expected as other primate species have also been observed exhibiting this behavior. On November 2008 a group of more than 10 individuals of *Mico intermedius* was seen and three of them photographed crossing a small bridge on an unpaved road over the Rio Água Branca (9° 09' 41.4" S and 60 ° 28' 03.7" W, road MT-206 connecting Colniza – Mato Grosso State and Machadinho D`oeste, Rondonia State), a small tributary of the Rio Guariba in northern Mato Grosso (I. Theobald, pers. comm.). These bridges over the rivers Mucuim and Água Branca do not exceed 30 and 15 m in length, respectively. These observations indicate that man-made structures may break down natural geographic barriers and thus interfere with biogeographic processes. The implications of such interference, e.g. potential for hybridization or displacement of one species by another, remain to be determined.

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Sleep Tree Use by White-Faced Capuchins (*Cebus capucinus*): Implications for Differences in Seedling Composition

Kim Valenta
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Introduction

White-faced capuchins are highly frugivorous, diurnal animals, and previous studies indicate that they are effective primary seed dispersers (Wehncke *et al.*, 2003; Smith, 2004; Valenta and Fedigan, 2009a) across several measures of seed dispersal effectiveness: quantity of seeds dispersed (Wehncke *et al.*, 2003; Valenta and Fedigan, 2008), quality of seed dispersal (Chapman, 1989; Smith, 2004; Wehncke and Dalling, 2005; Valenta and Fedigan, 2009a), and diurnal spatial patterns of seed dispersal (Wehncke *et al.*, 2003; Wehncke and Dalling, 2005; Valenta and Fedigan, 2009b). One aspect of capuchin seed dispersal that has not been studied is nocturnal seed input at sleeping sites. White-faced capuchins spend approximately half of their lives sleeping in a limited number of trees (Fragaszy *et al.*, 2004). Although they have not been observed to consume fruit at night, their gut passage rate of 35 minutes to 5 hours (Rowell and Mitchell, 1991; Wehncke *et al.*, 2003; Valenta and Fedigan, 2009b), coupled with their consumption of fruit until minutes before they retire to a sleeping tree (pers. obs.) lead us to the inference that they defecate a large number of seeds beneath sleep trees. Additionally, a great deal of capuchin feces is observed beneath sleep trees the morning after capuchins sleep in them, and capuchins defecate first thing in the morning before leaving sleep trees. Unfortunately, attempts to quantify nocturnal seed rain have not been successful, but the combination of capuchin gut passage rates, with observations of high seed input the morning after sleep trees are utilized by groups indicate that seed rain beneath sleep trees used by this species is significant. Here, we test the effect of repeated sleep

tree use by capuchins on forest regeneration by comparing seedling recruitment at two capuchin sleep trees to paired control trees. Given the increase in capuchin-dispersed seed input beneath sleep trees, we expect a higher density of capuchin-dispersed seedlings at these sites.

Methods

The study took place in the Area de Conservación Guanacaste (10.883611, -85.775), Santa Rosa Sector in Costa Rica. Sleep tree sites used by the group were flagged for each observation day that an observer remained with the group until 18:00 h (N = 59 observations). Two sleep tree sites were chosen for this study based on the existence of appropriate control sites. Both sleep trees were Guanacaste trees (*Enterolobium cyclocarpum,* FABACEAE) and were between 20 and 25 m tall. While there are two additional sympatric, diurnal primate species at the study site (*Alouatta palliata* and *Ateles geoffroyi*), *A. geoffroyi* have never been observed to enter into the home range of the capuchin study group, and *A. palliata* were never observed spending time in the capuchin sleep trees, and are primarily folivorous (Estrada and Coates-Estrada, 1985). Two control trees were chosen for sampling based on their similarity to sleep tree sites. Both are trees of the species *E. cyclocarpum*, and approximately the same height as the sleep trees. Control trees were in similar forest type (similar tree age in the immediate surroundings and similar location relative to forest edge) and located within 300 m of sleep trees. Over the course of 24 months of continuous researcher presence with this capuchin group, the monkeys were never observed to sleep in control trees.

One transect was laid out beneath each sleep tree and control tree. Transects consisted of a line running from the base of the trunk to the edge of the canopy, and were between 12 and 14.5 m long. All seedlings and saplings up to 200 cm in height lying within 2 m of the transect line (1 m on either side), or that were rooted within 2 m of the transect line, were identified to the species level in the field or transplanted to a shade house, where they were grown until positive identification could be made. Identifications were later confirmed by botanists at the Area de Conservación Guanacaste's plant inventory project (http://www.acguanacaste.ac.cr/paginas_especie/plantae_online/division.html). For a very small number of taxa, definitive identification below the genus level could not be made, and all individuals belonging to the genus were pooled for the purpose of analysis. In all such cases, dispersal syndrome did not differ among congeners. Each species recorded in a transect was assigned to one of four categories based on dispersal syndrome. This was accomplished using behavioral observations (see Valenta and Fedigan, 2009a for a detailed description), as well as a long-term database of capuchin food plants maintained by Dr. Linda Fedigan. The four categories were: Group I, wind or bird dispersed taxa not known to be dispersed by monkeys; Group II, taxa consumed by monkeys but whose seeds are destroyed by handling or gut passage; Group III, taxa consumed by monkeys but for which behavioral data are unavailable, with the result that seed survival after monkey handling/gut passage is unknown; and Group IV, taxa known to be dispersed by monkeys, in that the seeds are known to survive monkey consumption of the fruit. Paired t-tests were performed to compare species richness, Shannon diversity and seedling density in each of the four dispersal categories for the two paired sleep tree and control units. Results were also compared graphically.

Results

Visual inspection of species abundances in the seedling community did not reveal any obvious effect of sleep tree status on the seedling communities beneath our target trees (Figure 1). The only differences between the control and sleep trees were significantly higher Shannon diversity in the control samples and a slight but significant difference in stem density of wind-dispersed taxa, with densities beneath sleep trees slightly higher than beneath the controls (Table 1).

Discussion

The lack of a significant increase in seedling recruitment of monkey-dispersed taxa at sleep tree sites is contra our expectation that increased seed input would result in increased capuchin-dispersed seedlings at these sites. It is possible that this lack of significant difference results from a density-dependent seed mortality effect – i.e. an increased clumping of seeds leading to the decreased survival of seeds

Table 1. Species richness and stem density beneath sleeping trees of a group of *Cebus capucinus* and control trees.

	Control 1	Sleep 1	Control 2	Sleep 2	t	p
Species Richness	25.00	24.00	54.00	34.00	1.11	0.47
Stem Density	5.03	10.55	6.25	8.25	2.14	0.28
Shannon Diversity	2.54	1.85	3.45	2.68	18.25	0.034
Group I Density	2.48	2.55	3.46	3.54	13.69	0.046
Group II Density	0.07	0.15	0.17	0.00	0.37	0.78
Group III Density	0.83	1.09	0.63	1.00	5.96	0.11
Group IV Density	1.66	6.53	2.00	3.46	1.85	0.31

and seedlings at these sites (Chapman and Russo, 2007). Increased seed mortality in areas of high seed input has been documented for other species. Julliot (1997) and Russo and Augspurger (2004) have shown significantly increased seed mortality beneath primate sleeping sites during the seed-to-seedling transition. In neither of these previous sleep tree studies, however, has increased seed mortality led to a decrease in primate-dispersed seedling density at sleep tree sites; the overall recruitment of seedlings of these species is still higher than at sites of limited input, *contra* our evidence for white-faced capuchin-dispersed seedling recruitment. This discrepancy may be due to differences in the nature of seed input between these three primate species—seedling recruitment in areas of high seed rain can be affected not only by the density of seed input, but by the diversity of seed input as well. Although white-faced capuchins disperse a high variety of seeds over time (Wehncke *et al.*, 2003; Valenta and Fedigan, 2008), the mean number of fruit species consumed per all-day focal follow is only 5 (range = 1–9), and 52% of capuchin defecations contain seeds of only one species (N = 281) (Valenta and Fedigan, 2008). The mean number of species per capuchin defecation during this study was 1.3 (range = 1–4, N = 349). This is in contrast to the defecation patterns of red howler monkeys where the mean number of species dispersed per defecation is 4.73 (N = 154; E. Andresen, pers. comm.).

Empirical support for density-dependent mortality at some life stages for some plant species has been documented (Clark and Clark, 1984; Howe, 1990; Condit *et al.*, 1992;

Harms *et al.*, 2000). Harms *et al.* (2000) additionally documented a link between density-dependent seedling recruitment and community diversity. If a correlation exists between disperser-generated patterns of seed dispersal and seed and seedling mortality that is mediated by resistance against insect, pathogen or vertebrate predation (Howe, 1989) then the disruption of frugivore communities could have negative and cascading effects on forest regeneration. Howe (1989) has hypothesized that seedlings of scatter-dispersed species (seeds dispersed by small frugivores < 3kg) will rarely survive in clumps, as they will not evolve resistance to herbivores, pathogens, or other causes of density-dependent seed mortality. Scatter-dispersed plant species will thus be vulnerable to the loss of dispersal agents, due to reduced recruitment in situations of reduced dispersal (Howe, 1989). The lack of an increase of capuchin-dispersed species underneath sleep trees may indicate density-dependent seed mortality, an effect that may be mediated by the diversity of seed input as well as the density of seed input. Further research into repeated sleep tree use by frugivorous primates should include quantifying and qualifying seed rain beneath frequently used sleep tree sites and measuring the effect of variation of seed input (scattered versus clumped) on seed survival and seedling recruitment at these sites.
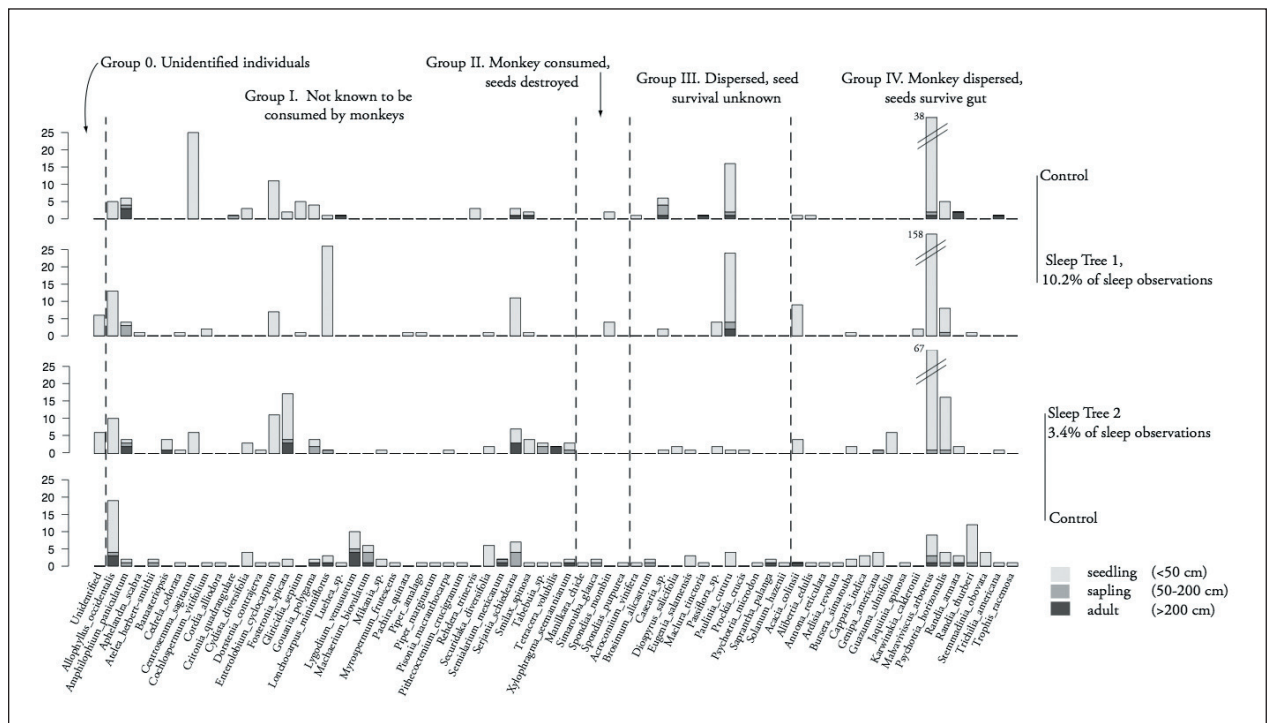
Acknowledgements

Figure 1. Relative abundance of species beneath four focal trees. Sleep trees are in the center of the diagram while control trees form the top and bottom margins. Species are arranged into dispersal types and alphabetically within those types. Where abundance values exceeded the y axis of the graph, a double score is drawn across the bar and the value appears to the left of the bar. Shadings within bars indicate whether individuals were seedlings, saplings, or adults.

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Possible Evidence of Male Dispersal in Common Woolly Monkeys (*Lagothrix lagotricha*)

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Introduction

The genus *Lagothrix*, the woolly monkeys, contains four closely related species, formerly considered subspecies (Groves, 2005). *Lagothrix spp.* are known to have female-biased dispersal (Nishimura, 2003; Di Fiore and Campbell, 2007), but genetic evidence suggests that male dispersal also occurs (Di Fiore and Fleischer, 2005). Through long term field studies, female dispersal has been observed in the wild (Stevenson *et al.,* 1994; Nishimura, 2003; Di Fiore and Campbell, 2007), but to date no observations of male dispersal have been recorded. Solitary adult males of *Lagothrix poeppigii* have been observed trying to join existing groups, but have been expelled by resident males (Di Fiore