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LONG DISTANCE AND SHORT TIME MOVEMENT OF A SMALL NEOTROPICAL MARSUPIAL

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Movements of animals, defined as the change in the spatial location of the individual (Nathan *et al.* 2008), play a major role in the ecology of species. It determines their spatial distribution, and is fundamental to understanding the nature of the exchange of genes between populations, feeding habits, mating systems, and exposure to predators, besides its importance for structuring metapopulations and metacommunities, depending on the rate and distance of movements (Bowler & Benton 2007, Baguette *et al*. 2013).

The individual decision to move is based on immediate needs like searching for resources, escaping predation, following adults, or searching for a mate, which are related to general aims like gaining energy, seeking safety, learning, and reproducing (Nathan *et al.* 2008). Long distance movements, beyond the limits of the home range, are considered dispersal events (Sutherland *et al.* 2000). Dispersal can be divided into two major types: juvenile dispersal (*i.e.*, emigration of young from their place of birth) and reproductive dispersal (*i.e.*, the adult movement between reproductive episodes). For mammals, juvenile dispersal has been widely documented, showing that in general, males disperse over larger distances in relation to females, which tend to stay in their place of birth (Greenwood 1980). Here we documented an exceptional long distance daily movement of a small opossum, *Gracilinanus microtarsus* (Wagner, 1842), in a two-year capture-recapture study at the Atlantic forest.

Gracilinanus microtarsus is an Atlantic forest small marsupial (15-25g, Paglia *et al.* 2012; Figure 1). This species is probably semelparous and reproductive period occurs in the wet season (Barros *et al.* 2015a), with a polygynous mating system (Martins *et al.* 2006). Records indicate that this species moves approximately 50 m between successive daily captures, with 200 m as the maximum length of movements recorded within a grid of 4 ha, and males move greater distances than females (Püttker *et al.* 2006).

We collected data at the Morro Grande Forest Reserve (23º39'-23º48'S, 47º01'-46º55'W), in the municipality of Cotia, state of São Paulo, Brazil (Figure 2). It is a 9,400 ha continuous forest connected to the largest tract of remaining Atlantic forest in Brazil, covered by Lower Montane Atlantic Rain Forest in different regeneration stages (Metzger *et al.* 2006). The altitude in the region varies from 850 to 1,100 m above sea level. Mean maximum temperature is 27°C and mean minimum temperature is 11°C. Mean annual rainfall is 1,339 mm, and the warm-wet season is from September to March (Metzger *et al.* 2006).

We set three trapping grids (100 m x 200 m) of approximately 2 ha, at least 2 km apart within the Reserve (Figure 2). All of them were located in the same altitude, type of forest, and regeneration stage. Each grid comprised eleven 100 m parallel lines, 20 m apart from each other, each composed of 11 trap stations every 10 m. Six alternated lines had only 11 Sherman traps (37.5 x 10.0 x 12.0 cm or 23.0 x 7.5 x

8.5 cm) on the ground. The other five lines contained, besides the Sherman traps, 11 pitfall traps (60 L buckets buried at the ground, connected by 50 cm high drift-fences) at the same trap stations, totaling 121 Sherman traps and 55 pitfall traps per grid (for detailed information see Barros *et al.* 2015b).

We performed 21 five-night capture sessions between March 2008 and October 2009 (licenses 11577-1, 11577-2, 11577-4 IBAMA). Captured individuals were marked with tags with unique codes, allowing individual recognition. The events of recapture permit to detect the distance moved by individuals on the trapping grid. The distance moved was calculated by the Euclidian distance between the traps where captures occurred. Age classes were based on the molar teeth eruption pattern (only M1 or M1 and M2 erupted - juveniles; M3 erupted - subadults; M4 erupted - adults) as described by Macedo *et al.* (2006). Voucher specimens of all species were collected in a pilot sample, identified by experts, and are kept in the Department of Zoology, University of São Paulo.

Although recapture rates were generally high in other small mammal species present in the studied community (Barros *et al*. 2005b), we detected only two events of recapture of the 21 individuals of *G. microtarsus* captured, which is probably due to the arboreal habits of this species (Paglia *et al*. 2012). Both events occurred overnight. While one recapture was of an adult female within grid M1 and accounted for 56.6 m of distance moved at the dry season, the other movement at the end of the wet season was of exceptionally long distance. A sub-adult male of 11 grams moved between grids (from grid M2 to grid M1; Figure 2) within 24 hours. The short linear distance between the grids is 1.6 km, thus we considered 1.6 km the minimum distance moved by this animal in an overnight period.

Figure 1. An individual of *Gracilinanus microtarsus* captured in this study.

Small mammals of the Atlantic forest usually have home ranges of at most few hectares, moving only short distances daily (Gentile & Cerqueira 1995, Pires *et al.* 2002, Püttker *et al.* 2006, Püttker *et al.* 2012a). Indeed, long distance dispersal in small mammal species is difficult to record with the usual capture-recapture studies due to the protocols of trapping grids/transects itself. On the other hand, radio tracking studies could most likely detect long distance movements, but the distances recorded with this method is also around few hundreds of meters, even for larger marsupials as *Philander frenatus* (Moraes & Chiarello 2005, Lira *et al.* 2007). As far as we know, the largest movement recorded for didelphid marsupials was 1,050 m for the large bodied *P. frenatus* (Prevedello *et al.* 2009). This movement was considered a homing behaviour - when the animal return to its home range after being moved out of it - registered after the release of an animal at an adjacent pasture and recaptured three days after at his home fragment (Prevedello *et al.* 2009). The movement recorded in this present study, in just 24 hours and without human interference, is unprecedented and reveals unknown abilities of short-time long distance dispersal for this species and probably for didelphid marsupials in general.

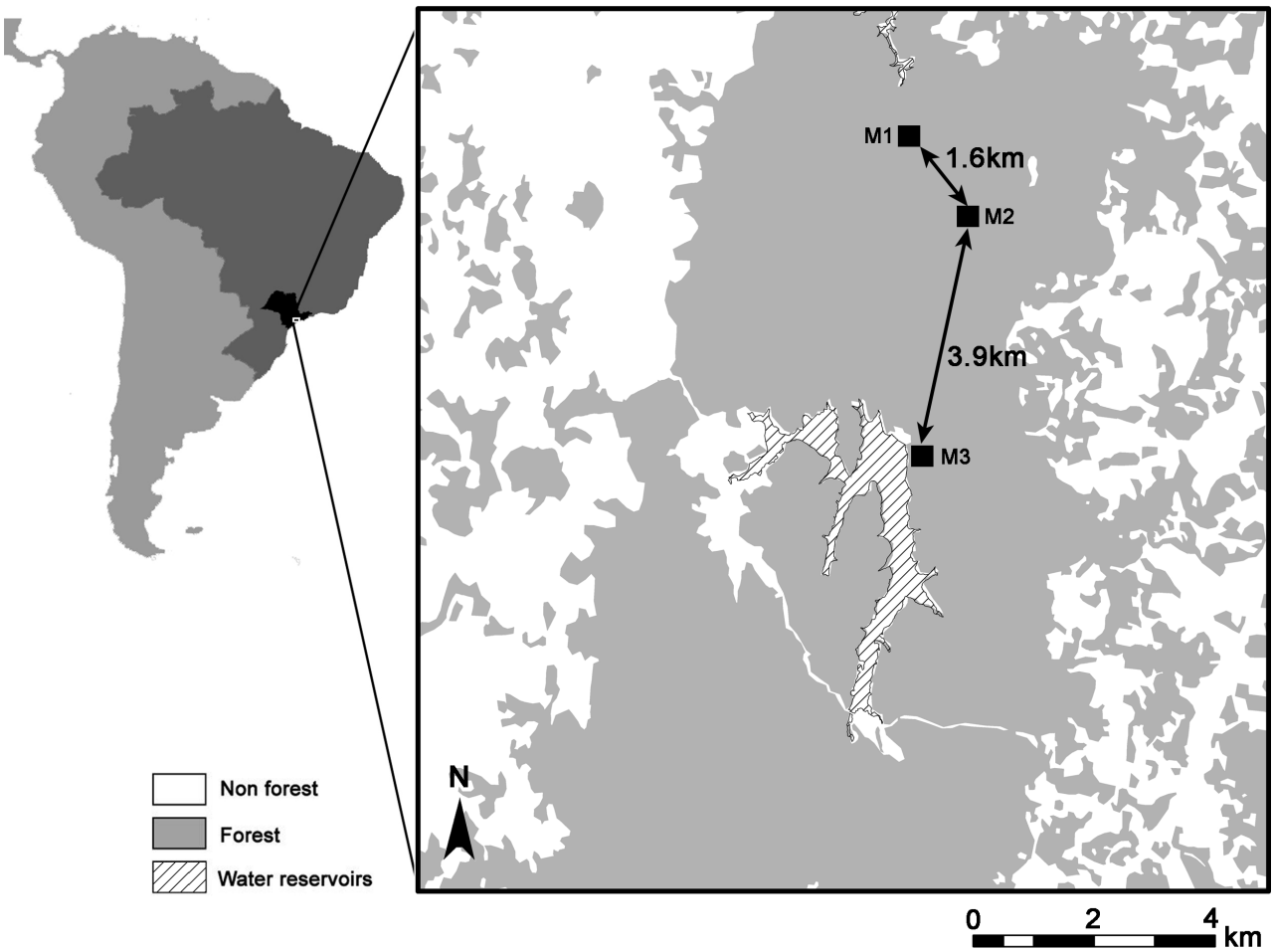

Figure 2. Location of the Morro Grande Forest Reserve (highlighted in a rectangle) in São Paulo State (black), Brazil, near to São Paulo City. Black dots represent the 2 ha trapping grids (North-South direction: M1, M2, M3 grids). Gray areas: forest; white areas: non-forest.

At Atlantic forest fragments, home ranges recorded for *G. microtarsus* varied from 0.05 to 1.1 ha (Passamani & Rosa 2015), and at Cerrado biome, the mean home range for this species is less than 0.2 ha, smaller than the usual home ranges of other Brazilian marsupials (Cáceres *et al.* 2012). The mean distance moved between successive captures were 65.22 ± 7.54 m for males and 38.86 ± 4.46 m for females considering a maximum of six nights between individual captures at fragments adjacent to our study site (Püttker *et al.* 2006). At a fragment in Espírito Santo state the maximum distance moved in 24 h for *G. microtarsus* was 96 m (Passamani & Rosa 2015). The uniqueness of the observation does not allow estimation of how frequent within individuals or among individuals these long-distance movements are in populations of *G. microtarsus*. However, the observation shows that *G. microtarsus* is physiologically able to perform long movements in short time.

The movement recorded exceeds more than 30 times the average values recorded for distance moved between successive captures for the species at Atlantic forest and is therefore considered here a dispersal movement as its high probability of inducing gene flow (Baguette *et al*. 2013). Long distance movements can be a consequence of foraging, juvenile or reproductive behaviour. The 1.6 km movement recorded occurred in the end of the wet season, the time when food resources for this species are considered to be most abundant in comparison to other seasons (Martins & Bonato 2004). Hence the probability that this dispersal is a consequence of foraging behaviour is low. Given the age of the individual, juvenile dispersal in combination with the search for mating partners represent a more likely explanation for the observed movement. In agreement with this hypothesis, Puttker *et al.* (2006) recorded longer distance moved by males than females at Atlantic forest fragments and argued that males of *G. microtarsus* might travel greater distances in the wet season in search for females.

Although the movement recorded here happened in a continuous forest area, it is possible that *G. microtarsus* is capable of short-time long-distance movements also in fragmented landscapes, where dispersal movements are particularly important due to their essential importance for connecting populations inhabiting forest remnants (Baguette *et al.* 2013). Indeed, this species is considered only moderately vulnerable to habitat loss and fragmentation measured by an index based on the occupancy pattern of species in fragmented areas (Püttker *et al.* 2012b). The ability of *G. microtarsus* to move longer distances might help this species to survive in fragmented areas. The occasional and exceptional observation of a short-time long distance movement of this small marsupial reported here highlights a gap of knowledge on space-use of Neotropical marsupials, and encourages future studies on basic species-traits, the description of which might be useful for conservation of species in anthropogenically altered landscapes.

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