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New observation on mycophagy: consumption of coconut mushroom *(Oudemansiella cubensis)* by the Brazilian squirrel *(Guerlinguetus brasiliensis)*

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New observation on mycophagy: consumption of coconut mushroom *(Oudemansiella cubensis)* by the Brazilian squirrel *(Guerlinguetus brasiliensis).* Squirrels and chipmunks are known to have mycophagous habits. Nonetheless, records of mycopaghy involving these animals not always present the fungal species involved, especially when they are epigeous mushrooms in Neotropical forests. Here, we report events of mycophagy involving the Brazilian squirrel *(Guerlinguetus brasiliensis)* and the coconut mushroom *(Oudemansiella cubensis),* including a description of the event and photographs. The aim of this study is to discuss the mycophagous habit of the Brazilian squirrel.
Palabras clave: feeding behaviour, fungal consumption, rodent diet

Nueva observación sobre la micofagia: consumo de seta de coco *(Oudemansiella cubensis)* por la ardilla brasileña *(Guerlinguetus brasiliensis).* Se sabe que las ardillas y 'chipmunks' tienen hábitos micófagos. Sin embargo, los registros de micofagia que involucran a estos animales no siempre presentan las especies de los hongos involucrados, especialmente cuando se trata de hongos epígeos en bosques Neotropicales. Aquí, informamos eventos de micofagia que involucran a la ardilla brasileña *(Guerlinguetus brasiliensis)* y al 'hongo del coco' *(Oudemansiella cubensis)*, incluida la descripción del evento y fotografías. El objetivo de este estudio es discutir el hábito micofágico de la ardilla brasileña.
Keywords: comportamiento alimentario, consumo de hongos, dieta de roedores

INTRODUCTION

Mycophagy is an important mechanism in the evolution of reproductive and dispersal systems of hypogeous and epigeous macrofungi (Johnson, 1994). Rodents are a group of animals notable for their mycophagous habit and feed on basidiomes of a great diversity of fungal taxa, although more studies focus on hypogeous ectomycorrhizal fungi, since they are completely dependent on external agents to disperse spores (García-Jiménez *et al*., 2012; Kües *et al*., 2018; Stephens & Rowe, 2020).

Basidiomes of fungal species are consumed by several species of squirrels and chipmunks around the world, for example, the red squirrel [*Tamiasciurus hudsoniscus* (Erxleben, 1777)], from the United States and Canada, that consumes about 90 different species of mushrooms

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(Fogel & Trappe, 1978). As doing so, squirrels act as spore dispersers and have an important role on fungal ecology (Mendes *et al*., 2019).

In the Neotropics, there are reports of squirrels eating mushrooms from Panama, Colombia and Brazil (Heaney & Thorington, 1978; Vasco-Palacios *et al*. , 2008; Ribeiro *et al*., 2009), but in the latter , there are no reports of a fungus consumed by squirrels that is identified to the specific level (Ribeiro *et al*., 2009; Trierveiler-Pereira *et al*., 2016). Therefore, the aim of this paper is to describe mycophagous events involving *Guerlinguetus brasiliensis* (Gmelin, 1788), the Brazilian squirrel.

MATERIALS & METHODS

Observation area

The present report is based on direct observations of fungivorous behavior in Ilhabela State Park, São Paulo State, Brazil (Fig. 1). Ilhabela, located between 23º46'28''S and 45º21'20''W, is an important fragment of insular Atlantic Forest (area = 347.5 km²). The regional climate, according to the Köppen classification, is type Cfb (regional humid tropical without a dry season), with an average annual temperature of 18–22 °C (Aguirre et al. 2018). The observation of the mycophagous event happened on 24 May 2019 at 2 p.m. (local coordinates: 23°50'02.9"S, 45°21'45.7"W).

Taxonomic identification

The squirrel species identification is based on literature (Patton *et al*., 2015; Graipel *et al*., 2017) and was confirmed by the mastozoologist MSc Hugo Borguezan Mozerle. All data collection was noninvasive and the animal was not captured for this study. Basidiomes were pho-

Figure 1. Location of Ilhabela, an archipelago in the Atlantic Ocean. Map modified from https://www.wikipedia.org/

tographed and identified following traditional fieldwork and taxonomic methods for macrofungi (Capelari & Gugliotta, 2005; Petersen *et al*., 2008; Petersen & Hughes, 2010; Magnago *et al*., 2016).

The observed mycophagous event was photographed and lasted about nine minutes. After the squirrel finished its meal, the mushrooms were also photographed.

RESULTS AND DISCUSSION

A single individual of *Guerlinguetus brasiliensis* came down from the branches of a mango tree (*Mangifera indica* L.) to its trunk where the mushrooms were growing, about 1.5 meters above the ground.

First, the squirrel bit the pileus (cap) of a mushroom, and soon bit it again, leaving only the stipe (stalk). The squirrel went to the other side of the trunk and with the aid of his front paws removed the pileus of another mushroom and ate it with a few bites (in sitting position) (Fig. 2a). Finally, the squirrel removed a third pileus and took it with him to branches higher in the tree.

The mushrooms consumed by the squirrel were identified as *Oudemansiella cubensis* (Berk. & M.A. Curtis) R.H. Petersen (= *O. platensis* (Speg.) Speg., according to Alberti *et al*., 2020).

Guerlinguetus brasiliensis (= *Sciurus aestuans* G. Marcgraf), commonly known as "serelepe" and "caxinguelê" in Brazil, is the only squirrel species in the Atlantic Forest (Patton *et al*., 2015). According to Patton *et al*. (2015), there

Figure 2. a. Brazilian squirrel *(Guerlinguetus brasiliensis)* eating mushrooms growing from a tree trunk. b-c. *Oudemansiella cubensis (Coconut mushrooms)* consumed by the squirrel (Photographs by A. Francisco)

are two subspecies in this biome: *G. brasiliensis brasiliensis* from northeastern Brazil, in the states of Ceará, Rio Grande do Norte, Pernambuco, Alagoas, Sergipe, and Bahia; and *G. brasiliensis ingrami* in coastal Brazil, from Espírito Santo south to Rio Grande do Sul (Fig. 3a). Despite that it is a small mammal (adult mass averages 193g), it is easily identified from photographs (Mazza *et al*., 2018).

The Brazilian squirrel has a generalist diet that mainly comprises palm fruits; however, it is also known to consume seeds, other plant parts, eggs, small birds, invertebrates (beetles), mushrooms, moss and lichens, depending on the circumstance and opportunity (Bordignon & Monteiro-Filho, 1999; Alvarenga & Talamoni, 2006; Mendes *et al*., 2019). Data presented in this study is relevant because fungal taxa consumed by *G. brasiliensis* have not been reported in literature yet (e.g., Bordignon & Monteiro-Filho, 1999).

The mushroom eaten by the squirrel in Ilhabela, *O. cubensis*, was identified based on the following features: geographical distribution (it is a common species in the Brazilian Atlantic Forest); basidiomes growing on tree trunk (lignicolous habitat); pileus campanulate to hemispherical, surface white with brown to gray scales; pileus margin appendiculate (with remnants from the ephemeral partial veil); lamellae white, adnate; stipe white, straight to curved (Figs. 3b, c).

The consumption of *Oudemansiella* mushrooms by a Neotropical squirrel is reported here for the first time. Probably, this was not an isolated event, as two other similar situations have already been reported to us by collaborators (data not published).

According to Mendes *et al*. (2019), the fungal taxa reported to be consumed by Neotropical squirrels are the following: *Lentinula raphanica* (Murrill) Mata & R.H. Petersen, *Trogia* aff. *buccinalis* (Mont.) Pat., *Hydropus* cf. *cavipes* (Pat. & Gaillard) Dennis, *Pleurotus* sp., and an unidentified member of *Tricholomataceae* (Table 1). Species of *Oudemansiella* are also edible to humans and consumed by different ethnic groups (Ruegger *et al*., 2001; Boa, 2004; Franco-Molano *et al*., 2005; Trierveiler-Pereira, 2024). In Brazil, *O. cubensis* it has been called "coconut mushroom" among mycologists and enthusiasts, due to its fragrance.

According to the observed event, the squirrel showed a preference for a specific part of the mushroom: the pileus. Castillo-Guevara (2012) stated that the hymenium is the most consumed structure in mycophagous events, suggesting that there is differential consumption of structures of epigeous basidiomes. Since the hymenophore

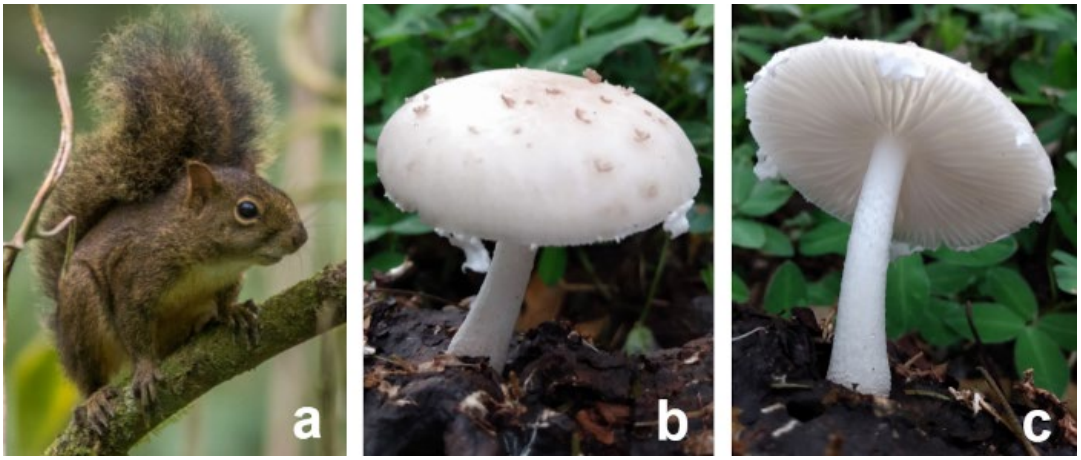

Figure 3. Brazilian squirrel, *Guerlinguetus brasiliensis*. b-c. Coconut mushroom, *Oudemansiella cubensis* (Photographs: a by Fernando Bittencourt de Farias; b, c by Larissa Trierveiler-Pereira)

Table 1. Reported fungal taxa consumed by Neotropical squirrels

Fungal taxa	Squirrel species	Country	Reference
Lentinula raphanica, Trogia aff. *buccinalis*, *Hydropus* cf. *cavipes*	*Microsciurus flaviventer*	Colombia	Vasco-Palacios *et al.* (2008)
Pleurotus sp.; unidentified *Tricholomataceae* species.	*Notosciurus granatensis*	Panama	Heaney & Thorington (1978)

produces the basidiospores, we assume that mycophagous animals are important dispersers of species.

It is also interesting that at the end of the event the squirrel removed the pileus of a mushroom and took it away. Although the squirrel might have left because it was disturbed by human presence, it is also possible that it took the mushroom for later consumption. There are reports that squirrels cache mushrooms for this purpose (Hardy, 1949; Lurz & South, 1998; Fogel & Trappe, 1978; Hendricks & Hendricks, 2015; Vernes & Poirier, 2007). First the squirrels dry the mushrooms, usually by hanging them on branches, store them; in doing so, they avoid mushroom damage caused by moisture (Buller, 1920; Vernes & Poirier, 2007).

Squirrel caches containing fungi can be hidden in tree hollows, dead standing trees, clusters of twigs on tree branches, nests, and holes beneath logs and stumps at ground level. One study from British Columbia found that a red squirrel cache in a burned-out tree stump contained almost 60 specimens of epigeous and hypogeous macrofungi, representing 13 species (Hardy 1949).

Concluding, we can state that saprotrophic, epigeous mushrooms are abundant in tropical forest ecosystems and represent an important source of water, protein, carbohydrates and minerals for many animals (Fogel & Trappe, 1978). Therefore, there is no reason to believe that Neotropical squirrels pay less attention to edible mushrooms.

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AUTHORS CONTRIBUTIONS

LTP: conceptualization, validation, writing (original draft, review & editing); AF: methodology, data curation, writing (review); JMB: validation, writing (original draft & review).

CONFLICTS OF INTEREST

None.

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