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New records of *Rhagomys rufescens* (Rodentia: Sigmodontinae) in the Atlantic forest of Brazil

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Abstract

Since it was trapped in the XIXth century, *Rhagomys rufescens* has been considered a rare endangered sigmodontine rodent and an endemic species of the Atlantic forest. Only a handful of vouchers of this taxon were known by Thomas, 1886. Recently, eight new individuals were collected, providing new geographical, morphological and phylogenetic (based on molecular evidence) information on this species. In the present work we report the southernmost occurrence record for *R. rufescens* at Indaial, Santa Catarina State, with the largest collected series of this species, the northernmost occurrence record at Santa Teresa, Espírito Santo State, and new records from Poços de Caldas, Minas Gerais State, from Ibiúna and Ribeirão Grande, São Paulo State.

Key words: *Rhagomys rufescens*, Atlantic forest, Montane forest and Biogeography

Introduction

Rhagomys rufescens (Thomas 1886) is a rare sigmodontine rodent and an endemic species of the Atlantic forest hotspot. For more than a century this species was thought to be restricted to the state of Rio de Janeiro and erroneously to the state of Minas Gerais (as clarified by Percequillo *et al*. 2004). Unfortunately, the first specimens of *R. rufescens* in the XIXth century lacked precise provenience and habitat description, which made it difficult to understand its geographic distribution. Also, the only known vouchers of this taxon were the two specimens employed by Thomas in the original description of both genus and species of *R. rufescens* (Percequillo *et al.* 2004; Pinheiro *et al.* 2004; Pardini & Umetsu *et al.* 2006; see also Luna & Patterson, 2003; Villalpando *et al.* 2006). Without additional records of this species and in view of widespread habitat conversion in the Atlantic Forest, *Rhagomys rufescens* was included in the IUCN red list (2006) as Critically Endangered and Presumably Extinct in the state of Rio de Janeiro (Baillie 1996; Bergallo 2000).

Recently, four new individuals of *R. rufescens* were collected, providing new geographical, morphological and molecular phylogenetic information on this species (Percequillo *et al.* 2004; Pinheiro *et al.* 2004; Pardini & Umetsu 2006). Even more surprising than its "rediscovery", was the discovery of a related species, *R. longilingua* (Luna & Patterson 2003), from the tropical Andes approximately 1.300 km from the closest Atlantic forest locality. Subsequent, Villalpando *et al*. (2006) recorded *R. longilingua* in Bolivia, extending the distribution of the genus in the tropical Andes.

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In the present work we report the southernmost occurrence record for *Rhagomys rufescens* at Indaial, Santa Catarina State, with the largest collected series of this species, the northernmost occurrence record at Santa Teresa, Espírito Santo State and new records from Poços de Caldas, Minas Gerais State, from Ibiúna and Ribeirão Grande, São Paulo State.

Material and methods

Study Area of Indaial, Santa Catarina State

Mammal inventory was conducted in the Parque Natural Municipal Nascentes do Garcia (PNMNG), located in the State of Santa Catarina, Brazil, south of the municipalities of Blumenau and Indaial. PNMNG presents approximately 5.800 hectares, and is mostly covered with Atlantic forest *sensu stricto* (Floresta Ombrófila Densa; Gaplan 1986), with altitudes ranging from 100 to 900 m. The trap site is located at the "Mono" region (27°02'58''S, 49°08'57''W), in the municipality of Indaial which is located at 650 m of altitude. The sampling area suffered complete deforestation for the establishment of pasture from 1970 until the 1980's (Bacca 1988). Nowadays, this area is characterized by a 25 year old vegetation with different stages of regeneration, apart from large areas of bamboo forest, with 15 meters of mean canopy height

A total of 16 field surveys, of three days each, were carried out between February 2005 and May 2006. Ten traps were used per night totaling a sampling effort of 480 trap-nights. A "catwalk" method modified from Kierulff *et al.* (1991) was used. The modified method consists in the traps installed over a dirt road that crosses through a presumably native bamboo patch. In order to enhance the trapping effectiveness, all natural pathways over the road were eliminated and replaced by ten bamboo "catwalks", placed every ten meters at 2m height for 110 meters of road. Ten two doors *Havarhart* traps (*Havarhart* Live Trap Co.) were placed on the "catwalks" without baits to capture the animals. Also, 90 wire mesh live traps of two types 26,5x14,0x15,5 cm and 35,0x18,0x28,0 cm were baited on the ground in a nearby area, obtaining a total of 8.640 traps/night effort (Steiner et al. in prep). Occasional and irregular pitfalls trapping with drift fences (15 traps / 25 liters buckets), resulting in 15 non consecutive days of effort, were made in the same and nearby areas.

Collections of Indaial, Santa Catarina State

Voucher specimens of small mammals sampled in Indaial, Santa Catarina State, were deposited at the Laboratório de Taxidermia/Zoologia – DCN/ Universidade Regional de Blumenau, with the following collection numbers: Males-- FURB 9620, 9861, 9887, 9921, 9949, 12010, 12157; Females-- FURB 9908, 12005, 12009. The collections of the Museu de Zoologia da Universidade de São Paulo were also screened for specimens of genus *Rhagomys* and for identification of the Indaial specimens.

Data analyses

We compiled information from literature on collecting localities for *Rhagomys rufescens* and *R. longilingua* (Luna & Patterson 2003; Percequillo *et al*. 2004; Pinheiro *et al*. 2004; Pardini & Umetsu, 2006; Villalpando *et al.* 2006). For localities with precise GPS information, we used a geographic information system (ArcView® 3.1) to assess distributional patterns regarding the South American vegetation (Eva *et al.* 2002). For specimens without precise coordinates, we tried posterior georeferencing using information for legal definition of preservation areas which contain geographical information and from online gazetteers (http://www.fallingrain.com/world/) and from GIS.

Results

Data from Indaial, Santa Catarina State

Ten specimens of *R. rufescens* were registered at PNMNG (see above). They were captured exclusively with the "catwalk" traps. Only single individuals were trapped in each survey, except in the August 2005 survey where 2 individuals were caught. These are the first males ever collected for this species, as all other specimens were either females or lacked gender determination (Thomas 1886; Pinheiro *et al*. 2004; Percequillo *et al*. 2004). All five individuals captured alive showed an active and agitated behavior and great climbing ability in the trap, corroborating the hypothesis of scansorial/arboreal habit. We tried to feed the animals with different types of food, once no bait was used in the capture. Fruits (*e.g.* bananas), bacon, small insects (dead and alive) and coleopteran larvae were offered but none was consumed, even though stomach content analyses suggested an insectivorous diet (Luna & Patterson 2003; Pinheiro *et al*. 2004).

Other newly mentionned records of *R. rufescens*

Two individuals of *Rhagomys rufescens* were recorded at the Museu de Zoologia da Universidade de São Paulo, under the field numbers MZUSP 33889 and MZUSP 33890. Both specimens were obtained by Cristina Monteiro-Leonel at the locality of Retiro-Branco (21°47'S, 46°31'W), Poços de Caldas, Minas Gerais state, in a property of ALCOA Alumínio S.A. The site has a total area of 6,44 ha and is located at 1.553 m of altitude in the high plateau of Poços de Caldas, Minas Gerais. The area has suffered great anthropogenic impact being deforested and the superficial layer of soil removed for bauxite mining between 1978 and 1981. Around 1983, the area was recovered and reforested (Monteiro-Leonel 2004). In the neighboring areas, the vegetation consists of a mosaic, with transition areas between semi-deciduous forest, evergreen mixed forests and cerrado (savanna-like vegetation; Nappo *et al.* 2005). At the capture site, leaf litter is abundant, the canopy is not continuous, but presents a dense arboreal stratum formed by young trees and bamboo. The trees have a mean diameter at breast height of 15cm and 20m of mean height (Nappo *et al.* 2005).

The three new individuals from the state of São Paulo were collected by A. A. Bueno and R. Pardini (pers. comm. and unpubl. data). One of the individuals was captured near the city of Ibiúna in a fragment of closed forest in the Reserva Florestal do Morro Grande, where two other specimens of *R. rufescens* have been registered (Pardini & Umetsu 2006). Method of capture, elevations and detailed description of the relief can be obtained in Metzger *et al.* (2006) and Pardini and Umetsu (2006). The other records are two individuals collected with pitfalls traps of 60 litres in a continuous forest adjacent to the Parque Estadual de Intervales, in Ribeirão Grande. With a vegetal physiognomy similar to the one found in the Reserva Florestal do Morro Grande, the areas are composed of mature or secondary forests that have an intense and selective deforestation with altitudes ranging from 800-1000m.

The northernmost occurrence of *R. rufescens* was discovered by M. Passamani (pers. comm. and unpubl. data). The study area (19º 58`S e 40º 35`W) is close to Estação Ecológica de Santa Lúcia, in Santa Teresa. The area is covered by Atlantic Forest in good stage of conservation, in altitudes ranging from 795-873 m. The capture was made with Sherman traps. The baits used were composed of banana and a mixture of cornmeal, peanut and oil of liver cod (Scot emulsion).

General geographic distribution

The new occurrences documented in the present work in addition to existing data on *R. rufescens* identified the southernmost occurrence of the species within the Atlantic forest around Indaial, Santa Catarina (27°02'S, 49°08'W), and the northernmost in the surroundings of Santa Teresa, Espírito Santo State (19º58`S e 40º35`W), localities which are separated by at least 1173 km. All the known specimens / records of *R. rufescens* are summarized in Table 1, consisting in one individual from Viçosa (Mata do Paraíso), Minas Gerais state; one individual from Ubatuba (Parque Estadual da Serra do Mar), two from Morro Grande (Reserva Florestal do Morro Grande), both in São Paulo state; the holotype described by O. Thomas supposedly from Rio de Janeiro state and two additional specimens without precise information (Pinheiro *et al.* 2004; Percequillo *et al.* 2004; Pardini & Umetsu *et al.* 2006).

TABLE 1. Geographic information of known specimens with collection numbers of *Rhagomys rufescens.* Vegetation types obtained from Eva *et al.*, 2002. A—Present work; B—Pinheiro *et al.*, 2004; C—http://www.fallingrain.com; D—Percequillo *et al.*, 2004; E—Collector; G—Metzger *et al.*, 2006 and Pardini & Umetsu, 2006; J—Passos *et al.*, 2003. Localities without number of collections are coded ???.

Specimens	Locality	State / Depart.	Country	Latitude	Longitude
FURB Series	PNMNG – Mono, Indaial	SC	Brazil	-27.0494	-49.1491
MN 65545	Parque Estadual Serra do Mar, Ubatuba	SP	Brazil	-23.3333	-44.8500
???	Ibiúna - Caucaia do Alto	SP	Brazil	-23.6833	-47.0330
??? ???	Reserva Florestal Morro Grande, Ibiúna	SP	Brazil	-23.7000	-47.5416
??? ???	Parque Estadual de Intervales, Ribeiro Grande	SP	Brazil	24.2666	48.4000
MZUSP 31952	Reserva Estadual Itapetinga, Atibaia	SP	Brazil	-	-
Type: BMNH 86.2.8.5	???	RJ	Brazil	-	-
MN 66056	Mata do Paraíso, Viçosa	MG	Brazil	-20.7500	-42.8833
MZUSP 33889 MZUSP 33890	Poços de Caldas	MG	Brazil	-21.7846	-46.5183
???	Santa Teresa	ES	Brazil	-19.9666	-40.5833
BMNH 48.5.6.13	???	-	Brazil	-	-

continued.

Specimens	Source of geographical coordinates	Vegetation	Comments on vegetation and altitude
FURB Series	A	Montane forest 500-900m dense evergreen	see text
MN 65545	B	Closed evergreen tropical forest	Montane forest open evergreen 0.5mi NE.
???	C	Open shrubland	Montane forest 500-1000m dense evergreen within 2mi E.
??? ???	G	Montane forest 860-1075m open evergreen	-
??? ???	J	Montane forest 800-1000m open evergreen	-
MZUSP 31952	-	-	Montane Forest 500-1000m closed deciduous within 1,6mi S.
Type: BMNH 86.2.8.5	-	-	-
MN 66056	D	Agriculture intensive	Patches of Montane forest closed deciduous within 0.6, 2, 4 mi E, E, SE.
MZUSP 33889 MZUSP 33890	E	Montane forest - fragment reforestation	see text
???	E	Shrub savannah	Montane 500-1000 Collected at 795 – 873m
BMNH 48.5.6.13	-	-	-

GIS plotting of collecting localities indicate that *R. rufescens* occurs mainly in or nearby montane forests (Fig. 1).

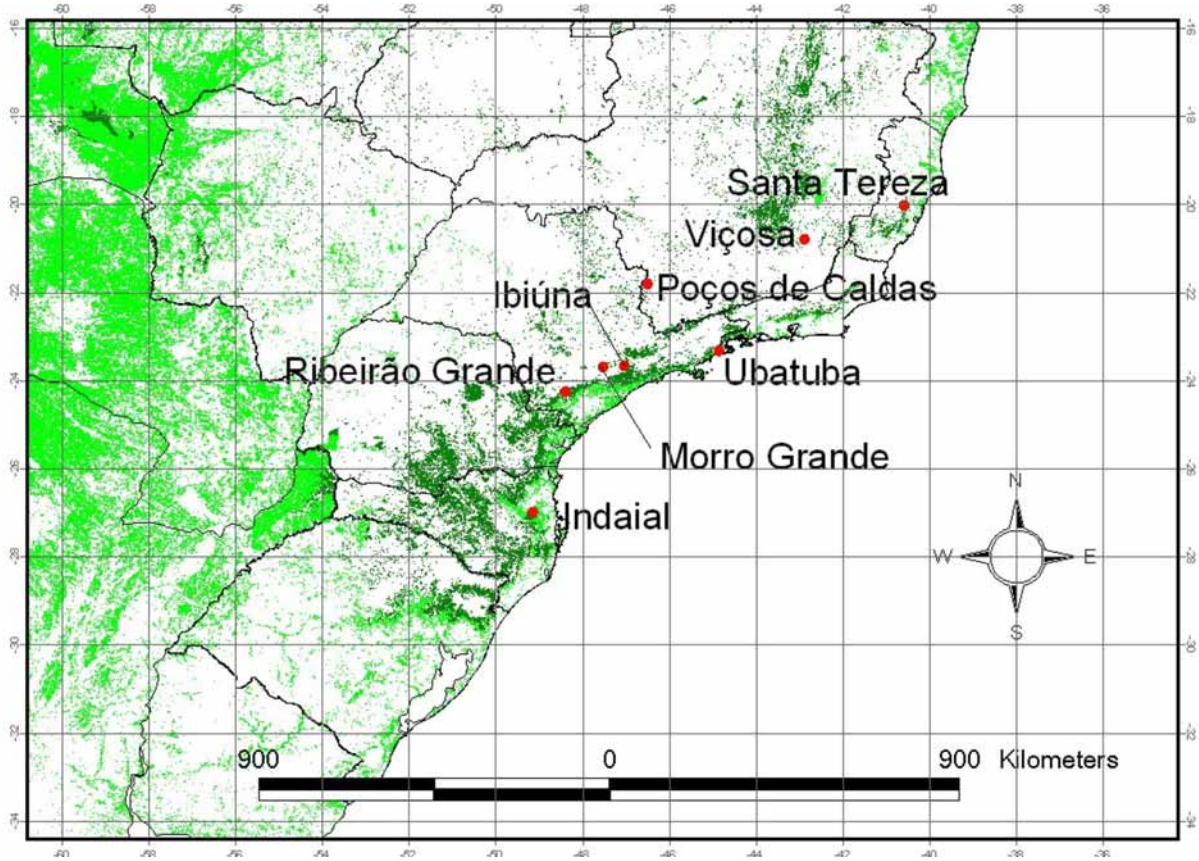

FIGURE 1. Collecting localities of *Rhagomys rufescens*. The details of localities are specified in Table 1. In light green lowland forests, in dark green montane forests with altitude range of 500–1000m, and in brown montane forests with altitudes superior to 1000 m. Vegetation map at 1 km resolution from Eva *et al*. (2002).

Discussion

The collection of a large series with a relatively small, yet specific sampling effort raises the questions whether *Rhagomys rufescens* is in fact a rare species or if it is under-sampled due to inadequate collecting methods. The rarity of records in the Atlantic forest, which is probably the best sampled Brazilian biome, favors the first hypothesis. Also, all the recent captures of *R. rufescens* available in the literature were made using pitfall traps (with the exception of the record from Santa Teresa), suggesting a higher efficiency of the pitfall traps in capturing the species (see Voss & Emmons 1996; Hice & Schimidly 2002). More specifically, Umetsu *et al*. (2006) have shown that pitfalls traps captured 16 out of 29 species of non-flying small mammals inventoried in 26 Atlantic forest sites, and took more individuals *per* species than other trapping methods.

Through our study in Indaial, with a strictly arboreal baitless capture method, we doubled the number of known specimens. Moreover, no individual of *R. rufescens* was captured nearby, despite two consecutive years of sampling with 90 Tomahawk type traps placed underground. Finally, 15 days of random sampling with 15 pitfall traps with drift fence in the same and nearby areas was not successful in capturing *R. rufescens* (unpubl. data). Nevertheless, considering the non-standardized sampling implied by this method, we did not envisage performing qualitative comparison with other methods to evaluate its efficiency. Our data and literature compilation seem to indicate that the rarity of *R. rufescens* might be more due to sampling bias than to its rarity in the wild, although this consideration is based only on a few field surveys.

The available collecting localities of *R. rufescens* indicate that this species might be an endemic of the Atlantic forest, despite its occurrence within this biome being not well understood. With the exception of the record from Ubatuba (Pinheiro *et al.* 2004), an interesting pattern is that all specimens with known informa-

tion are distributed at altitudes above 500 m in transitional vegetation zones with montane forests. However, more sampling efforts are needed in these ecosystems to confirm this pattern of occurrence. The present work also suggested that additional sampling is also needed in areas that suffered intense and selective deforestation, where the majority of the captures here reported occurred.

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