Forest Ecology and Management 259 (2010) 1642–1649

Contents lists available at ScienceDirect

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

The role of timber tree species in the nutritional ecology of spider monkeys in a certified logging concession, Bolivia

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ARTICLE INFO

Article history:
Received 19 November 2009
Received in revised form 20 January 2010
Accepted 22 January 2010

Keywords:
Reduced-impact logging
Conservation
Diet
Staple food
Primate
Ficus

ABSTRACT

Selective harvesting of timber can lead to population declines in some primate species. As frugivorous primates are important seed dispersers in tropical forests, the reduction of their populations may affect the ecological sustainability of selectively logged forests. This paper is the first to quantify the importance of timber tree species in the diet and nutritional ecology of a primate species. We studied spider monkeys (*Ateles chamek*) inhabiting a certified forestry concession in Bolivia where post-logging population declines of this species have been recorded. We show that spider monkeys occupying unlogged areas obtained approximately 50% of their total intake of macro-nutrients from timber tree species and exhibited a distinct preference for foraging within trees that were of harvestable size. Timber tree species dominated the spider monkeys' diet both during peak fruiting periods and during periods of fruit scarcity. We estimate that under current timber extraction intensities spider monkeys lose significant proportions of their food sources. Our results indicate that further extraction limits could be considered for *Ficus boliviana*, *Spondias mombin* and *Pouteria nemorosa*. We suggest that to ensure long-term ecological sustainability of certified forestry concessions, the importance of timber tree species in the ecology of seed dispersers needs to be taken into account.

1. Introduction

Approximately six million hectares of tropical forests are selectively logged every year (Asner et al., 2005; Foley et al., 2007). Associated changes to forest structure and plant species composition can lead to significant declines in populations of forest-dependent primates (e.g. Grieser Johns, 1997; Bawa and Seidler, 1998; Chapman et al., 2000). The extent to which selective logging impacts on primates depends in part on the type and frequency of selective logging procedures conducted, the timber species removed, and the primate species considered.

Reduced-impact logging (RIL) is a modified form of selective logging that incorporates a variety of techniques aimed at lowering levels of damage to the residual stand (Heinrich, 1995; Uhl et al., 1997; Putz et al., 2001). The expectation is that these actions, in combination with strict hunting bans, will greatly reduce logging-related impacts on forest-dependent species, including species sensitive to conventional logging (Putz et al., 2001). Identifying the cause of those population declines in RIL concessions that do occur can help in the continued improvement of RIL standards.

The primate species which are considered to be most vulnerable to selective logging are arboreal, large-bodied, ripe fruit specialists, with slow reproductive rates, and large home ranges (Johns and Skorupa, 1987; Symington, 1988a; Peres, 1994a; Sorensen and Fedigan, 2000; Felton et al., 2003). For these types of species, associated population declines in selectively logged forests are thought to result from the loss of significant amounts of food resources (Johns, 1986; Marsh et al., 1987; Oates, 1996; Felton et al., 2003), alteration of the nutritional quality of food (Rode et al., 2006), and disruption of canopy pathways (Marsh et al., 1987; Gebo and Chapman, 1995; Felton et al., 2003).

Spider monkeys (genus *Ateles*, subfamily Atelinae) are canopy dwelling frugivores found in Neotropical forests, and they have frequently been identified as sensitive to habitat degradation (Johns and Skorupa, 1987; Symington, 1988a; Plumptre and Grieser Johns, 2001). Spider monkeys are also strongly territorial (Valero et al., 2006) which reduces the possibility for spatial adjustments during and after logging. Surveys conducted in the certified RIL forestry concession La Chonta in Bolivia, showed that forest that had been logged 1 and 2 years previously contained only

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doi:10.1016/j.foreco.2010.01.042

25% of spider monkey population densities found in comparable unlogged sections (Fredericksen et al., 2007). Although long-term data in this case are lacking, rapid and dramatic changes in population densities for any species exhibiting strong territoriality and slow reproductive rates are worthy of concern. When that species is also a large-bodied seed disperser, then declines in their population may have long-term negative impacts on the forest ecosystem itself (Chapman and Chapman, 1996; Chapman and Onderdonk, 1998; Babweteera and Brown, 2009).

In order to address one of the potential causes of spider monkey population decline in forestry concessions, we document the role of timber tree species (TTS) in the diet and nutritional ecology of *A. chamek* in the La Chonta forestry concession. To our knowledge this is the first comprehensive analysis of the nutritional contributions of timber trees to a primate species. We present our results using three food/diet categories (not mutually exclusive):

(i) *staple foods*: foods which are fed upon all year-round independently of the availability of preferred foods (Knott, 2005; Marshall and Wrangham, 2007)
(ii) *peak season diet*: foods consumed during the period of peak fruit abundance (Felton et al., 2009b)
(iii) *fall-back diet*: foods of high abundance consumed when preferred foods are scarce (Marshall and Wrangham, 2007)

We place our findings in the context of actual timber extraction rates from this forest and speculate with regards to the likely impact of RIL on food resources for *Ateles chamek*. We discuss forest management practices which may be disproportionately detrimental to spider monkey populations.

2. Materials and methods

2.1. Study area

The study area (S: 15°36′26″–15°37′45″ and W: 62°46′59″–62°47′56″) was located in the 100,000 ha concession La Chonta, Departmento Santa Cruz, Bolivia. The concession is owned and managed by Agroindustría Forestal La Chonta Ltda, and certified by Smartwood©. This lowland semi-deciduous tropical moist forest occurs in a transitional zone between dry and wet forest (Peña-Claros et al., 2007). The average annual temperature and precipitation for La Chonta is 25 °C and 1580 mm, with 4 months receiving <100 mm (May–September). The seasonal distribution of rainfall during this study was not aberrant (Felton et al., 2008c).

We detected three distinct phenological periods in this forest during the course of this field study: an initial period of high ripe fruit abundance (late wet season, February to mid-April) followed by a 10-week long period of fruit scarcity (early–mid dry season, mid-April to June) before ripe fruit became more abundant again (late dry–early wet season, July to September).

The concession was selectively logged for mahogany (*Swietenia macrophylla*) and Spanish cedar (*Cedrela odorata*) 10–25 years prior to this study (Fredericksen, 2000; Quevedo, 2006). These two species do not produce fleshy fruits and are not spider monkey food sources. Our study area (ca 1.5 km × 2.5 km, covering the spider monkey territory) was situated at least 2 km from areas commercially logged by the current concession owners, and more than 8 km from the closest active harvesting. Hunting is strictly prohibited and enforced within the concession.

2.2. Study subjects

Spider monkeys (genus *Ateles*, subfamily Atelinae) are found in varying forest types from ever-green rainforest to deciduous forests throughout Central and South America (Kinzey, 1997). They are diurnal, arboreal, frugivorous, and large-bodied primates (7.5–9 kg) (Kinzey, 1997; Smith and Jungers, 1997). The largest social unit of the spider monkey society is called a community, and normally includes 15–40 individuals (Campbell, 2008). Communities split into subgroups during the day according to a fission–fusion pattern of social structure (Symington, 1988b; Chapman, 1990). Our study community consisted of 48–55 individuals.

2.3. Harvesting procedure

Approximately 2500 ha is annually harvested in La Chonta over three 850 ha blocks (Jackson et al., 2002). Average harvest intensity in this forest is 4 trees/ha, average harvest volumes are 6 m^3/ha, and the intended rotation time is 25–30 years (Jackson et al., 2002; Peña-Claros et al., 2007). Approximately 160 tree species have been identified at La Chonta, 23 of which are commercially valuable (Peña-Claros et al., 2007).

One year prior to logging, trees that are selected for felling are cleared of all vines and climbers. The minimum size for harvest (MCD = minimum cut diameter) is 70 cm diameter at breast height (dbh) for *Ficus boliviana* and *Hura crepitans*, and 50 cm dbh for all other species. Approximately 20% of target species above MCD are left as seed trees/future crop trees (Jackson et al., 2002).

The territory of our study community was located within part of a logging block that was inventoried for harvestable trees during 2005 and subsequently logged in 2006. In this paper, we include information regarding the inventory of this block and the extraction of timber from all three blocks logged during 2006.

2.4. Study design

We used a trail network covering the study community's territory (360–400 ha) for conducting follows, monthly phenology surveys and detailed vegetation surveys. Within 71 0.1 ha plots distributed throughout the territory, we recorded basal area of all trees >10 cm dbh. Tree density and basal area information derived indicated the availability of certain food and timber species within the territory (see Felton et al., 2008c).

2.5. Feeding observations

Following 5 months of habituating the study community, we collected feeding data February–September 2004. We conducted continuous observations of focal animals (FAs) from dawn to dusk, alternating between 8 males and 10 females. Females were either lactating or pregnant while caring for a juvenile. We followed 10–15 of the FAs for a whole day each month. We noted exact duration of each feeding event and recorded feeding rates (number of items consumed/min) for all food types (mean number of replicates: 10; range 1–107). We used feeding rates to calculate food intake when we could not count the actual number of food items eaten. We identified and tagged all plants that the monkeys ate.

For the purpose of the nutritional analysis presented in this paper we include 51 days where (i) the FA was successfully followed all day; (ii) all feeding events were documented in detail, and (iii) relevant analyses existed for all foods consumed (32 days of 8 females, 19 days of 8 males). We also use data from an additional 19 partial follow days when presenting the proportional use of various food sources in terms of time and total dry matter intake.

2.6. Food collection and laboratory analyses

We collected food items from marked feed trees and dried samples in a drying oven (40–50 °C). For this analysis, 69