

Luci F Ribeiro<sup>1,3</sup>, Luciana OM Conde<sup>2</sup>, Leôncio C. Guzzo<sup>2</sup> & Patrícia R. Papalambropoulos<sup>2</sup>

## Behavioral patterns of *Guerlinguetus ingrami* (Thomas, 1901) from three natural populations in Atlantic forest fragments in Espírito Santo state, Southeastern Brazil

Padrões comportamentais de *Guerlinguetus ingrami* (Thomas, 1901) em três populações naturais em fragmentos de Mata Atlântica no Espírito Santo, Sudeste do Brasil

**Resumo** Este artigo se propôs a compilar um padrão comportamental de *Guerlinguetus ingrami* (Thomas, 1901) a partir da observação de três populações trabalhos residentes em diferentes fragmentos de Floresta Atlântica no estado do Espírito Santo. Os trabalhos realizados com as populações tinham como enfoque a dieta, o comportamento e a ação da espécie como predadora e dispersora de sementes. Foram 1036 horas de observação resultando na identificação e descrição de 32 categorias distribuídas dentro de seis classes comportamentais: defesa, forrageamento, reprodução, interação social, deslocamento, interação interespecífica.

**Palavras-chaves** *Guerlinguetus ingrami*, esquilo, etograma, comportamento animal.

**Abstract** This article set out to build the behavioral pattern of *Guerlinguetus ingrami* Thomas, 1901 from the observation of three populations living in different fragments of Atlantic forest in Espírito Santo state. These populations were studied on diet, behavior and the effective role of the species as a predator and scatterer of seeds, and data presented here are a systematization of the behavioral guidelines that characterize *G. ingrami*. After 1,036 hours of field observation, it was possible the identification and description of 31 behavioral tasks grouped in four different categories: Locomotion, Foraging and feeding, Reproduction, Intra- and interspecific interactions.

**Keywords** *Guerlinguetus ingrami*, squirrel, ethogram, animal behavior.

### Introduction

Deforestation and fragmentation of the Atlantic forest have produced serious consequences for native biota, due to the drastic reduction of habitats and genetic isolation of natural populations. These processes generally facilitate the occurrence of other kinds of disturbance, such as hunting and fires caused by humans (Cullen Júnior. *et al.*, 2000). In general, anthropogenic environmental changes cause negative effects on specialized species and favor those with wide distribution and capable of association with humans (Lugo, 2001).

Some population aspects seem to characterize vertebrate species that respond positively to the process of fragmentation, such as small living area, high fecundity, wide distribution, rapid dispersal, increased abundance in disturbed areas and generalist feeding habits (Cossson *et al.*, 1999; Lugo, 2001). *Guerlinguetus ingrami* (Thomas, 1901) presents most of these characteristics and can therefore be regarded as a species less susceptible to fragmentation process.

Thus, in a community of frugivorous rodents, where there is diversity in selecting the type of fruit consumed, *G. ingrami* could replace other frugivorous rodents in effective scattering function for tree species that require manipulation of the fruit followed by burial to promote their germination and subsequent recruitment. In this case, this species would have an important role in the management of small forest fragments.

Much of the research carried out with *G. ingrami* refer to the diet (Bordignon & Monteiro-Filho, 1999; Miranda, 2005), the patterns of frugivory (Maia *et al.*, 1987; Paschoal & Galetti, 1992; Bordignon & Monteiro-Filho, 2000; Silva & Tabarelli, 2001; Alvarenga & Talamoni, 2006) and interactions involving the dispersion of seeds (Paschoal & Galetti, 1995; Bordignon & Monteiro-Filho, 2000). Only two studies focused on behavioral aspects of the species, both in man-made environments. One was developed in an area of *Araucaria* forest in the state of Paraná (Bordignon & Monteiro-Filho,

1 Instituto de Ciências Ambientais e Desenvolvimento Sustentável – ICADS. Campus Prof. Edgard Santos, Universidade Federal da Bahia – UFBA. R. Prof. José Seabra. S/N – Centro, Barreiras, Bahia. CEP. 47.805-100.

2 Escola Superior São Francisco de Assis - ESFA. Rua Bernardino Monteiro 700, Dois Pinheiros, Santa Teresa, Espírito Santo, Brasil CEP. 29650-000.

3 luz.ribeiro@ufba.br

2000), and the second study was conducted in dry forest in the state of Minas Gerais (Alvarenga, 2003).

The aim of this paper is to compile data from work carried out in natural populations by the authors, and establish a behavioral pattern for the species in the form a descriptive ethogram.

---

## Methods

### Study sites

This study was conducted in three Atlantic forest fragments located in Espírito Santo state, Southeast Brazil: (1) Estação Biológica de Santa Lúcia (ESBL, Biological Station of Santa Lucia, Santa Teresa county, 19°56' S and 40°37' W), (2) the green area of the Museu de Biologia Professor Mello Leitão (MBML, Mello Leitão Biology Museum, Santa Teresa county, 19°56' S and 40°36' W) and (3) Parque Natural Municipal David Victor Farina (PMDF, City Park David Victor Farina, Aracruz county, 19°55' S and 40°07' W). The first two are remnants of tropical montane rainforest and the third one is a fragment of open rainforest.

### Capture and marking

The activities of capture and marking were carried out monthly for ten consecutive days. The sample was obtained from the array of 21 traps (15 x 20 x 37 cm cage of galvanized wire) armed to 1.5 m above the ground in places close food resources. The traps were opened at dawn and closed at nightfall. The baits used were avocado (*Persea americana*, Lauraceae), banana (*Musa paradisiaca* complex, Musaceae) and coconut (*Cocos nucifera*, Arecaceae).

The captured animals were individually marked through the use of collars consisting of a chain of aluminum with two plastic beads attached. The color of one of the plastic beads was indicative of sex (red or yellow), while the other was exclusive for each individual, allowing to distinguish the animals.

### Behavior

The methods used for monitoring the activities of the species were “*ad libitum*” (Altmann, 1974) and focal animal (Altmann, 1974), totaling 1,036 hours of observation.

The observation activities were started in the morning (at approximately 05:30 h) and ended at dusk (around 18:00 h), following the diurnal habits of the species. In the method “*ad libitum*”, observations were based on daily monitoring of the first individual focused, being recorded all the activities observed. If this individual could no longer be observed, the same procedure was adopted for the next animal sighted.

The data obtained from the focal animal method were based on the monitoring of two adult females (purple and white) in the green area of the Museu de Biologia Professor Mello Leitão.

---

## Results and discussion

From the three studies with *Guerlinguetus ingrami* in fragments of Atlantic forest in the state of Espírito Santo, Southeastern Brazil, we are able to compile standards of behavior for the species. After 1,036 hours of observation, we identified and described 32 categories grouped into four behavioral classes, hereafter named as locomotion, foraging and feeding, reproduction, and intra- and interspecific interactions.

### Locomotion

We also observed some behavioral tasks described elsewhere, as well as identified a new kind of activity related to territoriality.

Horizontal displacement – The animal prepares the body and pushes forward, jumping and stretching the legs and tail in same direction (Bordignon & Monteiro-Filho, 1997).

Vertical downward – The animal moves about holding on with all four feet laterally to the trunk, being parallel to this with the head facing down (Bordignon & Monteiro-Filho, 1997).

Vertical upward – During the movement, the individual holds on with the four feet laterally disposed to the trunk, maintaining forelimbs perpendicular to the body axis and the head up (Bordignon & Monteiro-Filho, 1997).

Fixed routes – Upon monitoring the females (focal animal technique), we observed that the displacement between the nest and the food resources was done through fixed routes. The same also occurred in the opposite direction for both females. Probably, the nest location, near to trophic resources, would be related to time optimization by females during lactancy. The diminishing of the distance upon the foraging sites optimizes the time devoted to parental care and nest protection, increasing the reproductive success (Gurnell, 1996; Alvarenga, 2003; Alvarenga & Talamoni, 2005).

Territorial marking – During displacement activities, the animals mark tree trunks and litter, urinating and rubbing their buccal glands against substrate.

### Foraging and feeding

The observed animals presented a generalist diet composed by insects, lichens, bryophytes, bird eggs, mushrooms, dry leaves and fruits (Conde, 2003; Guzzo & Papalambropoulos, 2008). The fruit foraging showed

behavioral differences related to the kind of resource effectively consumed, since only the endocarp or the endosperm was eaten for some tree species.

**Inspection of fruiting trees** – Fruiting trees were systematically visited for inspection of fruits at the crown or on the soil. Such visits were done repeatedly to some individual trees, being the first inspection more detailed and time-consuming while the remaining visits were more objective and focused.

**Carrying marking** – During the fruit carrying, it was commonly observed the production of a furrow near the fruit base, probably facilitating fit of incisive teeth to allow effective transportation. Fruit drops were directly observed during scattering by young animals.

**Pulping** – Withdrawal of fruit epicarp and/or mesocarp without feeding purpose, to facilitate access to the endocarp and endosperm.

**Use of pulping perch** – The pulping behavior occurred at the gathering site (branches in the fruiting trees), in the forest floor near and below the fruiting trees or in a specific location chosen for this activity after fruit carrying. The use of a specific location to perform the pulping is named here as pulping perch.

**Use of feeding perch** – The effective fruit consumption was only performed in the fruiting tree when the resource used was the endocarp. When the resource used was the endosperm, the consumption always occurred far from the fruiting tree. This location is named here as feeding perch.

**Opening fruits** – The animals took to sitting posture, as described by Bordignon & Monteiro-Filho (1997) (hindlimbs parallel to the substrate, keeping their elbows close to the knees, the anal region near the substrate and the tail-shaped “S”). In this position, the front paws held the fruit and scraped off the endocarp to get full access to the endosperm. A single event could last from 10 to 50 minutes, and this kind of activity was done in the feeding perch.

**Storage resources** – Certain kinds of fruits were stored before consumption, being allocated from fruiting trees to forest floor. The scattered diaspores could be laid above the soil or buried.

**Soil storage** – Storage of diaspores at the forest floor in shallow holes covered with soil and leaf litter. The observed animals stocked only one diaspore per hole.

**Storage above ground** – Storage of diaspores in the canopy of trees, in the middle of trunks, branches or epiphytes. The seeds or fruits can be partially depredated or not. This is a form of temporary storage, with shorter duration than the stores of soil.

**Relocation of storage in the soil** – After reducing the supply of fruit of a certain tree species, the individuals of *G. ingrami* initiated relocation of stored resources, digging and

burying them elsewhere. This behavior has been observed in other rodents scatterhoarders, resulting in a less aggregated distribution in relation to the first storage, and a greater distance from the parent plant (Jansen et al., 2002; Vander Wall, 2002).

**Inspection of tree trunks** – The animal performs upwards and downwards shifts at the trunks of trees and thicker branches, searching for food such as mosses and insects.

**Inspection of bromeliads** – Frequent visits in cups of bromeliads associated with insect feeding and water intake.

### Reproduction

Thompson (1977) categorized the sexual behavior of *Sciurus carolinensis* in four phases: pre-chase, mating chase, copulation and post-copulation. The mating ritual of *G. ingrami* followed identically the same stages of behavior noted by that author.

The four phases can be characterized as follows: (1) pre-chase: the male pursues the “sexual trail” left by female (cf. Thompson, 1977) and, after the meeting, he assesses the female reproductive status through “genital sniffs”; (2) mating chase: after recognition of the female, it begins a chase that can last all day, in which males form a line that follows a hierarchical positioning, where the older male is placed in front of other males and closest to the female; agonistic behavior among male competitors were recorded and even between them and the female; (3) copulation: during the copulation the male covers the female, which remains motionless until the end of copulation; (4) post-copulation: after mating, the individuals remain close.

After the first copulation, there were new attempts made by the same male, with this remaining beside the female for some time during displacement or at rest. This behavior may be related to ensuring fertilization and paternity resulting from the female guard held by such male (Andersson, 1994).

**Removal of pieces of trees** – This behavioral task includes the removal of material from trees for the construction of nest as well as territory marking. Such behavior also has been observed in species of the genus *Sciurus* (Taylor, 1968).

**Displacement of puppies** – The females accompanied through the focal animal technique had more than one nest in their areas of life, and during the nursing period they moved their cubs to different nests.

### Intra- and interspecific interactions

**Vocalization** – We identified two types of vocalization: alert vocalization and vocalization used in harmonic social interactions (social vocalization). As no quantitative analyses were done, they are described below only in a qualitative manner.

**Alert vocalization** – often used vocalization consisting of short high whistles followed by a prolonged high whistle.

**Social vocalization** – soft and short chirps.

Harmonic interaction – relationships with conspecifics with or without vocalization and harassment. It was observed among females, between males and females, and between mother and young juveniles. This behavioral task was also observed by Bordignon & Monteiro-Filho (2000).

Intraspecific agonistic interaction – This kind of interaction consists of alert vocalization followed by persecution, and it was observed among adults during foraging and feeding.

Alert position – Body supported on the front and back legs and tail erect forming an angle of 90° to the body. During display there was alert vocalization.

Attack position – Body supported on the front and back legs and tail forming an angle of 180° to the body. During display there was vocalization consisting of high whistles in short pulses with higher tones than the vocalization associated to alert position. This behavior was observed against birds, primates (marmoset and capuchin) and conspecifics, always preceding persecution.

Interaction with hawks – Alert vocalization and position of lying, as described by Bordignon & Monteiro-Filho (1997). The anterior and posterior legs remain flat with the substrate, the jaw resting on the front legs and tail extended over the back (Bordignon & Monteiro-Filho, 1997).

Interaction with *Rattus norvegicus* – After detecting the individual of *R. norvegicus*, *G. ingrami* started alert vocalization followed by harassment and attack with bites. The escape of *R. norvegicus* into a burrow was followed by territory marking activities with intense and continuous vocalization.

Interaction with *Turdus rufiventris* – Approaching *T. rufiventris* with low-flying in the direction of *G. ingrami* accompanied by vocalization.

---

## References

- Altmann J (1974) Observational study of behavior: sampling methods. *Behavior* 49:227–265.
- Alvarenga CA & Talamoni AS (2005) Nests of the Brazilian squirrel *Sciurus ingrami* Thomas (Rodentia, Sciuridae). *Revista Brasileira de Zoologia* 22(3): 816–818.
- Alvarenga CA & Talamoni AS (2006) Foraging behavior of the Brazilian squirrel *Sciurus aestuans* (Rodentia, Sciuridae) *Acta Theriologica* 51 (1): 69–74
- Alvarenga CA (2003) **Estudo de uma população de *Sciurus ingrami* Thomas, 1901 (RODENTIA, SCIURIDAE) na Reserva Particular do Patrimônio Natural Serra do Caraça, Minas Gerais, Brasil.** Dissertação de Mestrado. Curso de Pós-Graduação em Zoologia dos Vertebrados, Pontifícia Universidade Católica, Belo Horizonte, MG.
- Andersson M (1994) **Sexual selection.** New Jersey: Princeton University Press.
- Bordignon M & Monteiro-Filho ELA (1997) Comportamentos e atividades diárias de *Sciurus ingrami* (Thomas) em cativeiro (Rodentia, Sciuridae). *Revista Brasileira de Zoologia* 14: 707–722.
- Bordignon M & Monteiro-Filho ELA (1999) Seasonal food resource of the squirrel *Sciurus ingrami* in a secondary Araucaria Forest in Southern Brazil. *Studies on Neotropical Fauna & Environment*, 34: 137–140.
- Bordignon M & Monteiro-Filho ELA (2000) O serelepe *Sciurus ingrami* (Sciuridae: Rodentia) como dispersor do Pinheiro do Paraná *Araucaria angustifolia* (Araucariaceae: Pinophyta). *Arquivos de Ciência Veterinária UNIPAR* 3(2): 139–144.
- Conde LOM (2003) **Padrão comportamental de *Sciurus aestuans* L. (1766) em um fragmento urbano de floresta ombrófila densa montana, Santa Teresa, ES.** Monografia de Bacharelado. Curso de Ciências Biológicas, Escola Superior São Francisco de Assis (ESFA), Santa Teresa, ES.
- Cosson JF, Ringuelet S, Claessens O, Massary JCDE, Dalecky A, Villiers JF, Grajon L & Pons JN (1999) Ecological changes in recent land-bridge islands in French Guiana, with emphasis on vertebrate communities. *Biological Conservation* 91: 213–222.
- Cullen Junior L, Bodmer RE & Pádua CV (2000) Effects of hunting in habitat fragments of the Atlantic Forest, Brazil. *Biological Conservation* 95: 49–56.
- Galetti M. (eds.). **Seed dispersal frugivory: ecology, evolution and conservation.** Pp. 209–225. CAB International.
- Gurnell J (1987). **The history natural of squirrels.** Christopher Helm Ltd., London.
- Guzzo LC & Papalambropoulos PR (2008) **Padrão comportamental e dieta de *Guerlinguetus ingrami* L. em um fragmento urbano na Praia dos Padres, Aracruz, ES.** Monografia de Bacharelado. Curso de Ciências Biológicas, Escola Superior São Francisco de Assis (ESFA), Santa Teresa, ES.
- Jansen PA, Bartholomeus M, Bongers F, Elzinga JA, Ouden J & Van Wieren EE (2002) The role of seed size in dispersal by scatter-hoarding rodent. In Levey DJ, Silva WR & Galetti M (eds.). **Seed dispersal frugivory: ecology, evolution and conservation.** CAB International.
- Lugo AE (2001) El manejo de la biodiversidad en el siglo XXI. *Interciencia* 26 (10): 484–490.
- Maia AA, Serran FP, Fernandes HQB, Oliveira RR, Oliveira RF & Penna TMP (1987) Inferências faunísticas por vestígios vegetais III: Inter-relações do caxinguelê (*Sciurus aestuans ingrami*, Thomas, 1901) com a palmeira baba de boi (*Syagrus romanzoffiana* (Chamisso) Glassman). *Atas da Sociedade Botânica do Brasil* 3:89–96.
- Miranda JMD (2005) Dieta de *Sciurus ingrami* Thomas (Rodentia, Sciuridae) em um remanescente de Floresta de Araucária, Paraná, Brasil. *Revista Brasileira de Zoologia* 22(4): 1141–1145.
- Paschoal M & Galetti M (1992) Predation on palm nuts (*Syagrus romanzoffiana*) by squirrels south-east Brazil. *Journal of Tropical Ecology* 8:121–123.
- Paschoal M & Galetti M (1995) Seasonal food use by the Neotropical squirrel *Sciurus ingrami* in Southeastern Brazil. *Biotropica* 27: 268–273.
- Silva MG & Tabarelli M (2001) Seed dispersal, plant recruitment and spatial distribution of *Bactris acanthocarpa* Martius (Arecaceae)

- in a remnant of Atlantic forest in northeast Brazil. **Acta Oecologia** 22:259–268.
- Taylor JC (1968) The use of marking points by grey squirrel. **Journal Zoologic** 155: 245-247.
- Thompson DC (1997) Reproductive behaviour of grey squirrel. **Canadian Journal of Zoology** 55: 1176-1184.
- Vander Wall SB (2002) Secondary dispersal of Jeffrey Pine seeds by rodent scatter–hoarders: the roles of pilfering, caching and variable environment. In Levey DJ, Silva WR & Galetti M (eds.). **Seed dispersal frugivory: ecology, evolution and conservation**. Pp. 193–208. CAB International.