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Density of the Tegu Lizard (*Tupinambis merianae*) and its Role as Nest Predator at Anchieta Island, Brazil

Densidade de teiús (*Tupinambis merianae*) e seu papel como predador de ninhos na ilha Anchieta, Brasil

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Abstract

Mammals has been pointed out to be the main nest predators in islands, but recent studies has shown that tree snakes are also important nest predator in tropical forests. Here we present information on the density tegu lizards *Tupinambis merianae* and its role as nest predator at Anchieta Island, Ubatuba, in southeastern Brazil. The mean density of tegu lizards was estimated to be 83 individuals/km^2, which is 1.83 times lower than other well-known population (Fernando de Noronha Archipelago). In the dense rainforest, the density was estimated in 20 individuas/km^2, and in the open rainforest, 109 ind/km^2. The high density of this lizard may have serious implications for nest predation. We found that 36% of artificial plasticine eggs were "preyed upon" by tegu lizards. Therefore, it is paramount to manage the tegu population on Anchieta Island to assure the survival of ground nesting birds in islands and possibly in forest fragments.

Key words: Teiidae, islands, insular ecosystems, nest predation.

Resumo

Mamíferos têm sido apontados como os principais predadores de ninhos em ilhas. Estudos recentes demonstram que serpentes arborícolas também são importantes predadores de ninhos em florestas tropicais. Este estudo apresenta dados sobre a densidade de *Tupinambis merianae* (teiús) na ilha de Anchieta (Ubatuba, SP) e seu papel como predador de ninhos. A densidade média de teiús na ilha foi estimada em 83 indivíduos/km^2, 1,83 vezes menor que outra população bem conhecida (e.g., arquipélago de Fernando de Noronha). Em florestas chuvosas densas, a densidade estimada de teiús é de 20 indivíduos/km^2, e de 109 indivíduos/km^2 nas abertas. A alta densidade de teiús pode ter sérias implicações na predação de ninhos. Na área estudada, 36% dos ovos artificiais utilizados no experimento foram "predados" por teiús. Assim, é fundamental monitorar a população de teiús na ilha Anchieta para garantir a sobrevivência de filhotes de pássaros que constroem seus ninhos no chão, em ilhas e, possivelmente, em fragmentos de florestas.

Palavras-chave: Teiidae, ilhas, ecossistemas insulares, predação de ninhos.

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Introduction

On islands, invasive predators have induced the extinction or reduction of populations of many endemic bird species (Atkinson, 1985; Thibault, *et al*., 2002), among other organisms. Mammals, especially small rodents, have been pointed out to be the main nest predators on islands (Cuthbert and Hilton, 2004; Pangau-Adam *et al*., 2006). However, video evidence of predators attacking understory bird nests on Barro Colorado Island, in Gatun Lake, Panama, indicated that 80% of the attacks were performed by snakes, not mammals (Weatherhead and Blouin-Demers, 2004; Robinson *et al*., 2005). Besides snakes, other sun-loving nest predators, such as large-bodied lizards, are more abundant in human-altered landscapes (Chalfoun *et al.*, 2002), but we still know very little the role of these reptiles on nest predation.

In many areas in the Neotropics, the tegu lizards (*Tupinambis* spp.) are the ubiquitous component of open areas, closed forests, forest fragments and disturbed areas (Sazima and Haddad, 1992; Werneck and Colli, 2006). The genus *Tupinambis* contains the largest lizards in the New World (Presch, 1973) being widespread throughout much of South America (Avila-Pires, 1995). Species in this genus are traditionally hunted by some indigenous peoples for subsistence, and are also important sources of leather and meat in some countries, such as Argentina (Fitzgerald *et al.*, 1991). *Tupinambis merianae* occurs in most of the open and forest regions in southeastern Brazil. They have an omnivorous diet that may include invertebrates, vertebrates, bird and turtle eggs, and various species of fruits (Presch, 1973; Sazima and Haddad, 1992; Tortato, 2007), and potentially can act as seed dispersers (Castro and Galetti, 2004). These lizards move about and forage in open areas and forest edges (Sazima and Haddad, 1992) and are frequently seen sunning themselves in the summer, whereas during the colder months they remain inactive in their burrows for a long period (King *et al*., 1994; Lopes, 1986; Abe, 1983; Van Sluys and Rocha, 1999).

In the 1950's, two male-female pairs of *Tupinambis merianae* were introduced on the Fernando de Noronha Archipelago (north of Brazil) with the intention of controlling the local rat population. Since then, the lizard population size on island increased dramatically. It is currently estimated that from 2,000-8,000 individuals inhabit the main island, a piece of land of approximately 17 km² (Péres Jr., 2003). This high population of tegu lizards had a large impact in the predation of eggs of birds that nest on the ground and sea turtles (Péres Jr., 2003). However, there is, as yet, no precise information regarding the impact of the tegu on nest predation.

At Anchieta Island, in the coast of São Paulo, the introduction of mammal nest predators, such as coatis, marmosets and capuchin monkeys, have been pointed out to be one important cause of the extinction of some bird species (M. Galetti, personal observation; Alvarez and Galetti, 2007). In this island, tegu lizards are native and present a high population, but their role as nest predators was never measured. Therefore, the present study was carried out to estimate the density and habitat use of the tegu lizard (*Tupinambis merianae*), as well as its role in nest predation in tropical Anchieta Island in the Southeastern Atlantic coast of Brazil.

Methods

The study was conducted on Anchieta Island (45º02'-45º04'W, 23º27'-23º34'S), located 540 m off the northern coast of the State of São Paulo, in Ubatuba, Brazil (Alvarez *et al*. 2008). With 828 ha, Anchieta Island has a history of degradation that dates back to the 19th Century, with deforestation starting in the 20th Century as a result of agricultural activities, including coffee and sugar cane plantations, and the construction of distilleries and, later, a prison. After it was declared a protected area in 1977 (Parque Estadual Ilha Anchieta), the island underwent no further drastic alterations directly provoked by human actions, except for the introduction of some animals in March of 1983 (Guillaumon *et al*., 1989).

The vegetation on the island is composed of premontane Atlantic Forest (pluvial tropical forest) with coastal plains highlighted by a stretch of "restinga" (coastal sand dune habitats dominated by herbaceous and schrubby vegetation), *Gleichenium* (ferns), seven beaches, and rocky coasts. Located on relief characterized by escarpments, the balance is considered fragile, and natural avalanches and landslides are common (Cruz, 1974). Anchieta Island is one of the largest tourist attractions in Ubatuba and one of the five most-visited state parks in the State of São Paulo, receiving approximately 90 million tourists annually (Robim, M.J. personal communication).

In March of 1983, the São Paulo Zoo introduced 100 animals from 15 species of mammals plus 48 reptiles from two species tortoise (Guillaumon *et al*., 1989). Despite these introductions, the tegu lizard (*Tupinambis merianae)* was not introduced on the island, but is native and one of the few species of reptile present. The most recent studies show that the density of mammals in 2005 reached 480 individuals/km² (Bovendorp and Galetti, 2007) and that this high density of animals has a strong impact on nest predation (Alvarez and Galetti, 2007) and plant recruitment (Alvarez *et al*., 2008).

To estimate the population density, the line transect method was used covering four trails on the island that varied from one to two kilometers in length. The vegetative coverage of the island consists of 454 ha of open rainforest and a portion of 162 ha of dense rainforest, as well as 198.5 ha of anthropic fields, restinga, sand, rocky coasts, and constructed area (M. Fleury, personal communication). The dense forest is characterized by larger trees and the smaller presence of *Gleichenium* ferns, and

is located mainly in the northwestern portion of the island, whereas the open rainforest, with larger clearings and significant stretches of ferns, is located in the southwest (Guillaumon *et al*., 1989). We performed transects both in the open rainforest and in the dense rainforest environments.

The density and population size of the tegu lizards were estimated using the *Distance* 4.1 software (Buckland *et al*., 1993). The trails were walked slowly (approximately 1km/h) from 06:30 to 11:00 h and from 13:00 to 17:00 h. This method is included in the category of methods for sampling at a distance and that use the detection function *g(y)*, which represents the probability of detecting the object (group or individual) at a distance *y* from the transect line (Buckland *et al*., 1993).

To assess the impact of the tegu lizards on nest predation, experiments were conducted with artificial nests containing eggs made of modeling clay. In February 2005, 30 nests manually constructed from leaves were placed on the ground (Maier and DeGraff, 2000). Two synthetic eggs made of white and black Acrilex® modeling clay were placed in each nest to simulate and substitute the eggs of birds that nest in the forest floor, such as Phasianidae, Tinamidae, Caprimulgidae (see Alvarez and Galetti, 2007). The nests were placed at least each 25 m along two trails and checked every three days for a period of 15 days (Bayne and Hobson, 1999). Rubber gloves and boots were used throughout the preparation of nests and the settlement of them on ground during the experiment to minimize the smell of humans (Burke *et al.*, 2004). The predators were identified based on marks (scars) left on the eggs. To aid in the identification, eggs made of modeling clay were offered to tegus lizards raised in captivity in the Department of Zoology at UNESP, Rio Claro. The marks left on the eggs models by the tegus in captivity were compared to those left on eggs models that were experimentally settled on Anchieta Island to confirm for *T. merianae* attempt of consumption of these last. In this paper we used the term "predation" for plasticine eggs because it is a term widely used in nest predation experiments (see Alvarez and Galetti, 2007).

Results and discussion

From January 2004, to March 2005, 118 km of transects along of trails were performed, with 86% of the records of *T. merianae* sightings occurring in the months of December, January, and February (summer). Only 14% of the records were registered in the months of winter in the area (June, July, and August), which corresponded to the period of usual inactivity known for the species (beginning of April to the end of July) (Lopes, 1986; Abe, 1983; Van Sluys and Rocha, 1999).

The estimated effective strip width (ESW) from our census was not significantly different between the two environments sampled (4.3 m for the open forest and 4.5 for the dense forest). The model that best fit our data set was the Half-normal key and gave us an estimate of overall density of 83 ± 16.8 individuals/km^2 for the whole island.

However, we found a considerable difference in terms of density of tegus lizards among the two types of vegetation assessed. In the open forest, we found a density of 109 ± 21.7 individuals/km^2, whereas in the dense forest, the density was 20 ± 15.4 individuals/km^2. The estimated population size of *T. merianae* for Anchieta Island was 688 tegus (ranging from 463 to 1021; CV = 20%). There are few areas to which estimates of the density of *Tupinambis* lizards have been made. For the Fernando de Noronha Archipelago, Péres Jr. (2003) found an estimated density about 1.83 times higher than that we found in Anchieta Island (153 ± 23 individuals/km^2). However, this species was introduced in the archipelago in the 1950's and locally has no natural predators (supposedly only juveniles of this lizard may constitute potential prey of sea birds). On Anchieta Island, the eggs and juveniles of tegu lizards can be preyed on by coatis (*Nasua nasua*), which occur with relatively high density in the area (25 ind/km^2, Bovendorp and Galetti, 2007). The highest abundance of tegus lizards on Anchieta Island occurred in areas usually dominated by open habitats and areas which had undergone some anthropic interference.

Following 15 days of exposure, 86.7 % (N = 26) of the artificial nests had discovered and the eggs models presented marks of attempt to be consumed (based on bite marks). The bite marks left on the eggs made of modeling clay indicated that the tegu lizards tried to consume eggs models on at least 36.7% (N = 11) of the nests since some eggs models were completely destroyed. Our data are suggestive that the high density of tegu lizards at Anchieta Island may negatively influence predation of nests on the forest floor, as has been demonstrated to occur in Fernando de Noronha Archipelago (Péres Jr., 2003). Alvarez and Galetti (2007) suggested that the tegu may be responsible for the disappearance of quail and canary eggs on Anchieta Island due to their ability to swallow the whole eggs, but the identification as predators in natural eggs is rather imprecise compared to plasticine eggs (Marini and Melo, 1998). Currently, no bird species (such as tinamous and quails) are known to nest on the ground at Anchieta Island (although K. Alves recently recorded two species of nightjars *Nyctidromus albicollis* and *Hydropsalis torquata*, but we do not have evidence that they nest in the island), and we do not know in which extent this can be a result of the high local density of tegu lizards and other mesopredators (Bovendorp and Galetti, 2007). Thus, tegu lizards may have profound impact on ground nesting birds in islands (and possibly in forest fragments) and must be taken into account in management programs of biodiversity restoration.

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