

The effects of introducing the Amazonian squirrel monkey on the behavior of the northeast marmoset

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ABSTRACT

The squirrel monkey *Saimiri sciureus*, an endemic primate of the Amazonian Basin, has been introduced in many localities of the Atlantic Forest biome. Introduced exotic species gain a competitive advantage in their new environment because of a lack of natural predators, competitors or diseases. This advantage can result in a reduction in the resources for the endemic species. The aims of this work were to evaluate the level of adaptation, and monitor the forms of interaction and the impact caused by *S. sciureus* on the behavior of the native species *Callithrix jacchus* in the Saltinho Biological Reserve, Tamandaré, Pernambuco, Brazil. The behavior was assessed by use of scan sampling method, every 5 min. A total of 382 h (191 h or 2,292 scans per group) of time sampling was performed. Sixteen interactions were recorded. The interaction index was low and represented 2.4% of the total observation time. Interactions were significantly higher during the dry season (58.5%) relative to the rainy season (41.5%). *Callithrix jacchus* was intolerant to the presence of *S. sciureus* and the last one was more tolerant during the interactions. In the presence of *S. sciureus*, *C. jacchus* eating, foraging, resting, socializing, and self-grooming behaviors were reduced while alertness was increased. Territorial behavior showed no significant difference. In the presence of *S. sciureus*, on average, the group of marmosets assembled at a higher layer of the forest stratum. The results might indicate a negative effect of *S. sciureus* on the native species, *C. jacchus*.

KEYWORDS: Exotic primate, *Saimiri sciureus*, *Callithrix jacchus*, interspecific interactions.

Efeitos da introdução do macaco-de-cheiro amazônico sobre o comportamento do sagui-do-nordeste

RESUMO

O mico-de-cheiro, *Saimiri sciureus*, uma espécie endêmica da Bacia Amazônica, tem sido introduzido com sucesso em muitas localidades do bioma Mata Atlântica. Espécies exóticas introduzidas adquirem uma vantagem competitiva em seu novo ambiente por causa da ausência de seus predadores naturais, resultando em uma redução dos recursos alimentares para as espécies endêmicas. Nossos objetivos foram avaliar o nível de adaptação e monitorar as formas de interação e do impacto causado pelo *S. sciureus* sobre o comportamento da espécie nativa, *Callithrix jacchus*, na Reserva Biológica de Saltinho, Tamandaré, Pernambuco, Brasil. O comportamento foi estudado através do método de amostragem scan sampling a cada 5 minutos. Um esforço amostral de 382 h (191 h ou 2.292 scans por grupo) foi obtido. Dezesesseis interações foram registradas. O índice de interação foi baixo e representou 2,4% do total de tempo de observação. As interações foram significativamente maiores na estação seca (58,5%) do que na estação chuvosa (41,5%). Em termos de tipos de interação, *C. jacchus* foi intolerante à presença de *S. sciureus*, que por sua vez apresentou alto nível de tolerância. Na presença de *S. sciureus*, o *C. jacchus* reduziu a alimentação, forrageamento, descanso, comportamentos sociais e autocatação e aumentou o comportamento de alerta. O comportamento territorial não apresentou diferença significativa. Na presença do *S. sciureus*, no geral, o grupo de saguis permaneceu em um estrato mais alto na floresta. Os resultados parecem indicar um possível efeito negativo do *S. sciureus* sobre a espécie nativa, *C. jacchus*.

PALAVRAS-CHAVE: Primata exótico, *Saimiri sciureus*, *Callithrix jacchus*, interações interespecíficas.

INTRODUCTION

The introduction of exotic or allochthonous species corresponds to the accidental or intentional release of individuals into an area where they usually do not occur (Moura-Brito and Patrocínio 2006; Ruiz-Miranda *et al.* 2006). The introduced species may assume the role of competitors, reducing food resources and potentially introducing diseases to the new environment (Primack and Rodrigues 2001; Moura-Brito and Patrocínio 2006). Such competition can occur in two forms (Begon *et al.* 2006): Firstly by exploration, when the species consumes the food of a particular territory and depleting the food stock of the other species. Secondly by interference, when the animal keeps individuals of another species away from resources through agonistic behaviors such as fighting and aggressive displays. When a species is potentially invasive, it has advantages that allow it to expand its territory, conquering new areas in the ecosystem and establishing itself as the dominant population (Valéry *et al.* 2008).

In 1987, approximately 25 Amazonian squirrel monkeys (*Saimiri sciureus* Linnaeus, 1758) were seized to combat illegal trafficking and were subsequently released in an area of the Atlantic Forest in the Saltinho Biological Reserve. At that time, the only reported native primate species in the reserve was the common marmoset, *Callithrix jacchus* (Linnaeus, 1758), which is a small, endemic species of northeast Brazil (Rylands *et al.* 2000). Squirrel monkeys live in social groups ranging in size from 25 to 75 individuals (Boinski 1999; Stone 2007) or more (Baldwin and Baldwin 1981) and tend to associate for long periods with other Amazonian primates such as *Cebus*, *Callicebus*, *Saguinus*, and *Ateles* (Terborgh 1983, Mendes-Pontes 1997; Pinheiro *et al.* 2011). It is common for some sympatric primate species to maintain polyspecific associations for a considerable time each day. These associations offer benefits in foraging, feeding (Pook and Pook 1982; Fleagle *et al.* 1981; Podolsky 1990) locomotion and protection against predators (Peres 1993; Heymann 1995, 2011; Porter 2001). Although uncommon, squirrel monkeys may also be associated with or encounter other mammalian species such as coati *Nasua nasua* (Haugaasen and Peres 2008; Pinheiro *et al.* 2011), tayra *Eira barbara* (Haugaasen and Peres 2008), agoutis *Dasyprocta prymnolopha* and *Dasyprocta leporina*, and deer *Mazama gouazoubira* (Pinheiro *et al.* 2011). At first, nothing about the relation between *S. sciureus* and *C. jacchus* has been published and nothing about the nature of their behavior in this situation is known. Thus, we can expect any kind of relation between this two non-sympatric species. We hypothesized that the presence of *S. sciureus* modifies the behavior of the native primate, *C. jacchus*. Our goals were to evaluate their level of adaptation, and monitor the forms of interaction and the impact caused by the presence of *S. sciureus* on the behavior of the native species *C. jacchus*.

MATERIALS AND METHODS

The study area and the *Saimiri sciureus* population

The study was conducted in the Saltinho Biological Reserve (REBIO) (08°43'09"S and 35°10'11"W), located between the municipalities of Rio Formoso and Tamandaré, in the South Coast of the State of Pernambuco, northeast of Brazil. The rainy season lasts from May to August (Lira *et al.* 2006). The REBIO is an area protected by the Brazilian Institute of Environment and Renewable Natural Resources—IBAMA, and has 548 ha of ombrophilous dense forest of secondary vegetation, with a hot-humid climate, annual average temperature are approximately 25 °C with annual rainfall ranging from 1,500 to 1,700 mm. The REBIO is surrounded by sugar cane plantations. The local population maintains a rural economy characterized by agriculture and grazing. The population of *S. sciureus* introduced in the REBIO area has grown over the years. Through regular monitoring of their sleeping sites (bamboo groves of *Bambusa sp.*) the groups were seen to be composed of juvenile animals of various age classes, as well as adults at the reproductive stage. The appearance of new groups was also observed.

Data collection

One group of *S. sciureus* "M1" (nine animals) and two groups of *C. jacchus*, "A1" and "A2" (six and nine animals, respectively) were initially observed from September 2007 to January 2008. This period included selection of the study site, habituation and monitoring of the primates, and ascertain the existence of interactions between the two species (total 126 h of observation). None of the individuals was captured or tagged. Systematic collection of behavioral data was conducted between February and September 2008 with five to six days per month. The schedule covered the whole period of daily activity of the animals (8-10 h), resulting in 382 h of observation (2,292 scan sampling units) for both marmoset groups (191 h for each one). We used the *ad libitum* and the *scan sampling* behavioral sampling methods (Altmann 1974) with 1-min duration with 5-min intervals. An inter-species interaction was defined as any event involving a distance of less than 50 m between the two species (Eckardt and Zuberbühler 2004). All interactions began with the *S. sciureus* approaching to less than 50 meters of the marmosets. We classified the interactions into two distinct types, according to the observed behaviors: (1) Intolerance (*Int*) - if agonistic vocalizations, chases, fights, or other types of alertness or clashes occurred between species; and (2) Tolerance (*Tol*) - if no agonist behavior was observed during interactions. The behavioral categories displayed by *C. jacchus* in the

absence and presence of *S. sciureus* were based on those described by Affonso *et al.* (2004) (Table 1). Five casual interactions between *S. sciureus* and non-monitored marmoset groups were recorded when the observer was moving to the observation post. In these instances, the same methodology applied to monitored groups, totalizing the observed behaviors during the scans. This data was included, except to compare the behavior between the two monitored groups of *C. jacchus*. The height of each individual was estimated using a hypsometer during each scan sample unit. Then, marmoset heights were averaged for each scan sample unit in the absence and presence of squirrel monkeys for analysis.

Table 1. Description of behavioral categories

Behavior	Code	Description
Foraging	FR	Searching for food
Eating	EA	Eating food
Resting	RE	Lying on a branch in a relaxed position
Alertness	AL	Being alert with a “scanning” look
Territorial	TR	Emitting frequent “long call” vocalizations, which may be associated with persecutions, odor markings, cries of alarm, and arched walking
Socializing	SO	Behaving in an affiliative manner (picking another group member, breastfeeding, transporting infant(s), and playing)
Self-grooming	GR	Grooming its own body

Data analysis

Statistical analysis was performed using Excel® and Statistica 6.0®. To calculate the interaction index (I_i), the following formula was used: $I_i = (N_s/N_{TS}) \times 100$, in which N_s = number of scans in the presence of *S. sciureus*; and N_{TS} = total number of scans. Only the sum of interaction events of marmoset groups “A1” and “A2” was used for interaction index. We tested whether scan frequency with interactions differed between dry and rainy seasons using a Chi-square test. Behavioral data was compared using the Wilcoxon-Mann Whithney test (Siegel 1975). We calculated the relative frequency of each behavior of common marmoset in the presence and absence of squirrel monkeys. Significance was set at $p \leq 0.05$ bilaterally for all tests. The results test with statistical significance are shown on Table 2. Graphs were generated using Origin 8.0. This study was authorized by SISBIO/ICMBio under the protocol n. 13194-1.

Table 2. Results of statistical tests.

Comparison	Results
Interactions during different season	$\chi^2=6.072$; $p=0.001$; 857 total scans in dry season and 32 scans with interaction; 1,435 total scans in wet season and 23 scans with interaction
Kinds of interaction <i>C. jacchus</i>	$\chi^2=5.086$; $p=0.02$; 50 total scans with interaction, 36 intolerant
Kinds of interaction <i>S. sciureus</i>	$\chi^2=7.250$; $p=0.007$; 50 total scans with interaction, 37 tolerant
Difference in forest strata used by <i>C. jacchus</i> between presence and absence of <i>S. sciureus</i>	$U = 30.00$; $p < 0.05$; $n1=42$; $n2=16$
Behavior of <i>C. jacchus</i> . Presence versus absence of <i>S. sciureus</i>	Resting: $U=15.89$; $p < 0.05$; $n1=42$; $n2=11$ Socializing: $U=16.97$; $p < 0.05$; $n1=42$; $n2=11$ Self-grooming: $U=21.50$; $p < 0.05$; $n1=42$; $n2=11$ Alertness: $U=9.548$; $p < 0.05$; $n1=42$; $n2=11$
Behavior of <i>C. jacchus</i> versus behavior of <i>S. sciureus</i>	Foraging: $U=6.53$; $p=0.05$; $n1=11$; $n2=11$ Vigilance: $U=8.66$; $p < 0.05$; $n1=11$; $n2=11$

RESULTS

A total of 16 interactions were recorded, 11 of which involved our two marmoset study groups and five opportunistic interactions with other marmoset groups. The interaction index was low, representing 2.4% of the total observation period and significantly higher in the dry (58.5%) than in the rainy season (41.5%), Table 2. *Callithrix jacchus* was intolerant to the presence of *S. sciureus* ($Int=72\%$; $Tol=28$), whereas *S. sciureus* showed a high tolerance level ($Int=24.5\%$; $Tol=75.5\%$) Table 2. The duration of interaction events lasted from 2 to 45 min (Mean=13.0 min; SD=13.9 min).

Behavior and use of forest strata by *Callithrix jacchus* in the presence and absence of *Saimiri sciureus*

The behavioral categories of foraging and eating were more commonly observed when *S. sciureus* individuals were absent. In the presence of the introduced species, these behaviors occurred prior to the interactions but were immediately interrupted. Resting, socializing, and self-grooming were all significantly higher in the absence of *S. sciureus*. Conversely, the behavioral category alertness was significantly higher in the presence of *S. sciureus* (Figure 1).

In terms of forest strata use, the group A1 of *C. jacchus* used a significantly higher height during the interactions with *S. sciureus*. *Callithrix jacchus* was normally located at a height between 8-18m (Mean = 12.1m; SD = 2.76m) during interactions, and they were located at a height of 3-13m (Mean = 6.6m; SD = 1.91m) in the absence of *S. sciureus*. The data showed no significant difference for group “A2” of *C. jacchus*.

The height occupied by this group was 4-12m (Mean = 6.3m; SD = 2.94m) and 3-9 m (Mean = 5.4m; SD = 1.56m) in the presence and absence of *S. sciureus* respectively. Together with the results obtained from group A1, this suggests a tendency to occupy higher forest strata in the presence of *S. sciureus*.

Behavior of *Callithrix jacchus* and *Saimiri sciureus* during interactions

Callithrix jacchus spent less time foraging and more time in vigilance (alertness) than *S. sciureus* during interactions. *Saimiri sciureus* was far less vigilant than *C. jacchus*. Other behavioral categories such as eating, resting, social, and self-grooming and territorial did not show significant differences (Figure 2).

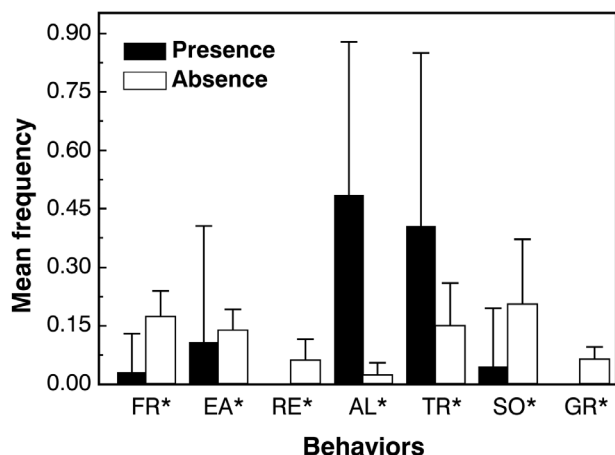


Figure 1. Mean frequency per scan of the behavioral categories shown by *Callithrix jacchus* in the presence and absence of *Saimiri sciureus*. FR = Foraging; EA = Eating; RE = Resting; VG = Vigilance; TR = Territorial; SO = Socializing; GR = Self-grooming. (* $P \leq 0.05$)

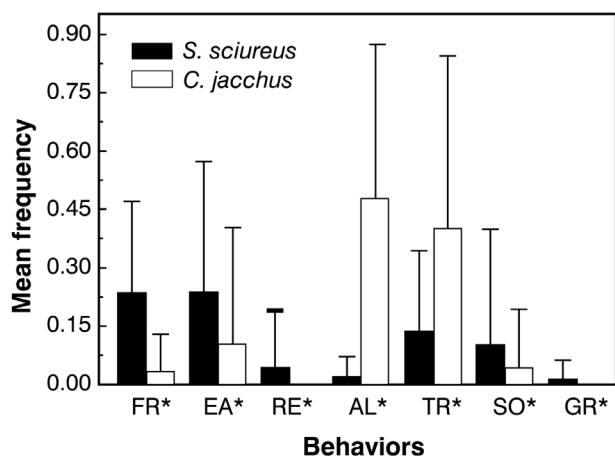


Figure 2. Mean frequency per scan of the behavioral categories during interactions between *Saimiri sciureus* and *Callithrix jacchus*. FR = Foraging; EA = Eating; RE = Resting; VG = Vigilance; TR = Territorial; SO = Socializing; GR = Self-grooming. (* $P \leq 0.05$)

DISCUSSION

In this study, we observed a low frequency of interactions between *S. sciureus* and *C. jacchus*, with no clear evidence of cooperative behaviors between these species. In addition, the observed interactions did not indicate any kind of mutual advantage, which typifies polyspecific interactions common to species of the genus *Saimiri* in their natural habitat (Mendes-Pontes 1997; Heymann 2011; Pinheiro *et al.* 2011). When such mutual benefits occur, it is possible to observe the different primate species spending much of their daily activities within the same ecological niche (Terborgh 1983).

During the dry season, a period of food shortage, interactions between *S. sciureus* and *C. jacchus* occurred with significantly greater frequency than during the rainy season. In periods of food shortage, competition for food is increased which increased the probability of interactions between species. *Saimiri sciureus* can follow *Cebus apella* groups searching for food resources (Terborgh 1983), hence, “parasitizing” them, and making the association advantageous for only one species. We cannot rule out the possibility that *S. sciureus* “parasitizes” the marmoset, since the same food items were consumed by both, with the exception of the gums consumed exclusively by the marmosets (personal observation).

In the presence of *S. sciureus*, *C. jacchus* appear to change their behavioral repertoire, suggesting intolerance. *Saimiri sciureus* showed a significant degree of tolerance. The territorial behaviors that we observed between the groups of *C. jacchus* and *S. sciureus* have also been shown in a previous study by Ruiz-Miranda *et al.* (2006). In that case, *C. jacchus* was the introduced species and the native species was *Leontopithecus rosalia*. Although aggressive exhibitions were observed between *C. jacchus* and *L. rosalia*, an affiliative behavior of playing was also present. Affiliative behaviors were not observed between *C. jacchus* and *S. sciureus* in this study. Even for sympatric species such as *C. kuhlii* and *L. chrysomelas*, only aggressive behaviors were reported (Rylands 1989). Therefore, intolerance between primate species cannot be explained solely because one of them was an introduced species. Common marmosets chased the squirrel monkeys at least in pairs. Nevertheless, they appeared to avoid interactions with the squirrel monkeys by moving in opposite directions, hiding or going close to the ground.

During the interactions, the high rate of alertness by *C. jacchus* explained a reduction in their mobility. Nevertheless, there were aggressive displays and home range expulsion attempts against *S. sciureus*. Our results showed that only the group A1 of *C. jacchus* modified their height in response to the presence of *S. sciureus*. The home range of the group “A2” was overlapped with the *S. sciureus* sleeping site and this could have made this group more tolerant to their presence. However, the small amount of data does not permit confirmation.

At the Saltinho Biological Reserve, *S. sciureus* individuals did not form a mixed group with *C. jacchus*. The two species may compete for food and space in the forest. *Callithrix jacchus* exhibited changes in their behavioral patterns in the presence and absence of *S. sciureus*, with a high rate of intolerance, indicating a possible negative effect of *S. sciureus* on the native species, *C. jacchus*. The low level of interaction could be a result of the sample effort that must be increased. Despite this, the current data shows that the behavior of *C. jacchus* changed in a significant way in the presence of *S. sciureus*. Specific data on food acquisition, reproduction and population survival are needed to provide a definitive conclusion.

The Saltinho Biological Reserve is reportedly native habitat of another primate, *Sapajus flavius*. This species is critically endangered and there are projects to reintroduce it into that area. Thus, we suggest that management measures be immediately implemented to control the expansion of the *S. sciureus* population.

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