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Original Investigation

Home range, movements and diurnal roosts of the endangered thin-spined porcupine, *Chaetomys subspinosus* (Rodentia: Erethizontidae), in the Brazilian Atlantic Forest

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ABSTRACT

Chaetomys subspinosus is the sole species within the Chaetomyinae subfamily of Caviomorph rodents. This poorly studied porcupine is restricted to the Atlantic Forest in eastern Brazil, where deforestation and habitat fragmentation threaten its survival. Data on the ranging and roosting behavior of *C. subspinosus* is fairly scarce as it is difficult to observe these behaviors in nature and, consequently, it is very rarely detected during field surveys. We monitored the home ranges of three radio-tagged females over the course of 1 year (2005–2006) and collected data on several aspects of their natural history including movement patterns and the use of diurnal roosts and latrines. The animals were monitored at Parque Estadual Paulo Cesar Vinha, a nature reserve dominated by restinga forests, a subtype of Atlantic Forest occurring on sandy soil. The estimated home range varied little between individuals and was relatively small (mean = 2.14 ha/individual and 1.09 ha/individual using minimum convex polygon and kernel methods, respectively). The animals travelled an average of 147 m/night (range: 21–324 m/night) between two consecutive day roosts. The day roosts were mostly located on vine and liana tangles in the canopy which also aid in connecting the canopy to adjacent trees or the forest floor. Latrines were mostly located near the ground in places heavily protected by spiny bromeliads or by other tangled vegetation. Our data suggests that *C. subspinosus* has the smallest range among all Neotropical Erethizontids which is likely due to its small size and strictly folivorous diet. Our data also helps explain why *C. subspinosus* is so difficult to observe in nature: researchers should focus on arboreal masses of tangled vegetation where individuals will normally rest during the day.

Introduction

The New World porcupines (Erethizontidae) consist of five genera grouped into two subfamilies: Erethizontinae which includes *Erethizon*, *Echinoprocta*, *Coendou* and *Sphiggurus* species, and Chaetomyinae which is comprised of a single species: the thin-spined porcupine *Chaetomys subspinosus* (Woods and Kilpatrick 2005; Oliveira and Bonvicino 2006). The taxonomic status of *Coendou*, *Sphiggurus* and *Chaetomys* are controversial and in need of review (Carvalho 2000; Voss and da Silva 2001; Bonvicino et al. 2002; Leite et al. 2011; Voss 2011). A recent phylogenetic analysis using mitochondrial markers ratified the position of *Chaetomys* within the Erethizontidae and considered it as the most basal member of the group (Vilela et al. 2009). Similar to other Neotropical porcupines, *C. subspinosus* is nocturnal and arboreal; however other species seem to be less strictly folivorous (Giné et al. 2010; Souto Lima et al. 2010). It is endemic to the central portion of the Brazilian Atlantic Forest (Ávila-Pires 1967; Oliver and Santos 1991) which is considered a biodiversity hotspot (Mittermeier et al. 2004; Laurance 2009) and where only 11.3% of the original habitat remains (Ribeiro et al. 2009). The thin-spined porcupine is listed as "vulnerable" mainly due to habitat destruction and forest fragmentation (Chiarello et al. 2008; IUCN 2010). Its rareness, and nocturnal and elusive behavior have made its natural history difficult to study. As a result, *Chaetomys* had not been recorded for decades until the 1980s when a pioneering survey helped identify its existence, geographic distribution and conservation status (Santos et al. 1987). Although some studies have appeared since that survey (Chiarello et al. 1997; Oliveira 2006; Giné 2009; Giné et al. 2010; Souto Lima et al. 2010; Zortéa and Brito 2010), there is still scant information on several aspects of its natural history. Results of the first long-term study on ecology and behavior of free-ranging individuals were only recently published, showing that *C. subspinosus* adopt

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behavioral strategies to conserve energy, as expected for small arboreal folivores (Oliveira 2006; Giné 2009) and has a very selective diet (Giné et al. 2010; Souto Lima et al. 2010).

The current knowledge of the home range and movement patterns of Erethizontids has been collected from very few species: the North American *Erethizon dorsatum* (Dodge and Barnes 1975; Smith 1979; Roze 1987, 2009; Sweitzer 2003; Morin et al. 2005) and the widespread Neotropical *Coendou prehensilis* (Montgomery and Lubin 1978; Charles-Dominique et al. 1981; Roberts et al. 1985; Santos Junior 1998). Range data for Atlantic Forest species are restricted to two studies on *C. subspinosus* (Giné 2009; Zortéa and Brito 2010) and one study on *Sphiggurus villosus* (Passamani, 2010).

Here we present new data on home range, movement, habitat and diurnal roosts of three wild *C. subspinosus* inhabiting the restinga, a subtype of Atlantic Forest that occurs on sandy soils of marine origins found alongside the Brazilian littoral (Suguio and Tessler 1984). The restinga is a unique ecosystem that is quickly disappearing due to tourism development and urban growth: it comprises less than 0.5% of the Atlantic Forest (Fundação SOS Mata Atlântica and INPE 2008; Ribeiro et al. 2009). Obtaining a deeper knowledge of *Chaetomys*' natural history, including where and how it hides, is a central question for this endangered species' future conservation measures and imminent fieldwork and research initiatives.

Material and methods

Study area

This study was carried out in Parque Estadual Paulo César Vinha (PEPCV) (20°33′ 20°38′S and 40°23′–40°26′W), a 1500 ha reserve (MMA 2000) located in the municipality of Guarapari in the state of Espírito Santo, southeastern Brazil (Fig. 1). The reserve lies on a sandy coastal plain a few meters above sea level. The predominant vegetation is a mosaic of open shrub, low-canopy restinga forest and seasonally flooded areas. The climate (*Aw* in Koppen's classification) is tropical with a rainy summer (October–March) and a dry winter (April–September) (INCAPER 2006). Mean annual temperature is 23 °C and mean annual precipitation is 1307 mm (Fabris and Cesar 1996). The array of mammals in the study area includes 40 continental species and three marine species (Venturini et al. 1996). A second species of tree porcupine, *Sphiggurus* sp., is also present and appears to be more abundant than *C. subspinosus* (Galvão 2003; Pedro Oliveira, pers. obs.). According to Santos et al. (1987) and Bonvicino et al. (2008), the porcupine species expected to occur in PEPCV is *Sphiggurus insidiosus* (=*Coendou insidiosus sensu* Voss (2011)). Since Voss (2011) mentions however that both *Coendou insidiosus* and *C. spinosus* occur in the state of Espírito Santo, further studies are required for correct identification of the second species of the porcupine occurring in PEPCV.

Capture and radio tagging

In March 2005 we captured three adult female *C. subspinosus* after several hours of intensive searching by two observers and one local experienced field assistant. We tried to find specimens of both sexes but failed to find males. All three females were found in their diurnal roosts (hereafter referred to as roosts). The field assistant who is an agile and experienced local tree climber, climbed the tree and captured the animal by securing the terminal third of the tail where there are fewer quills. Specialized climbing equipment was not necessary as trees are relatively short (<15 m) locally. The animal was brought to the ground, weighed, and anaesthetized with a mixture of Xylazine (2 mg/kg of body weight) and Ketamine (5 mg/kg of body weight), which resulted in moderate sedation (Curi et al., in press). A VHF transmitter attached to a ball and chain collar was fitted to the neck of each animal, similarly to previous studies (Chiarello et al. 1997; Giné 2009; Passamani 2010). Experience acquired during a pilot study carried out in another location was useful in judging how tight the collars should be. The transmitter (Telonics Inc., model 205) and collar weighed 60 g, less than 3% of the body weight of an adult *C. subspinosus* (Table 1). Highly reflective tape (3M®) was attached to the transmitter to facilitate locating the animals at night. After a full recovery from the sedative (an average of 46 min), we released the animal back into its tree of capture and monitoring began 20 days afterwards. During handling, we noticed that one female (Ch-970) was pregnant, and throughout the study we observed her caring for her infant as well (see "Results").

Sampling methods

We began radio tracking the animals 3 weeks after capture assuming that this period allowed the animals to adjust to the collar and resume normal activity. We collected monthly data between March 2005 and February 2006 through direct observation. The three porcupines seemed to adapt very quickly to the collars and to our presence; they did not show conspicuous signs of discomfort, illness or sudden changes in behavior and only seemed to be disturbed by loud noises. The distance between the animal and the observer varied between 1.5 and 15 m allowing accurate observations of their feeding and moving activities (Souto Lima et al. 2010) without disturbing their natural behavior.

We conducted campaigns of 3 nights each, totalling 33 nights of monitoring and 150 h and 50 min of nocturnal observation (Table 1). Each study animal was observed one night per month. We radio-located the animals in the late afternoon and observed them throughout the first half of the night (1800–2300 h), and again radio-located them at their resting sites in the following morning. A large proportion of movement and feeding takes place during this period (Chiarello et al. 1997), but nocturnal activity is not restricted to it (Giné 2009). We used binoculars (8 × 40), hand-held torches (rechargeable Maglite® with 12 Watt halogen bulb) and head lamps (3 W Petzl Duo®) to record all observations which were always conducted by two observers. We could not collect observations on the Ch-160 individual in November 2005 because her home range was temporarily flooded. Ch-970 was monitored for nine months in total (from her capture date until December 2005) and was found dead on the forest floor in January 2006. Cause of death could not be determined. At the end of the study period we recaptured the two surviving animals, removed their collars and released them.

Ranging pattern

We calculated home range, movement and habitat use using the locations (i.e. fixes) of diurnal roosts and non-roost trees where the animals performed nocturnal activities such as feeding, defecation (i.e. latrines) and social interactions (e.g. parental care). We marked the location of these trees with flagging tape to map later. We used a sighting compass (Suunto KB-14) and a 20-m measuring tape to precisely map the marked trees. UTM coordinates of all marked trees were recorded, and we measured the night range of each monitoring night using the software AutoCAD Map-2000 (Autodesk, Inc. San Rafael, CA, USA). Nightly range estimates included the following parameters: their afternoon roost (i.e. starting point), to all the trees they visited throughout the night and finally to the roost where they were found the following morning. For each roost, we recorded the tree's height and diameter at breast height (DBH), estimated the number of lianas and vines in the tree crown using four classes (<5, 6–10, 11–20, or >20 vines or lianas); determined the presence or absence of lianas connecting the tree crown to