Original Investigation

The home range and multi-scale habitat selection of the threatened maned three-toed sloth (Bradypus torquatus)

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A B S T R A C T

Habitat selection is a scale-dependent process of paramount importance to the understanding of how species deal with environmental variation. This process has practical implications for wildlife conservation, aiding in the identification of key resources for animals and in the definition of scales relevant to the proposal of practical conservation actions. In this study, we investigated in different spatial scales the habitat selection of the maned three-toed sloth (Bradypus torquatus), a threatened and endemic arboreal folivore of the Atlantic rainforest (vulnerable, sensu IUCN). We radio-tracked and monitored seven sloths for 18 months in landscapes of Southern Bahia, Brazil, the current core region of the species’ distribution. The average values of the home-range estimates were low, but varied considerably among individuals regardless of the estimator (from 0.95 to 27.8 ha, MCP method, and from 0.39 to 21.52 ha, fixed kernel method). At the landscape scale, the maned sloths preferred early secondary forest and shade cacao plantations, avoided open areas, and occupied late secondary forest as expected compared to its availability. At the home range scale, however, the sloths did not show preference for any forest category, though, again, avoided open areas. At smaller spatial scales, the sloths were highly selective towards forest patches characterized by complex vegetation structures (i.e., areas with a high density of trees, closed and dense canopies), and selected large trees with lianas and bromeliads and also with connected crowns. The high selectivity observed at finer scales appeared to be the result of limited spatial perception and experience due to the species’ characteristic slow mobility. Our results support the notion that maned sloths can effectively occupy (and even select for) disturbed forested habitats. However, we do not know whether sloth populations are viable in landscapes containing only disturbed habitats or low proportions of undisturbed habitats.

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Introduction

Habitat loss, disturbance, and fragmentation are synergistic processes that account for the current and unprecedented rates of species loss on a global scale (Fischer and Lindenmayer, 2007). Due to the fact that extinction proneness is closely linked with a species’ capacity to utilize and thrive in disturbed, anthropogenic habitats, species-specific information on habitat use and selection is of paramount importance for conservation purposes. Patterns of habitat selection affect species distribution and abundance (Saavedra-Rodríguez et al., 2012) and are often scale dependent (Kelt et al., 1999; Morin et al., 2005; Finlayson et al., 2007). Due to the fact that ecosystem processes encompass different spatial scales, the understanding of the effects of scale-dependent variation in habitat and resource quality is highly relevant for the effective conservation of any species (Milne et al., 1989).

The evaluation of habitat-use patterns is particularly needed for the establishment of adequate strategies for the conservation of rare, threatened, and highly-specialized species (Croak et al., 2013), such as the maned three-toed sloth (or simply maned sloth) Bradypus torquatus (Mammalia, Bradypodidae). It is an arboreal folivore endemic to the Brazilian Atlantic forest whose populations are...
currently listed as vulnerable due to habitat loss and fragmentation (Machado et al., 2008; IUCN, 2014). This species inhabits isolated areas of central-northeastern to central portion of the Atlantic forest, from Rio de Janeiro to Southern Sergipe, along the coast of Brazil (Hirsch and Chiarello, 2011). The region of Southern Bahia maintains the largest and most genetically diverse population of this species (Lara-Ruíz and Chiarello, 2005; Hirsch and Chiarello, 2011), and thus represents a key location where conservation actions should be focused.

Our current limited knowledge on the space use of the maned sloths shows wide variation in individual home range estimates, varying from 0.44 to 29.33 ha in the Southern Bahia state in Northeastern Brazil (Cassano et al., 2011), 0.8 to 10.8 ha in the Espírito Santo state (Chiarello, 1998; Chiarello et al., 2004), and 4.7 to 16.2 ha in the Rio de Janeiro state (Pinder, 1997). Such variation may be attributed not only to differences in the methodologies of previous studies, but also to distinct individual needs and to specific features that characterize distinct forest types (Chiarello, 2008), as well as the landscape contexts of each study area.

The available information on the habitat selection of maned sloths comes from one adult sloth and two juveniles from a single plantation in Southern Bahia (Cassano et al., 2011). This study suggested that sloths use mature forests and that they may prefer shaded cacao plantations and avoids pastures, swamps, or early secondary forests (Cassano et al., 2011).

Given the scarcity of data on the home range and habitat selection of maned sloths and their necessity for conservation purposes, we evaluated patterns of maned sloths’ habitat use at different scales within the landscape of Southern Bahia. More specifically, we aimed to (i) estimate the home range size of maned sloths in Southern Bahia, (ii) investigate the species’ habitat selection and its level of congruence across four different spatial scales (landscape, home range, forest patch, and tree levels), and (iii) identify features connected to habitat preference or avoidance in each spatial scale.

Sloths are slow-moving and low-metabolism animals whose physiological and locomotion constraints do not allow for leaping between trees to cross canopy discontinuities, which results in their weak dispersal ability compared to other mammal species (Emmons, 1995; Peery and Pauli, 2014). In addition, due to slow mobility, sloths depend on crypticity to avoid predators (Eisenberg, 1978). Thus, considering the species’ locomotory limitations and need to maintain cryptic habits, we anticipated that the structural characteristics of vegetation in their environment would be important factors in the habitat selection of the species across the study’s multiple scales.

Material and methods

Study area

Our study was conducted in landscapes of Southern Bahia, including areas located within the limits of the Una Biological Reserve (Rebio-Una) and neighboring farms located in the municipality of Una, the Southern Bahia state, and Northeastern Brazil (39°18’–39°00’W, 15°23’–15°03’S) [Fig. 1]. The forest of this region is classified as tropical lowland rainforest characterized by a canopy height of 25 to 30 meters and abundant epiphytes and woody lianas (Amorim et al., 2008). The average rainfall is around 2000 mm/year, with no regular dry season, and an annual temperature that ranges from 24 to 25 °C (Mori et al., 1983).

The region of Una contains the largest remains of the Atlantic Forest in the Northeast of Brazil, a biome currently representing less than 16% of the original area (Ribeiro et al., 2009). Its landscape is composed primarily of forests in different successional stages, with nearly 50% of the land cover comprised of late secondary forest fragments, and 16% early secondary forests (Faria et al., 2007). Shaded cacao plantations cover 6% of the landscape, the majority of which are quite small (median patch size: 2.73 ha) and immersed in a forest-dominated landscape (Faria et al., 2007). Open areas make up the remaining ~27% of the landscape. Therefore, forested areas, including shaded cacao plantations, make up the bulk of the available habitat in the region. These plantations are the result of specific management interventions that vary according to region. Previous studies that compared native forests with shaded plantations in the Una region of Southern Bahia indicated that these latter form a distinct forest category, characterized by decreasing densities of woody lianas and foliage within the superior forest strata (Faria, 2002). In particular, the shaded cacao plantations of Rebio-Una and its neighboring farms commonly show higher structural complexity and greater density of native trees compared to the shaded cacao plantations of other regions of Southern Bahia, this mainly due to the Rebio-Una’s laws and conservation goals.

Sloth capture and radiotracking

We captured seven maned sloths between May 2011 and March 2012 (Table 1). The sloths were physically immobilized following a technique used in previous studies (Chiarello, 1998; Chiarello et al., 2004; Cassano et al., 2011), and each sloth was fitted with a ball-chain collar attached to a VHF radiotransmitter (Biotrack Ltd.; Model TW35M) weighing 30 g (<1% of the weight of the animals). Four maned sloths were captured inside the forest and released back into the same tree where they had been captured. The other three animals were captured after being sighted by local people or park rangers on the roads of the Rebio-Una near high hunting pressure areas. We translocated these sloths into more protected areas within the Rebio-Una. Except for one individual whose radio signal was lost at the end of the study, we recaptured the remaining six sloths and removed the radio collars without injury. We followed the recommended procedures of the American Society of Mammalogists (Sikes and Gannon, 2011) in the capture, handling, and tagging of the species.

Each sloth was radio-tracked with the aid of a receptor (Telonics Inc.; Model TR-4) coupled to a Yagi three-element antenna (Telonics Inc.). We began monitoring each sloth seven days after its release to ensure a period of habituation. For each monitored sloth, we collected one to three locations per week during diurnal period (0600 to 1700 hrs) from 8 to 17 months, totaling 23 to 50 localizations per animal (Table 1). We sampled during all hours of diurnal periods homogeneously across individuals in order to avoid temporal bias.

Habitat evaluation

For the coarse scale, we mapped and categorized the vegetation types present in the surrounding landscape of each studied sloth according to their structural characteristics and definitions found in Brazilian legislation (CONAMA, 1994). These categories included late secondary forests (LSF, a forest with canopy height greater than 12 m and an average diameter at breast height (DBH) greater than 18 cm), early secondary forests (ESF, a forest with a canopy height lower than 12 m and an average DBH smaller than 18 cm), shaded cacao plantations (SCP, including shaded cacao plantations and forested crops with similar structures), and open areas (OA, including pastures and monocultures). Mapping was done to define the limits of each type of vegetation using aerial photographs (scale of 1:5000; taken in 2001–2002; IESB, unpublished data) and Google Earth® imagery (Spot image, captured May 26, 2010) and also confirming such limits in the field with a GPS (GPSMAP 60CSX, Garmin International, Inc., Olathe, KA, USA). We then calculated the area of each vegetation type within each individual home range and the
landscape. Landscape limits were defined by a circular area with a 1000-m radius (area ≈ 314 ha) around the center of each sloth’s home range. This radius was based on the distance from the center of a sloth’s home range to the furthest location where it was found. We assumed that such a defined area would allow us to detect at the landscape level the potential importance of habitat mosaics in the sloths’ selection processes for a home range.

At the finer scale, we measured all trees used by sloths in terms of diameter at breast height (DBH), total tree height, and the occurrence of lianas, bromeliads, and connected crowns. For each forest area used, we established a 100 m² plot around each used tree and took the same measurements for all trees with a DBH > 3.2 cm inside the plot, as well as measured tree density (number of trees per 100 m²), canopy openness, and the vertical profile of the foliage. We estimated canopy openness using hemispheric photographs taken at 1-m height from three points located 1 m from the used tree. These points were on the vertices of an imaginary equilateral triangle located 1 m from the center (used tree), one of these vertices was located to the north of it. Posterior estimates were obtained using the Gap Light Analyzer (GLA) 2.0 (Frazer et al., 1999). Modifying the method described in Hubbell and Foster (1986), the vertical profile of the foliage was evaluated at the same three points using a 3 m pole to allow for vertical sighting and estimation of the foliage density of the superior (height > 10 m) and inferior (height < 10 m) stratum as percentages of the foliage in these strata. We used the mean of the three measurements of canopy openness and foliage density obtained in the “used” plot for the analysis of habitat selection. Lastly, for each animal location (Table 1), we randomly chose one tree within each home range, established a 100 m² plot around it, and then took the same measurements as described previously.

**Home range estimates**

In the present study, there was a high frequency of no or small displacement between successive fixes obtained for the sloths. Thus, we estimated home ranges using only one fix per weekly interval in an effort to increase independence between successive locations (Cassano et al., 2011). Home ranges were estimated using the 100% minimum convex polygon method (MCP100%; Mohr, 1947) and the 95% fixed kernel estimator (FK95%; Worton, 1989) with bandwidth (h) estimated using the least square cross validation process (h_{LSCV}). In addition, we estimated core area sizes

![Map of the Una Biological Reserve in the Bahia state of Northeastern Brazil, highlighting the Una region (black rectangle). The delimitation of Una Biological Reserve and the geographic position of the center of the home range of seven maned sloths radio-tracked are shown on the right.](image)

**Table 1**

<table>
<thead>
<tr>
<th>Code</th>
<th>Sex/age</th>
<th>Period</th>
<th>Fixes (weekly)</th>
<th>MCP</th>
<th>Fixed kernel</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>95%</td>
</tr>
<tr>
<td>BT171a</td>
<td>F/adult</td>
<td>May 2011–Dec 2011</td>
<td>23 (23)</td>
<td>27.8</td>
<td>21.52</td>
</tr>
<tr>
<td>BT163</td>
<td>M/sub-adult</td>
<td>Jun 2011–Jan 2012</td>
<td>24 (23)</td>
<td>10.64</td>
<td>6.89</td>
</tr>
<tr>
<td>BT323a</td>
<td>F/sub-adult</td>
<td>Jul 2011–Aug 2012</td>
<td>50 (34)</td>
<td>13.71</td>
<td>6.59</td>
</tr>
<tr>
<td>BT393</td>
<td>F/adult</td>
<td>Dec 2011–Oct 2012</td>
<td>36 (24)</td>
<td>2.92</td>
<td>7.14</td>
</tr>
<tr>
<td>BT182</td>
<td>F/adult</td>
<td>Jan 2012–Oct 2012</td>
<td>43 (21)</td>
<td>11.5</td>
<td>2.35</td>
</tr>
<tr>
<td>BT033a</td>
<td>F/sub-adult</td>
<td>Mar 2012–Oct 2012</td>
<td>41 (21)</td>
<td>1.09</td>
<td>0.39</td>
</tr>
<tr>
<td>BT122</td>
<td>F/adult</td>
<td>Apr 2012–Oct 2012</td>
<td>34 (18)</td>
<td>0.95</td>
<td>3.32</td>
</tr>
</tbody>
</table>

*a* Sex determination based on Lara-Ruiz (2004).

*b* Translocated animals.
using a fixed kernel method based on 50% of the utilization distribution (FK50%). We performed these analyses using the Home Range Tools (HRT) extension (Rodgers et al., 2007) to the ArcGIS® 9.3 software (Environmental Systems Research Institute, 2008). We built a cumulative curve in order to check the stability of the home ranges in terms of home range size (MCP) in relation to the sample size of each animal using the Animal Movement Extension, v.2.04 (Hooge and Eichenlaub, 1997) of the ArcView GIS 3.2 program (Environmental Systems Research, 1999).

We used the non-parametric Mann–Whitney test to evaluate differences in the home range sizes of adult and sub-adult sloths, as well as between translocated and non-translocated sloths. These analyses were performed using version 3.0.2 of the R software (R Core Team, 2013).

**Habitat selection analysis**

We performed the habitat selection analysis using Resource Selection for Windows version 1.0 (Leban, 1999) with each animal as a sampling unit. We employed a chi-square goodness-of-fit test and Bonferroni confidence intervals a posteriori (Neu et al., 1974) to detect any resource used disproportionately compared to its availability. When the observed use of a habitat category did not differ significantly from the expected one compared to its availability, it was considered as not selected (a random use). Otherwise, the habitat was considered to be preferred (more frequently used than expected by chance) or avoided (less frequently used than expected by chance) (Byers et al., 1984).

According to Johnson (1980), we evaluated habitat selection in terms of four spatial scales. At the landscape scale (Johnson’s second order), the proportion of the area occupied by each vegetation type within each sloth’s home range (FK95%) was compared with its availability in the landscape (1000 m-radius circular area). At the home range scale (Johnson’s third order), the proportion of localizations for each vegetation type was compared with the proportion of area occupied by each vegetation type within the home ranges (FK95%). At the patch scale (Johnson’s fourth order), the relative frequency of the measured structural variables reported in the 100-m² plots was compared with randomly selected plots of the same size. Finally, we considered an additional “fifth order” at the tree scale in terms of the relative frequency of the measured attributes of the used trees compared to those measured for non-used trees within the same 100-m² plot. This order was used to calculate sloth preferences in terms of tree scale. Spearman correlations were performed prior to the habitat selection analysis between all tree attribute pairs, and due to the high correlation ($r > 0.5$) between DBH and tree height, the latter variable was removed from the analysis. The other paired comparisons showed low correlation values ($r < 0.5$).

**Results**

**Home range**

The estimated mean [SD] home range sizes were 9.80 [9.53] ha (MCP100%) and 6.89 [6.95] ha (FK95%), with mean core areas (FK50%) of 1.59 [1.40] ha (Table 1). The estimated median values of home ranges were 10.64 ha (MCP100%), 6.88 ha (FK95%), and 1.35 ha (FK50%). Home range size was not significantly different between translocated and non-translocated animals when estimated using the MCP100% method (translocated: median = 13.71 ha, n = 3; non-translocated: median = 6.78 ha, n = 4; Mann–Whitney U = 9, P = 0.29) or the FK95% method (translocated: median = 6.59 ha, n = 3; Mann–Whitney U = 6, P = 1.0). Furthermore, we did not detect any significant differences between the adult and subadult sloth home ranges using the MCP100% method (adult: median = 7.21 ha, n = 4; subadult: median = 10.64 ha, n = 3; Mann–Whitney U = 6, P = 1.0) or the FK95% method (adult: median = 5.23 ha, n = 4; subadult: median = 6.59 ha, n = 3; Mann–Whitney U = 4, P = 0.48). The home range size of the only male sloth monitored (BT163) held an intermediate position between those of females, being similar or very close to the median values considering the home ranges of all sloths. Home range size stabilized around seven months for most sloths, except for BT171 (a translocated individual) and BT182 (non-translocated), whose cumulative curves suggested that their home ranges could increase (Supplemental Material, Fig. A).

**Habitat use and selection**

Habitats such as LSF (57.4%) and ESF (30.7%) represented the major part of sloths’ home ranges (FK95%), followed by OA (6.4%) and SCP (5.6%). Within their home ranges, the tagged sloths were located predominantly in LSF (56.4%) and ESF (34.9%), and less frequently in the SCP (6.6%) and OA (2.1%). At both the landscape and the home range scales, sloths did not use habitats randomly ($\chi^2 = 306.2, df = 3, P < 0.0001$) and $\chi^2 = 25.8, df = 3, P < 0.0001$. 

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**Fig. 2.** Habitat selection by B. torquatus at the landscape (second spatial-scale order; a) and home-range (third spatial-scale order; b) scales in the Atlantic Forest of Southern Bahia, Brazil. Dark dots indicate mean proportional utilization using the confidence intervals of Bonferroni (Neu et al., 1974). Dark triangles indicate mean proportional availability. Selection occurs when utilization falls above (positive) or below (negative) availability. Codes: LSF = late secondary forest; ESF = early secondary forest; SCP = shaded cacao plantations; and OA = open areas.
respectively). At the landscape scale, the sloths preferred both ESF and SCP, avoided OA, and did not select LSF (Fig. 2). At the home range scale, the sloths used all forested vegetation types according to their availability, though avoided OAs (Fig. 2).

The maned sloths were also selective at the patch scale (Fig. 3). The observed use of forest patches differed significantly from the expected values considering the availability of habitat variables in terms of the density of trees ($\chi^2 = 449.3$, $df = 2$, $P < 0.0001$), canopy openness ($\chi^2 = 90.3$, $df = 2$, $P < 0.0001$), and foliage density in the stratum above 10 m ($\chi^2 = 85.2$, $df = 2$, $P < 0.0001$). The sloths preferred structurally complex patches characterized by high densities of trees (>20 trees per 100 m$^2$), intermittently open canopies (10–20% of openness), and moderate densities of foliage in the superior stratum (20–40% of foliage density at the stratum above 10-m high). In contrast, the sloths avoided forest patches with low densities of trees (<20 individuals per 100 m$^2$) or in extreme cases of canopy openness (<10% or >20%). They were also indifferent to variation in foliage densities below 10 m, using them in similar proportion to what was expected to be used compared to their availability ($\chi^2 = 2.6$, $df = 2$, $P = 0.26$).

At the finer spatial scale (trees scale), the use of trees by the tagged sloths was not random in terms of DBH ($\chi^2 = 3677.7$, $df = 2$, $P < 0.0001$) and the occurrence of lianas ($\chi^2 = 1254.2$, $df = 1$, $P < 0.0001$), bromeliads ($\chi^2 = 1293.7$, $df = 1$, $P < 0.0001$), and connected crowns ($\chi^2 = 188.5$, $df = 1$, $P < 0.0001$). The maned sloths preferred thick (>20 cm of DBH) trees, as well as trees with sections of lianas, bromeliads, and connected crowns (Fig. 4). Conversely, the trees that did not have such structures were avoided by sloths.

**Discussion**

To our knowledge, our study is the most complete published research addressing the use of space and habitat selection of the vulnerable maned sloth. Our results indicated that the home-range sizes of these sloths vary markedly in Southern Bahia, and that this species is selective in its habitat requirements across different spatial scales. The sloths selected early secondary forests and shaded cacao plantations at the landscape level, while avoiding open areas at several other scales (Fig. 5). At the lower spatial scales, maned sloths preferred forest patches with a high tree density, intermediate canopy openness, and a well-developed canopy stratum, as well as larger trees with lianas, bromeliads, and connected crowns.

**Home range**

The wide variation in terms of home range size reported in this study (0.95 to 27.8; minimum convex polygon 100% method) has also been observed in previous studies (0.56 to 29.33 ha; Pinder, 1997; Chiarello, 1998; Chiarello et al., 2004; Cassano et al., 2011). This variation may reflect some aspects, such as environmental conditions, individual sloth histories (translocated or not translocated),
or else distinct individual needs (e.g., related to sex, age or reproductive condition; Pinder, 1997; Chiarelli, 1998; Chiarelli et al., 2004; Chiarelli, 2008; Cassano et al., 2011). Unfortunately, we were unable to identify which factors cause significant variation in the home range size of our study animals.

Except for the sloth that seemed to be dispersing (BT171), the observed home range values (range: 0.95 to 13.71 ha) were similar to those of the non-dispersing maned sloths previously studied (0.56 to 10.8 ha; Chiarelli et al., 2004; Chiarelli, 2008; Cassano et al., 2011), as well as similar to the values observed for other sloth species, such as B. variegatus (0.5 to 3.7 ha; Montgomery and Sunquist, 1975; Queiroz, 1995) and Choloepus hoffmanni (0.4 to 3.9 ha; Montgomery and Sunquist, 1975). Moreover, the values were lower than those estimated for herbivorous mammals of similar size to the maned sloth (based on data presented in Damuth, 1981), as expected for a low-metabolism arboreal folivore mammal (Eisenberg, 1978).

Habitat selection

At the landscape scale, the studied sloths predominantly used more than one habitat type. Similarly, Vaughan et al. (2007) reported that, in a diverse landscape within Central America, B. variegatus and Choloepus hoffmanni commonly had two or three distinct habitats, such as cacao agroforests, living-fence rows, open areas, and riparian forest strips. This suggests that sloths require a mosaic of habitats to fulfill their basic living requirements.

Our results indicated that maned sloths preferred shaded cacao plantations and early secondary forests among their available habitats to establish a home range. The floristic composition of these areas likely makes their vegetation types attractive to sloths despite the fact that these structurally simplified habitats may increase exposure to potential predators. Shaded cacao plantations and early secondary forests harbor high abundances of pioneer tree species, such as Ficus, Tapirira, and Ocotea, which are commonly consumed by sloths (Mariano-Neto, 2004; Sambuichi, 2006; Cassano et al., 2011). The preference of the sloths for shaded cacao plantations and early secondary forests was observed even for those that were translocated to the interior of late secondary forests. Thus, at this scale (Johnson’s second order), the composition and abundance of tree species seemed to be more important in determining a maned sloth’s home range than the high structural complexity of the forested habitat.

At the home range scale (Johnson’s third order), the various types of forested habitats did not appear to influence the movement of the maned sloths. The sloths appeared to be capable of adapting their diets according to differences in the composition and abundance of consumed plant species available in a given habitat, feeding mostly on shade-tolerant species in forest remnants and predominantly on shade-intolerant plants present at shaded cacao plantations (Cassano et al., 2011). Such adaptation indicates
a certain flexibility of the sloth when engaging habitats of differing quality, a flexibility which has been previously reported (cf. marsupials, Finlayson et al., 2007; Smith et al., 2013; ungulates, Schaefer and Messier, 1995).

The observed habitat selection of the maned sloths was generally congruent across spatial scales, although some inconsistencies were observed. The main discrepancy between the sloths was their preference for more complex components of habitat at the finer scale (trees and patches), yet this was not the case at the coarser scale (vegetation types). However, sloths may prefer more complex forest patches even within more simplified habitat types, such as shaded cacao plantations. They also selected large-sized trees within areas where such trees are not the most abundant type, such as in early secondary forests.

In particular, there was a notable congruence in terms of habitat preferences between the finer and coarser scales. Part of the structural differences between the shaded cacao plantations and late secondary forests from this region is that the former habitat is characterized by lower densities of vegetation in the middle and lower forest strata (Faria, 2002). Shaded cacao plantations and late secondary forests had no influence on habitat selection within the sloths’ home ranges and our fine-scale results indicated that the sloths’ habitat selection was not influenced by vegetation densities below 10 m high. In particular, open areas were the only habitats avoided at both coarse scales, which is to be expected from mammals that are strongly adapted to arboreal life.

The studied maned sloths preferred thick (diameter at breast height >20 cm) trees, similarly to other sloth species (Choloepus hoffmanni and Bradypus variegatus; Montgomery and Sunquist, 1978; Queiroz, 1995) and arboreal folivorous mammals (Ganzhorn, 1995; Milner and Harris, 1999; Cunningham et al., 2004; GAFG, unpublished data). Predation risk from terrestrial predators, such as pumas and ocelots (still present in the study area), can be potentially reduced when an arboreal mammal locates itself in tall trees (Switzer and Berger, 1992). Considering that the species’ main aerial predator (the harpy eagle Harpia harpyja) is locally very rare or absent in the study region, exposure in tall crowns is likely a non-risky action for these sloths.

In addition, thick trees tend to have wide crows, a factor that can potentially be related to high availability of foliar biomass (Ganzhorn, 1992). The maned sloth’s selection of large trees may optimize its rate of food intake, representing an energy-saving strategy important for an arboreal folivore energetically constrained by its diet (McNab, 1978). Indeed, the tagged maned sloths selected sites with a canopy openness of 10 to 20%, which is relatively high compared to the values reported for native forests and shaded cacao plantations in Southern Bahia (3.1 to 7.7% and 2.5 to 6.1%, respectively; Pinheiro et al., 2013). These animals also preferred (at the landscape scale) habitats with typically more open canopies, such as in the early secondary forests and shaded cacao plantations. The sloths’ preference for forest patches with relatively high canopy openness could be the result of their preference for forested sites with canopies of high sunlight exposition, foliar production, and dominated by pioneer tree species.

Conservation remarks

The shaded cacao plantations surrounding the Una Biological Reserve included in both our and Cassano et al.’s (2011) studies on the habitat selection of maned sloths are undermanaged and have greater structural complexity than other shaded cacao plantations of the Southern Bahia region (Cassano et al., 2011). We believe that the presence and abundance of specific tree species, coupled with the maintenance of a relatively open, yet complex canopy, are the main factors that account for the use and selection of the shaded cacao plantations by maned sloths.

Among the local management practices currently recommended to increase farm productivity in the region is the use of less shade, which often reduces tree density in these newly-managed plantations to only a third of what is found on traditional shaded cacao plantations (Schroth et al., 2014). This procedure markedly reduces the quality of these highly managed plantations as habitats for maned sloths and other mammals (Rolim and Chiarelli, 2004; Cassano et al., 2014) by decreasing the availability of trees while triggering structural simplification on a local scale, also through the consequent reduction of canopy connectivity and overall foliage density.

Although our results support the observations made by Cassano et al. (2011) that the maned sloth can effectively use and even select shaded cacao plantations and other modified habitats, this pattern was observed within a landscape with a large proportion of mature forests. It has already been shown that, in the Bahia state, the capacity of shaded cacao plantations to support diverse mammal assemblages is strongly context-dependent and largely influenced by the presence of large forest tracts in the landscape (Faria et al., 2007). It is not clear whether maned sloths can maintain long-term viable populations in shaded cacao plantations in the absence of undisturbed forests, or even simply with a low proportion of such habitats in a landscape. For instance, although Peery and Pauli (2014) estimated the population growth rates of B. variegatus (brown-throated sloths) and Choloepus hoffmanni (Hoffmann’s two-toed sloths) in a shade-grown cacao farm in Central
America, only the two-toed sloth populations were stable in the absence of immigration, while the brown-throated sloth populations could only be maintained via immigration from nearby forests.

Therefore, it is possible that the population of the曼秒o sloths in Southern Bahia can only be maintained in protected landscapes with a high proportion of forests, such as Rebio-Una. In fact, this species is rarely found in landscapes with a limited occurrence of forests and high proportions of shaded cacao plantations, such as those from the municipality of Linhares, Espírito Santo state, which is located roughly 580 km south of our study region (Rolim and Chiarello, 2004), and those of the neighboring municipality of Ilhéus, 60 km to the north (GAFG, pers. obs.).

The selection of shaded cacao plantations as a habitat by mantled sloths can be influenced by local management of such plantations and, most likely, landscape context. Thus, we predict that the overall abundance of Bradypus torquatus has already been greatly reduced in the cacao producing region of southern Bahia, mainly where tree-reduction management has been intensified and native forests are scarce. On the other hand, the small home range and high plasticity of this species in the disturbed and human-modified forests of the Atlantic Forest biome (Ribeiro et al., 2009) speak positively to the possible conservation of this species. This plasticity suggests that the species’ conservation situation is not as alarming as one could suppose. However, further studies are required to address and understand the influence of environmental variables and varying landscape contexts on the species. Given the currently available information on Bradypus torquatus habitat requirements, we suggest that the conservation status of this species (vulnerable, sensu IUCN) should be maintained.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.mambio.2015.01.009

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