

SHORT NOTE

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Extension of gray-brown mouse lemur (*Microcebus griseorufus*) activity period in a disturbed forest in southwestern Madagascar

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ABSTRACT

Habitat disturbances may impact behaviors of animals, including their activity patterns. In southwestern Madagascar, timing of gray-brown mouse lemur activities was investigated in adjacent forests with different levels of human disturbance. Mouse lemurs were encountered more frequently during the second part of the night in the unfenced, more disturbed forest than in the fenced, less-disturbed forest. The extension of mouse lemur activity period in the unfenced forest may be due to differences in forest composition resulting in higher travel costs or a loss of canopy cover which may limit their use of torpor.

RÉSUMÉ

Les perturbations de l'habitat peuvent avoir un impact sur le comportement des animaux, y compris sur leur rythme d'activité. Le déroulement des activités des microcèbes a été étudié dans des forêts adjacentes du Sud-ouest de Madagascar. Une de ces forêts a été protégée du pâturage par une clôture tandis que l'autre ne profitait pas d'un tel dispositif en étant ainsi nettement exploitée par l'Homme et son bétail. Les microcèbes ont été rencontrés plus fréquemment au cours de la deuxième partie de la nuit dans la forêt non clôturée que dans la forêt clôturée. Bien que cette étude n'ait pas permis de détecter des différences dans la disponibilité des insectes ou des fruits, des évaluations plus détaillées de la composition des espèces d'arbres et l'abondance des insectes sont nécessaires pour déterminer l'impact de la qualité nutritionnelle ou de la distribution des ressources sur les rythmes d'activité des microcèbes dans la forêt non clôturée. D'un autre côté, l'allongement de la période d'activité des microcèbes dans la forêt non clôturée peut être lié à une perte de la couverture de la canopée, elle-même à l'origine d'une élévation des températures diurnes dans la forêt non clôturée qui réduirait la durée pendant laquelle les microcèbes pourraient être en torpeur dans cette forêt.

INTRODUCTION

Forest loss, fragmentation, and degradation in Madagascar are threats to its unique biodiversity (Harper et al. 2007). Human activities including hunting of animals, illegal harvesting of plants, and clearing of land for agriculture disturb Malagasy forests (Goodman 2006, Patel 2007, Irwin et al. 2010, Brown et al. 2013). These disturbances degrade forests by altering their

structure, affecting resource availability and community composition (Irwin et al. 2010, Brown et al. 2013).

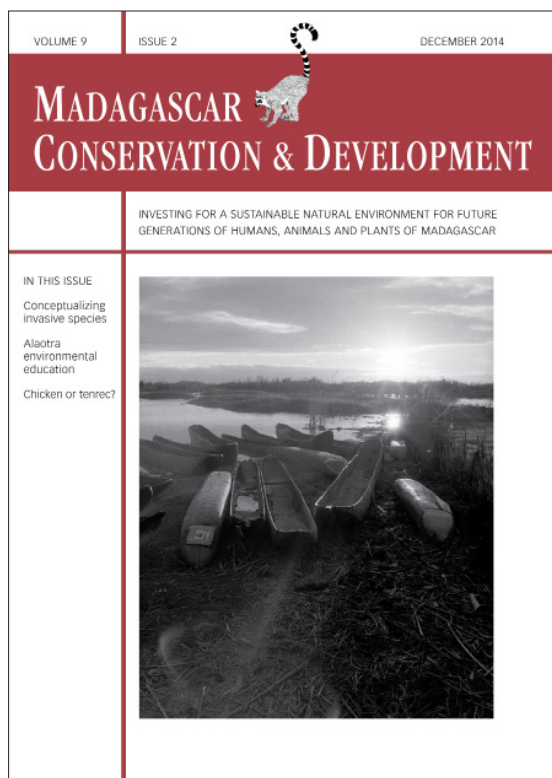
Madagascar's endemic lemurs are tied to forests, yet few studies explore lemur behavioral ecology across disturbance gradients (Irwin et al. 2010). Mouse lemurs (*Microcebus* spp.) are widespread in a variety of forest types including areas of anthropogenic disturbance (Radespiel 2007, Atsalis 2008). Ranging from 30–110 g in body mass (Atsalis et al. 1996, Rasoloarison et al. 2000, Wrogemann et al. 2001), nocturnal mouse lemurs consume an omnivorous diet (Radespiel 2007, Atsalis 2008). In resource-poor seasons, mouse lemurs may enter a daily or extended period of torpor in which they lower their metabolic rate and reduce energy needs (Schmid 2000, Schmid and Speakman 2000, Kobbe and Dausmann 2009).

Mouse lemurs show an array of responses to different habitat disturbances. In western Madagascar, population densities of gray mouse lemurs (*Microcebus murinus*) were lower in a secondary forest than in a primary forest (Ganzhorn and Schmid 1998). Gray mouse lemurs in large forest fragments along the east coast were found to have a higher parasite load if they inhabited a more degraded fragment (Raharivololona and Ganzhorn 2009). Mouse lemurs (*M. rufus* and *M. lehilahytsara*) from eastern rainforest localities had stable isotope values that suggested a shift toward a more faunivorous diet in fragments and degraded habitats (Crowley et al. 2013) and gray-brown mouse lemurs (*M. griseorufus*) in the southeast reduced gum feeding and increased insect feeding in disturbed forests (Rasoazanabary 2011).

Habitat degradation may also impact the activity pattern of mouse lemurs. Resources may be spaced further apart in degraded habitat, causing mouse lemurs to increase their ranges and activity period to obtain sufficient resources. Alternatively, because mouse lemurs can reduce their energy needs through the use of torpor, they may shorten their activity period. During a 1.5 month study during the dry season at the Beza Mahafaly Special Reserve (BMSR) in southeastern Madagascar, I assessed whether the activity period of gray-brown mouse lemurs (*Microcebus griseorufus*) varied in two adjacent deciduous forests with differing disturbance levels.

METHODS

Parcel 1 of BMSR is approximately 80 hectares in size and bordered on one side by the ephemeral Sakamena River (Figure 1).



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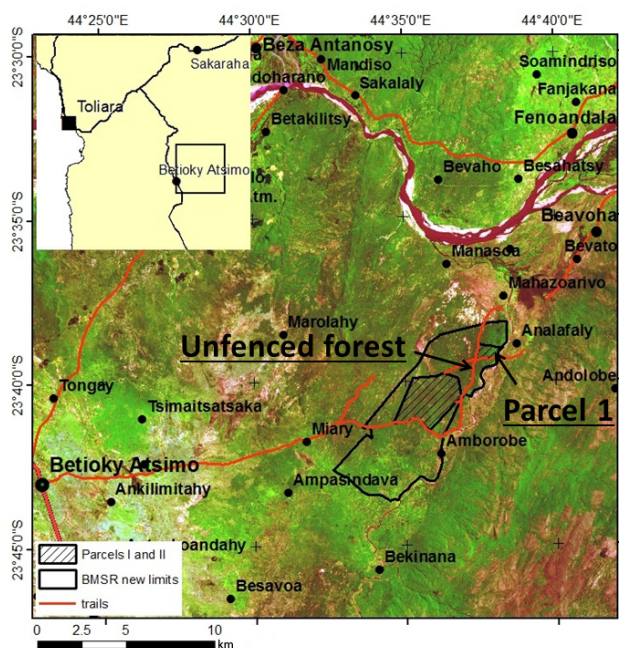


FIGURE 1. Beza Mahafaly Special Reserve with locations of Parcel 1 and the unfenced forests highlighted. Map modified from <<http://bezamahafaly.commons.yale.edu/en/maps-and-direction/>>

Because of its proximity to the river, soils in the eastern side are moister and support a gallery forest (Sussman and Ratsirason 2006, Axel and Maurer 2011). Moving west from the river the soils become drier and the forest composition transitions to dry deciduous forest (*ibid*). This parcel is relatively undisturbed as it is protected from grazing animals by a perimeter fence (Sussman and Ratsirason 2006). Grazing animals occasionally enter Parcel 1 when fences are down (*pers. observ.*) or they are hidden in the reserve by local villagers to protect the animals from thieves (Youssef and Rasoazanabary 2008). Minor disturbances come from a 100 m x 100 m grid of footpaths created for researchers and also used by local villagers for travel. Local villagers also enter the reserve for occasional collection of fruits (Rasoazanabary 2011).

The neighboring forest (approximately 850 hectares) is located between Parcel 1 and Parcel 2 (Axel and Maurer 2011). Separated from Parcel 1 by the intersection of two dirt roads, this dry deciduous forest is similar to the adjacent western edge of Parcel 1 (*ibid*). The boundaries of BMSR were recently extended to include this forest; however no perimeter fence protects it. Grazing by goats and cattle in this forest is common and trees have been cut down so that browsing animals can feed on their leaves. Numerous oxcart trails, footpaths, and corral clearings are found in this forest. Because the protected Parcel 1 and this unfenced forest are only separated by the road intersection, variables such as local weather conditions and noise disturbances from the roads are similar.

Between 1 June and 10 July 2011, a six-person research team examined forest structure, food availability, and mouse lemur behaviors in Parcel 1 and the unfenced forest. To compare forest structure between the two forests, we established three transects approximately 1 km in length in the unfenced forest. Transects paralleled each other, running due west from the road, with 200 m between each transect. In Parcel 1, I selected three established trails from the existing gridded trail system. As with the transects constructed in the unfenced forest, the selected

trails were approximately 1 km in length running east-west from the river, parallel, and separated by 200 m. I selected trees along transects in the unfenced forest and established trails in Parcel 1 every 50 m and recorded their dbh (diameter at breast height) and height.

Weekly sampling of food abundance took place during the last four weeks of the study. Sampled trees along transects and trails were marked with flagging tape and examined for the presence or absence of fruits, flowers, immature or mature leaves. In order to compare insect abundance, sweep net sampling using a 33 cm diameter net was conducted at three 10 m x 10 m plots along trails and transects in both forests. Beat traps were also set under trees within these plots. Total number of insect captures was tallied for each forest.

The research team conducted 246 hours of walks in Parcel 1 and the unfenced forest to locate mouse lemurs. Walks were evenly distributed throughout the night, with half of the walks occurring between 1800 and 2400 and the other half between 2400 and 0600. At a pace of approximately 2 km per hour, researchers traveled on trails, transects, clearings, and animal paths while using their headlamps to scan the forests for mouse lemurs. When mouse lemurs were located, we recorded the time and their behaviors using continuous focal sampling until they went out of sight.

I examined variation in forest structure and resource availability between the two forests using a proportions t-test. A chi-square test was used to determine: i) if the total number of insects captured in each habitat differed and ii) if differences existed in the number of encounters with mouse lemurs between Parcel 1 and unfenced forest throughout the night. I used only the time and behavior of a mouse lemur upon initial encounter to avoid oversampling the behaviors of well-habituated mouse lemurs. The level of significance for all analyses was set at $p < 0.05$.

RESULTS

The trees in the unfenced habitat were smaller and shorter on average than trees in Parcel 1 in terms of dbh (Parcel 1_{Mean} = 17.5 cm, $n = 70$, $SD = 23.3$ cm; Unfenced_{Mean} = 12.6 cm, $n = 66$, $SD = 16.3$ cm) and tree height (Parcel 1_{Mean} = 8.1 m, $n = 70$, $SD = 5.5$ m; Unfenced_{Mean} = 5.0 m, $n = 66$, $SD = 2.2$ m), but these differences were not significant. Although the presence of mature and immature leaves declined in both forests during this study, a higher percentage of trees in Parcel 1 contained both mature and immature leaves in comparison to the unfenced habitat during three of the four weeks of surveys (week 1: $t = -3.104$, $df = 95$, $p = 0.001$; week 2: $t = -1.588$, $df = 77.8$, $p = 0.059$; week 3: $t = -1.735$, $df = 92.6$, $p = 0.043$; week 4: $t = -1.674$, $df = 107.7$, $p = 0.048$). The total number of insects captured in both habitats was low (Parcel 1_n = 20; Unfenced_n = 15) and did not differ significantly between habitats (chi-square = 0.7, $df = 1$, $p = 0.4$). Abundance of trees producing fruits or flowers in both forests was low ($n < 3$) during each week of sampling for each forest and precluded statistical testing.

The frequency of mouse lemur encounters in both forests was similar before midnight when they were encountered 206 times in Parcel 1 and 193 times in the unfenced forest (chi-square = 0.424, $df = 1$, $p = 0.515$). Upon initial encounter, mouse lemurs in Parcel 1 traveled most frequently (49% of initial encounters), followed by resting (28% of initial encounters),

foraging (21% of initial encounters), and other (2% of initial encounters). Those in the unfenced habitat also traveled most frequently (43% of initial encounters), followed by resting (39% of initial encounters), foraging (15% of initial encounters), and other (3% of initial encounters).

After midnight, mouse lemurs in the unfenced habitat were encountered more frequently ($n = 210$) than mouse lemurs in Parcel 1 ($n = 137$) (chi-square = 15.357, $df = 1$, $p = 0.001$). After midnight, mouse lemurs in Parcel 1 traveled in 43% of initial encounters, rested in 39%, foraged in 17%, and engaged in other behaviors in 1%. Mouse lemurs in the unfenced forest traveled in 44% of initial encounters, rested in 32%, foraged in 23%, and engaged in other behaviors in 1%.

DISCUSSION

In both forests, mouse lemurs were encountered at similar frequencies before midnight. This suggests that a similar number of individuals are roused from torpor to commence traveling and foraging in both forests. After midnight, mouse lemurs in the unfenced habitat were encountered more frequently. Mouse lemurs in the unfenced forest may have been more visible to our research team, however, similar encounter frequencies in both forests before midnight argue against this sample bias. The lower encounter frequency with mouse lemurs in Parcel 1 suggests that many individuals retreat to sleeping nests after midnight while those in the unfenced habitat continue their activity period. This study builds on the work of Rasoazanabary (2011) who documented a higher percentage of active nights for mouse lemurs in another disturbed forest (Ihazoara) near BMSR. An extension of the activity period for mouse lemurs in disturbed forests may contribute to the activity increase observed by Rasoazanabary.

Mouse lemurs in Parcel 1 may be more efficient at foraging, allowing them to retreat to nests earlier in the night. There may be greater food availability in Parcel 1 or lower travel costs due to differences in forest structure between Parcel 1 and the unfenced forest. The similar percentages of time spent traveling by mouse lemurs in both forests argues against differences in travel costs, but more extensive follows of mouse lemurs in each forest are necessary to fully evaluate this. My limited dataset suggest low levels of insects, fruits, and flowers in both forests during this dry season study. However, more extensive phenological monitoring and assessments of plant species composition in the forests, including abundance of trees utilized for gums, are needed. Lower nutritional quality based on differences in tree species composition in each forest may underlie the extension of activity period.

Additionally, higher levels of leaf availability may explain the activity pattern of mouse lemurs in the unfenced habitat. The greater leaf availability in Parcel 1 suggests that more of this forest is shaded throughout the day. Because of a reduction in leaf availability, mouse lemur tree holes in the unfenced forest are likely exposed to more solar radiation during the time of the year when trees have their lowest insulative capacities (Schmid 1998). As a result, tree holes in the unfenced forest may exceed the temperature threshold above which mouse lemurs terminate torpor (Schmid 1998) at earlier times in the day. Because torpor results in energetic savings due to reduced metabolic activity (Schmid and Speakman 2000, Kobbe and Dausmann 2009), mouse lemurs in Parcel 1 may remain in energy-saving

torpor longer while those in the unfenced forest are roused from torpor and return to a more active metabolic state earlier in the day. Thus, energy costs may be higher for mouse lemurs in the unfenced habitat, forcing them to remain active longer. Further information regarding daytime temperatures in tree holes in both unfenced and Parcel 1 habitats at BMSR as well as assessments of mouse lemur body temperatures and timing of arousal from torpor in these habitats are needed to test this hypothesis.

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