Short Note

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Movement and use of environmental structures, climbing supports and shelters by *Akodon montensis* (Sigmodontinae, Rodentia) in the Atlantic Forest of southern Brazil

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Abstract: Movements under environmental structures and on supports, and the use of shelters by *Akodon montensis* were assessed using the spool-and-line technique. Movements of a few individuals of *Thaptomys nigrita*, *Bucepattersonius iheringi* and *Oligoryzomys nigripes* were also assessed and briefly described. *Akodon montensis* often used fallen logs, lianas and ferns as climbing supports for movements. The species moved under different environmental structures with differing frequencies, with greater use of dense litter followed by lianas and fallen branches. The studied sigmodontine species used shelters of different compositions and structures, and differed in displacement behavior. This study is the first to contribute to understanding the movement and use of environmental structures, shelters and climbing supports by *A. montensis*.

Keywords: foraging path; Neotropical cricetid rodents; small mammals; spool-and-line technique; supports for locomotion; use of space.

Several small mammal species coexist in the Neotropics (Emmons and Feer 1997). Mechanisms for reducing

competition among coexisting species may lead to resource partitioning, with the use of space being one of most important niche dimensions in this context (Schoener 1974). Studies on the use of space by small mammals have shown that species tend to travel by specific routes during their foraging activity, selecting different microhabitats (Lozada et al. 2000, Bonaventura et al. 2003, Dalmagro and Vieira 2005, Vieira et al. 2005, Lima et al. 2010); using different refuges, shelters and nests (Miles et al. 1981, Antinuchi and Busch 1992, Cherem et al. 1996, Briani et al. 2001, Loretto et al. 2005, Vieira et al. 2005, Udrizar Sauthier et al. 2010, Brito et al. 2012, Rengifo and Aquino 2012, Brito et al. 2014, Formoso and Sánchez 2014); and moving through different forest strata (Cunha and Vieira 2002, Grelle 2003, Vieira and Monteiro-Filho 2003). Thus, understanding the movement of species can provide insight into the mechanisms of their coexistence (Gordon 2000).

The use of specific environmental structures, such as fallen branches, roots and litter, by rodents may be associated with foraging sites or may represent a strategy for reducing predation risk during foraging as predator avoidance often affects foraging behavior (Kotler 1984, Brown et al. 1988, Schooley et al. 1996, Mandelik et al. 2003, Orrock et al. 2004). Environmental structures that are used for hiding or resting protected during foraging activity are classified as secondary refuges (Pereoglou et al. 2011). On the other hand, shelters and nests are classified as primary refuges, which have specific attributes including nesting structure. Animals exhibit higher fidelity for primary refuges, and use them for resting and to care for offspring. We follow the classification of structures presented by Pereoglou et al. (2011), with some adaptations. We considered “environmental structures” as any environmental structure composed of different substrates that an individual animal moves under, whether to forage, to hide or to rest. Such structures are partially equivalent to the secondary refuges of Pereoglou et al. (2011), although we avoid using the term “refuge” because we were not able to differentiate between refuge and using a foraging site for temporary protection. In turn, we considered “shelters” as more complex and constructed structures that are used with more fidelity (based on the frequency of use),

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which is similar to the primary refuges of Pereoglou et al. (2011). We also evaluate movements over environmental structures, which we considered as “supports”. The spool-and-line technique described by Miles (1976) provides a means of making detailed evaluations of the structures and shelters used by small mammals, as well as assessing the movements and the types of support used to climb (Prevedello et al. 2008), which have been rarely described for Neotropical rodents (but see Melo et al. 2013).

Although *Akodon montensis* Thomas, 1913 is a common species in the southern Atlantic Forest, no information is available concerning this species’ use of shelters, climbing supports and environmental structures. *Akodon montensis* is a cricetid rodent of the subfamily Sigmodontinae. It occurs in southern Brazil (Geise et al. 2001), northeastern Argentina (Pardiñas et al. 2003) and eastern Paraguay (Gamarra de Fox and Martin 1996). It is terrestrial, insectivorous and a forest dweller (Reis et al. 2011), and is particularly abundant in secondary forest formations of Atlantic Forest. The species is commonly associated with sites with abundant leaf litter

layer and dense herbaceous cover (Gentile and Fernandez 1999, Melo et al. 2011, 2013), although this has yet to be investigated directly, which can be done using the spool-and-line technique.

Thus, the aim of this study was to investigate the movements of the rodent *Akodon montensis* in the Atlantic Forest in southern Brazil using the spool-and-line technique. We provide information about the species’ movements under environmental structures and over climbing supports, and its use of shelters. This study also provides limited observations regarding the movements of, and structures and shelters used by, some individuals of other sigmodontine rodent species.

The study was carried out in Parque Estadual do Turvo (PET) located in northwestern Rio Grande do Sul State, Brazil, on the left bank of the Uruguay River, across from which is the province of Misiones in Argentina (27°00’S to 27°20’S, 54°10’W to 53°40’W) (Figure 1). The park encompasses 17,491 ha of Atlantic Forest and is one of the largest protected areas of remaining Atlantic Forest in the region. The vegetation is classified as seasonal deciduous forest

Figure 1: Study area in Parque Estadual do Turvo (PET; gray area of 17,491 ha) in the state of Rio Grande do Sul, Brazil. Top right: Individual of *Akodon montensis* equipped with spool-and-line device. Sample units can be found in Melo et al. (2011).

of the upper Uruguay River (Teixeira et al. 1986, Leite and Klein 1990). The climate of the region is classified as subtropical humid temperate (Cfa according to Köppen), usually with hot humid summers, mild to cold winters, frequent fog, average annual rainfall of 1900 mm and average temperatures between 6.6 and 37.4°C (Vasconcellos et al. 1992).

Twelve linear transects were established spaced 500–1500 m apart and integrating the animal trapping system of another study that sampled several species of small mammals (see Melo et al. 2011). Fifteen Sherman and wire live-traps were placed along each transect at 15-m intervals, alternating between the ground and the understory (3 m high). Additionally, two pitfall traps (30-l buckets) connected by a plastic drift fence (36 m) were installed 100 m from the end of each transect. The live-traps were baited with a mixture of bacon, pumpkin and peanut butter. The fieldwork was carried out in six bimonthly phases at eight transects (T1–T8), starting in October 2008 and ending in September 2009; and in five bimonthly phases at the remaining four transects (T9–T12), starting in December 2008 and ending in September 2009. Three additional field campaigns in July, October and November 2010 were conducted in T1 and T2. Each captured individual was tagged with a numbered ear tag (Fish and Small Animal Tag size 1, National Band and Tag Co., Newport, KY, USA) and their species, sex and location of capture were recorded.

We selected four abundant rodent species frequently captured in PET (Melo et al. 2011) for tracking using the spool-and-line technique. Individuals were equipped with spool-and-line tracking devices (Cansew Inc., Montréal, Québec, Canada) weighing 1.7 g and possessing 100 m of line, following Cunha and Vieira (2002) and detailed by Delciellos et al. (2006) (Figure 1). Individuals with tracking devices were released during the day with the path they traveled being recorded the following day. Due to the nocturnal habit of the species, the first 20 m traveled was discarded as potentially representing unusual patterns of displacement due to escape behavior. For the remainder of the trajectory we recorded the geographical coordinates of the starting point and mapped the line with a compass and a measuring tape. We also recorded the distance and degree of azimuth between each point whenever there was a change of direction or inclination of greater than 30°.

Information on the structures and shelters used was recorded, including their composition (type of environmental structures), their use as either supports to climb above ground level or as environmental structures to move under. The following criteria were considered to differentiate the structures to move under, shelters and climbing supports: (1) any environmental structure used

as a substrate to move under, whether for hiding, resting or foraging was considered an environmental structure; (2) more complex constructed structures with one or more entrances and used more than once were considered shelters; (3) any structure used to climb above the ground when the inclination angle marked by the path of the line was greater than 30° in relation to the ground was considered a “support”. Differences in the frequency of use of the different types of environmental structures to move under and different types of supports by *Akodon montensis* were evaluated with the Kruskal-Wallis test using Past v.2.17 software (Hammer et al. 2001).

A total of 1194 m of track-line was recorded for 14 individuals of the four studied species: *Akodon montensis* Thomas 1913 (nine individuals), *Thaptomys nigrita* (Lichtenstein 1830) (two), *Bucepattersonius iheringi* (Thomas 1896) (one) and *Oligoryzomys nigripes* (Olfers 1818) (two). Frequent losses of spool-and-line devices, associated with the rainy conditions common in the region, were responsible for the low number of observations for most species. In general, the species mostly moved on the forest floor, with the exception being *O. nigripes*, which travelled more in the understory climbing on shrubs than did the other species ($\bar{X}=159.0 \pm 54$ cm; 6% of total tracked distance). For mainly terrestrial species, most of the substrates used as supports for climbing above the ground did not reach the understory (maximum 40 cm in height), such as fallen logs, rhizome trunks of arborescent ferns and lianas close to the ground. The specific environmental structures used by most of the species were roots, dense leaf litter layer, fallen dry branches, fern rhizome trunks, fallen logs, liana tangles and bamboos. The relative frequency of use of each structure was calculated considering all structures observed in each category (environmental structure or support) for each species (Table 1). Twenty shelters were found for *A. montensis*, one shelter for *T. nigrita* and six shelters for *B. iheringi*; no shelters were found for *O. nigripes*.

The frequencies by which the different types of substrates, i.e. the number of events observed for the use of each structure, were used by *Akodon montensis* (two young, three females and four adult males) differed significantly ($H=21.74$, $n=9$, $p<0.001$), with the most frequent being the dense leaf litter layer (median=6 events observed, 25th–75th percentile range=3–8), followed by lianas (median=6, 25th–75th percentile range=3–9) and fallen branches (median=3, with a percentile range=1–8). There were also significant differences in the frequencies of use of the types of climbing supports ($H=19.4$, $n=9$, $p<0.001$), with the most frequent being fallen logs (median=5, 25th–75th percentile range=3–9), followed by

Table 1: Summary of data collected on Neotropical rodent species using the spool-and-line technique in an area of Atlantic Forest (Parque Estadual do Turvo) in Southern Brazil.

	Akodontini			Oryzomyini
	<i>Akodon montensis</i>	<i>Thaptomys nigrita</i>	<i>Brucepattersonius iheringi</i>	<i>Oligoryzomys nigripes</i>
Number of individuals (N)	9	2	1	2
Total line length (m)	795.22	103.05	80.39	127.56
Average line length (m)	88.36	51.52	–	63.78
Line length range (m)	80.3–106.91	9.75–93.30	–	26.61–100.95
Number of shelters	20	4	6	0
Average path under leaf litter (m)	1.10	8.35	3.27	0
Total number of movements under environmental structures	205	62	28	9
Used structures (%)				
Roots	3	6	0	0
Dense leaf litter layer	28	36	57	0
Fallen dry branches	18	6	4	0
Fallen logs	13	26	25	67
Tree fern rhizome trunks	2	6	10	0
Tangle of lianas	24	10	4	33
Bamboos	12	10	0	0
Total number of movements on supports	86	4	3	18
Use of climbing supports (%)				
Fallen logs	63	100	100	61
Tree fern rhizome trunks	13	0	0	0
<i>Piper</i> sp.	3	0	0	5
Lianas	19	0	0	17
Bamboos	2	0	0	17

lianas (median = 2, 25th–75th percentile range = 1–3) and ferns (median = 0, 25th–75th percentile range = 0–2). Some individuals climbed elongated rhizome trunks of ferns of the species *Neoblechnum brasiliense* (Desv.) Gasper *et al.* V. A. O. Dittrich (Table 1 and Figure 2A1), where they reached a maximum height of 35 cm (average 29 ± 11 cm, $n = 4$). Melo *et al.* (2013) found *A. montensis* to selectively use microhabitats on the ground to reduce predation risk, including small ferns and fallen logs. In the present study, shelters found at the ground level for this species were usually in the dense leaf litter layer, but some fallen dry branches and tangles of lianas close to the ground were also used (Figure 2B). An excavation in the soil exposing two roots with no signs of predation was found along the path of one individual (Figure 2C). One individual used what was probably an uninhabited burrow of another animal for shelter (Figure 2D). Although direct evidence of the use of structures for reproduction (such as the presence of offspring) was not observed, some shelters of *Akodon montensis* were hypothesized to represent nests ($n = 3$) because they were more elaborately constructed structures. These structures were 30–80 cm in diameter, had three to five entrances that averaged about 6 cm in diameter, were

composed of dense leaf litter and fallen dry branches and were used more frequently (2 to 11 times) than other types of shelters (Figure 2E and F). In addition, two adult males were captured at the same time in the same trap. Suárez and Kravetz (2001) reported the sharing of nests by individuals of *Akodon azarae* (Fischer, 1829), which may also occur with *A. montensis*, a hypothesis that is supported by the large, elaborate and complex structure of the presumed nests of *A. montensis*.

The observed individuals of *Thaptomys nigrita* (two adult males) and *Brucepattersonius iheringi* (an adult male) exhibited similar displacement behavior, moving only at the ground level. These species moved under the dense leaf litter layer for long distances, and moved under fallen logs and rhizome trunks of the tree fern *Neoblechnum brasiliense* (Figure 2A2). Both species constructed shelters below the ground, either within the leaf litter layer (*B. iheringi*) (Figure 2H) or under root tangles of a large unidentified tree (*T. nigrita*) (Figure 2G). *Oligoryzomys nigripes* (one male and one female, both adults) exhibited a different pattern of use of environmental structures compared to other species, using only fallen logs and tangles of lianas close to the ground; no shelter

Figure 2: Environmental structures, climbing supports and shelters used by Sigmodontinae rodents in the Atlantic Forest of southern Brazil. (A) Rhizome trunk of the tree fern *Neoblechnum brasiliense* used: (1) as climbing support by *Akodon montensis*; and (2) by *Bucepattersonius iheringi* and *Thaptomys nigrita* to move under environmental structures. (B) Excavation found in the path of *A. montensis*. (C) *Akodon montensis* shelter between fallen dry branches (7 cm in diameter). (D) Burrow used as shelter by *A. montensis* (7 cm). (E) *Akodon montensis* shelter (possible nest), under leaf litter layer, fallen dry branches and liana tangles (five entrances). (F) Close-up of an entrance (6 cm) to the *A. montensis* shelter (possible nest). (G) Shelter of *T. nigrita* under tangle of roots of a large tree. (H) View from above of a *B. iheringi* shelter under leaf litter layer (5 cm). (I) *Piper aduncum* shrub used as climbing support by *Oligoryzomys nigripes*.

was found for this species. This species used above ground strata more frequently compared to other species, climbing on fallen logs, lianas, the bamboo *Chusquea ramosissima* Lindm and the shrub *Piper aduncum* L. (Figure 2I) (Table 1). In conclusion, the present study is the first to investigate the use of environmental structures, shelters and climbing supports by *Akodon montensis*, and provide brief observations for three other species of Neotropical sigmodontine rodents. The types of shelters and potential

nests used by *A. montensis* were also described for the first time. Although the sample sizes were small, the results presented here represents a first step to better understanding the movement and use of environmental structures by individuals of these species, as information on fine-scale spatial use by small mammals is still scarce.

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