 89(1): 71–82. https://doi.org/10.1016/S0006-3207(98)00130-X

Clarke MR, Crockett CM, Zucker EL, Zaldivar M (2002) Mantled howler population of Hacienda La Pacifica, Costa Rica, between 1991 and 1998: effects of deforestation. American Journal of Primatology 56(3): 155–163. https://doi.org/10.1002/ajp.1071

Cosenza BAP, Melo FR (1998) Primates of the Serra do Brigadeiro State Park, Minas Gerais, Brazil. Neotropical Primates 6(1): 18–20.

Crockett CM, Eisenberg JF (1987) Howlers: variations in group size and demography. In: Smuts BB, Cheney DL, Seyfarth RM, Wrangham RW, Struhsaker TT (Eds) Primates societies. The University of Chicago Press, Chicago, 54–68.

Cullen L, Bodmer RE, Valladares-Padua C (2001) Ecological consequences of hunting in Atlantic forest patches, São Paulo, Brazil. Oryx 35(2): 137–144. https://doi.org/10.1046/j.1365-3008.2001.00163.x

Cunha FMA, Loyola RD (2011) Spatial priorities for the conservation of threatened mammals in the Neotropics. Bioikos 9(2): 355–368. https://doi.org/10.1365/3201/92011

Di Bitetti MS, Placci G, Brown AD, Rode DI (1994). Conservation and population status of the brown howling monkey (Alouatta fisca clamitans) in Argentina. Neotropical Primates 2(4): 1–4.

Fernandes NCC, Cunha MS, Guerra JM, Rêssio RA, dos Santos C, Iglezias SDA, Diaz-Delgado J (2017) Outbreak of Yellow Fever among Nonhuman Primates, Espírito Santo, Brazil, 2017. Emerging Infectious Diseases 23(12): 2038. https://doi.org/10.3201/ eid2312.170685

Ferreguetti ÁC, Tomás WM, Bergallo HG (2016) Abundância e densidade de mamíferos de médio e grande porte na Reserva Natural Vale. In: Rolim SG, Menezes LFT, Srek-Araujo AC (Eds) Floresta Atlântica de Tabuleiro: Diversidade e Endemismos na Reserva Natural Vale. Editora Rona, Belo Horizonte, 453–467.

González-Sólis J, Guix JC, Mateos E, Llorens L (2001) Population density of primates in a large fragment of the Brazilian Atlantic rainforest. Biodiversity and Conservation 10: 1267–1282. https://doi.org/10.1023/A:1016678126099

Gregorin R (2006) Taxonomy and variação geográfica das espécies do género Alouatta Lacépède (Primates, Atelidae) no Brasil. Revista Brasileira de Zoologia 23(1): 64–144. https://doi.org/10.1590/S0101-81752006000100005

Heltne PG, Turner DC, Scott NJ Jr (1975) Comparison of census data on Alouatta palliata from Costa Rica and Panama. In: Thorington RW Jr, Heltne PG (Eds) Neotropical Primates: Field Studies and Conservation. National Academic of Sciences, Washington, DC, 10–19.

Hervé JP, Travassos da Rosa APA (1983) Ecologia da febre amarela no Brasil. Revista da Fundação SESP 28(1): 11–19.

Hirano ZMB, Tramonte R, Silva ARM, Rodrigues RB, Santos WD (2003) Morphology of epidermal glands responsible for the release of colored secretions in Alouatta guariba clamitans. Laboratory Primate Newsletter 42(2): 4–7.

Hirsch A (1995) Census of Alouatta fusca and habitat quality in two areas of Atlantic Forest in Minas Gerais, Brazil. Neotropical Primates 3: 185–186.

Horwich RH (1998) Effective solutions for howler conservation. International Journal of Primatology 19(3): 579–598. https://doi.org/10.1023/A:1020368624121

Horwich RH, Gebhard K (1983) Roaring rhythms in black howler monkeys (Alouatta pigra) of Belize. Primates 24(2): 290–296. https://doi.org/10.1016/0032-5985(83)90040-3

ICMBio (2018) Livro Vermelho da Fauna Brasileira Ameaçada de Extinção. Instituto Chico Mendes de Conservação da Biodiversidade, Brasilia. Available online at: http://www.icmbio.gov.br/portal/images/stories/comunicacao/publicacoes/publicacoes-diversas/dcom_sumario_executivo_livro_vermelho_ed_2016.pdf [Accessed: 26/03/2019]

INEA (2010) Parque Estadual da Ilha Grande (PEIG). Instituto Estadual do Ambiente, Rio de Janeiro. Available online at: http://www.inea.rj.gov.br/publicacoes/sobre-a-pesquisa-cientifica-nas-ucs/pesquisas-e-publicacoes/parque-estadual-da-ilha-grande [Accessed: 14/05/2019]

Ingberman B, Fusco-Costa R, Monteiro-Filho EL (2009) Population survey and demographic features of a coastal island population of Alouatta clamitans in Atlantic Forest, southeastern Brazil. International journal of primatology 30(1): 1–14. https://doi.org/10.1007/s10764-008-9324-z

IUCN (2018) The IUCN Red List of threatened species version 2018.4. International Union for Conservation of Nature. Available online at: http://www.iucnredlist.org. [Accessed: 14/05/2019]

Jardim MMA (2005) Ecologia populacional de Bugios-Ruivos (Alouatta guariba) nos Municípios de Porto Alegre e Viamão, RS, Brasil. PhD thesis, Universidade Estadual de Campinas,
São Paulo, 114 pp. Available online at: http://repositorio.unicamp.br/bitstream/REPOSIP/315854/1/Jardim_Marcia-MariadeAssis_D.pdf [Accessed: 14/05/2019]
Kinsey WG (1982) Distribution of primates and forest refuges. In: Prance GT (Ed.) Biological diversification in the Tropics. Columbia University Press, New York, 455–482.
Kumm HW, Laemmert HW Jr (1950) The Geographical distribution of immunity to yellow fever among the Primates of Brazil. The American Journal of Tropical Medicine and Hygiene 1(5): 733–748. https://doi.org/10.4269/ajtmh.1950.s1-30.733
Lehner PN (1996) Handbook of Ethological Methods. Cambridge University Press, Cambridge, 2nd ed., 672 pp.
Limeira VLAG (2000) Uso do espaço por um grupo de *Alouatta fusca clamitans* em um fragmento de Mata Atlântica no Estado de São Paulo: uma população de *Alouatta fusca clamitans* Cabrera, 1940. In: Anais e Resumos da 58ª Reunião Anual da SBPC. SBPC/UFSC, São Paulo, ISBN: 978-85-86957-11-6. Available online at: http://www.sbpccnet.org.br/livro/s8ra/JNIC/RESUMOS/resumo_1593.html
Moraes LH (2015) Impactos antrópicos sobre uma população de *Alouatta clamitans* Cabrera, 1940 em um fragmento de Mata Atlântica no Estado de São Paulo: apontamento de medidas mitigatórias. Revista Biociências 21(1): 14–26.
Moro-Rios RF, Miranda JMD, Passos FC (2006) Comportamento social do bugio ruivo (*Alouatta guariba clamitans* Cabrera, 1940) em um fragmento de floresta ombrófila. In: Anais e Resumos da 58ª Reunião Anual da SBPC. SBPC/UFSC, São Paulo, ISBN: 978-85-86957-11-6. Available online at: http://www.sbpccnet.org.br/livro/s8ra/JNIC/RESUMOS/resumo_1593.html
Neville MK, Glander KE, Braza F, Rylands AB (1988) The hollowng monkeys, genus *Alouatta*. In: Mittemeer RA, Rylands AB, Coimbra-Filho AF, Fonseca GAB da (Eds) Ecology and Behavior of Neotropical Primates. World Wildlife Fund, Washington, DC, vol. 2, 349–453.
Oliveira RR (2002) Ação antrópica e resultantes sobre a estrutura e composição da Mata Atlântica na Ilha Grande, RJ. Rodriguésia 53(82): 33–58. https://doi.org/10.1590/2175-78602002538203 349-453
Oliveira DAG, Ades C (1993) Aspectos do comportamento do bugio *Alouatta fusca* (Primates, Cebidae) no Parque Estadual da Cantareira (São Paulo). Revista do Instituto Florestal de São Paulo 5: 163–174.
Pereira BC, Ferreguetti AC, Bergallo HG (2017) Factors affecting mammalian encounter rates in transect surveys: a case study in Ilha Grande State Park, State of Rio de Janeiro, Brazil. Oecologia Australis 21(4): 422–430. https://doi.org/10.4257/oeco.2017.2104.06
Pinto LPS, Costa CM, Strier KB, da Fonseca GA (1993) Habitat, density and group size of primates in a Brazilian tropical forest. Folia Primatologica 61(3): 135–143. https://doi.org/10.1159/000156740
Prates HM, Bicca-Marques JC (2008). Age-sex analysis of activity budget, diet, and positional behavior in *Alouatta caraya* in an orchard forest. International Journal of Primatology 29(3): 703. https://doi.org/10.1007/s10764-008-9257-6
Printes RC, Liesenfeld MV, Jerusalinsky L (2001) *Alouatta guariba clamitans* Cabrera, 1940: A new southern limit for the species and for Neotropical primates. Neotropical Primates 9(3): 118–121.
R Development Core Team (2010) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna.
Rudran R, Fernandez-Duque E (2003) Demographic changes over thirty years in a red howler population in Venezuela. International Journal of Primatology 24(5): 925–947. https://doi.org/10.1023/A:1026241625910
Rumiz DI (1990) *Alouatta caraya*: population density and demography in northern Argentina. American Journal of Primatology 21(4): 279–294. https://doi.org/10.1002/aip.1350210404
Rylands AB, Fonseca GAB, Leite YLR, Mittermeier RA (1996) Primates of the Atlantic Forest: Origin, distributions, endemism and communities. In: Norconk MA, Rosenberg AL, Garber PA (Eds) Adaptive radiations of neotropical primates. Plenum Press, New York, 21–51.
Setz EZF (1991) Métodos de quantificação de comportamento de primatas em estudos de campo. In: Rylands AB, Bernardes AT (Eds) A Primatologia no Brasil. Fundação Biodiversitas para a Conservação da Diversidade Biológica, Belo Horizonte, 3rd ed., 63–81.
Silva-Junior ED (1981) A preliminary survey of brown howler monkeys (Alouatta fusca) at the Cantareira Reserve (São Paulo, Brazil). Revista Brasileira de Biologia 41(4): 897–909.
Steinmetz S (2001). Densidade e conservação do bugio (Alouatta fusca) no Parque Estadual Intervales. Neotropical Primates 9: 69–73.
Thoisy B, Dussart P, Kazanji M (2004) Wild terrestrial rainforest mammals as potential reservoirs for flaviviruses (yellow fever, dengue 2 and St Louis encephalitis viruses) in French Guiana. Transactions of the Royal Society of Tropical Medicine and Hygiene 98(7): 409–412. https://doi.org/10.1016/j.trstmh.2003.12.003
Zar JH (1996) Biostatistical analysis. Prentice-Hall International, London.

Zucker EL, Clarke MR (2003) Longitudinal assessment of immature-to-adult ratios in two groups of Costa Rican Alouatta palliata. International Journal of Primatology 24(1): 87–101. https://doi.org/10.1023/A:1021498529202

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