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Diurnal Activity and Food Choice of Free-foraging Captive Elephants at the Seblat Elephant Conservation Center, Sumatra, Indonesia

Arnold F. Sitompul[1,2]*, Curtice R. Griffin[2] and Todd K. Fuller[2]

[1]*Conservation Science Initiative, Bogor, Indonesia*
[2]*Department of Environmental Conservation, University of Massachusetts, Amherst, MA, USA*
**Corresponding author's e-mail: asitompul@hotmail.com*

Abstract. Since the early 1980s, hundreds of "problem" elephants (*Elephas maximus*) have been captured and translocated to elephant training centres across Sumatra, Indonesia, yet there is little information on elephant activity patterns or food choices when being managed at such centres. Using the lead animal technique, 14 free-foraging, tame elephants at a centre in Seblat were observed for 4496 daytime hours to describe their activity and diet. The majority of their daily activity was feeding (82.2 ± 5.0%), followed by moving (9.5 ± 4.0%), resting (6.6 ± 2.1%) and drinking (1.7 ± 0.6%), and individual activity budgets varied among individuals for all activities. At least 273 plant species belonging to 69 plant families were eaten by elephants, but plants from five plant families (Moraceae, Arecaceae, Fabaceae, Poaceae, and Euphorbiacea) were most commonly consumed. Elephants browsed more frequently than grazed, especially in the wet season. Elephants at the Seblat Elephant Conservation Center compensate for night-time confinement by increasing activity during the day, appear to have normal dietary intake, and thus seem well-adapted to captive management. .

Introduction

Over the past three decades, human-elephant conflict and habitat loss have been the major factors causing the decline of Sumatran elephants (Nyhus *et al*. 2000; Sitompul 2004; Hedges *et al*. 2005). Conflict occurs when elephants enter human settlements and agricultural areas, causing property damage, crop-raiding and injuring/ killing people (Nyhus *et al*. 2000; Sitompul 2004). Since the early 1980s, the response of the Indonesian Government was to capture "problem elephants" and translocate them into Elephant Training Centres (ETCs) (Santiapillai & Jackson 1990; Lair 1997). By 1996, 570 elephants had been captured and moved to six ETCs across Sumatra (Lair 1997). Despite this intensive conservation intervention, there is little information on the suitability of these ETCs to adequately maintain elephants.

Two concerns of captive elephant management are activity patterns and diet choices. These elephants are kept confined at night, a period during which wild elephants often are active (and presumably foraging) for perhaps 50-69% of the time (van Schaik & Griffiths 1996; Grassman *et al*. 2006; Gray & Phan 2011). Thus, we wondered what compensation there might be in the captive elephants' diurnal foraging activity. Also, though elephants are known to be generalist feeders (Sukumar 1989), we wanted to find out if the translocated elephants maintained a broad diet under new circumstances, and the degree to which they continued to exhibit seasonal patterns in browsing versus grazing (Sukumar 1989). Thus, the purposes of this study were to describe the general foraging ecology and diet composition of Sumatran elephants at the Seblat Elephant Conservation Center and its adjacent lowland forest.

Methods

The study was conducted in Bengkulu Province on the west coast of Sumatra and included the Seblat Elephant Conservation Center (SECC) (lat 03°03'12" – 03°09'24"S, long 101°39'18"

– 101°44'50" E) and surrounding forested and developed areas that are 50-200 m above sea level. Annual rainfall typically exceeds 3000 mm, with somewhat less precipitation during a short dry season (June-September). The perennial Seblat River forms the northern boundary of the SECC, providing a reliable water supply for elephants. The SECC comprise 6865 ha of which 70% was in forest cover in 2007. These forests are regenerating following selective logging operations in the late 1980s. In addition to 23 elephants captured as part of the government's human-elephant conflict mitigation program and housed at the SECC, 40-60 wild elephants are believed to occur on the SECC. With extensive agriculture and human settlements surrounding much of the SECC, there is much human-elephant conflict in the area.

Fourteen tame elephants (2 males and 12 females) at the SECC were used for the study between April 2007 and August 2008. Although attended by a mahout throughout each observation period, the tame elephants were permitted to forage freely, consuming a natural diet. Using the lead animal technique (i.e., tame animals followed closely by the researcher, allowing accurate identification of the foods consumed; Litvaitis 2000) individual elephants or sometimes 2-3 elephants, were observed between 7:00 to 17:00 h.

The activity of each elephant was recorded at 5-min intervals (Altman 1974); feeding activity was considered all behaviours directly involved with gathering, manipulating, chewing and swallowing food items; moving was recorded only when elephants travelled from one place to another, but excluded movements while feeding; resting was recorded when elephants were standing or lying down and there was no feeding activity; and drinking was recorded when elephants drank water from streams or ponds. Samples of all food plants eaten by elephants during the study were collected and identified to species/family based upon comparisons with specimens in the herbarium collection in Bogor (Indonesia Institute of Sciences).

The daily activities of individual elephants were averaged providing an activity budget for each elephant observed, and pooled by sex. A one-way ANOVA (Sokal & Rohlf 1995) was used to test for differences in activity budgets between individual elephants. We used post hoc TUKEY-HSD statistical tests to identify differences between time-activity budgets of individual elephants.

Proportion of time spent browsing and grazing was based upon the plants utilized. Grazing occurred when elephants consumed grass and small herbaceous plants on the ground. Browsing occurred when elephants consumed foliage from shrubs, young trees, tree bark, and bamboo. We used a Pearson's statistical regressions analysis (Sokal & Rohlf 1995) to examine relationships between season and grazing/browsing feeding behaviours. All statistical tests were conducted using SPSS statistical software version 17.0 (SPSS. Inc).

Results

Activity budget

In total, 4496 hours of observation were made on the daily activities of 14 elephants. Most of their daily activity was feeding (82.2 ± 5.0%), followed by moving (9.5 ± 4.0 %), resting (6.6 ± 2.1%) and drinking (1.7 ± 0.6%). Individual activity budgets varied among individuals for all activities (feeding [$F = 23.55$, $df = 13$, $P<0.001$], moving [$F = 18.62$, $df = 13$, $P<0.001$], resting [$F = 21.38$, $df = 13$, $P<0.001$] and drinking [$F = 8.23$, $df = 13$, $P<0.001$]). Post hoc Tukey-HSD analyses indicated that the activity budget of each individual elephant differed from at least one other elephant (Sitompul 2010). Male elephants tended to spend more time feeding and drinking, but less time moving, compared to female elephants (Table 1).

Diet

At least 273 plant species belonging to 69 plant families were eaten by elephants (Fig. 1). The most common plant taxa consumed were in the Moraceae family (mulberry family-32 species), followed by Arecaeae (palm family-26 species), Fabaceae (legume family-25 species), *Poaceae*

Table 1. Mean (SD) percent diurnal activity exhibited by 2 male and 12 female elephants at SECC, April 2007 to August 2008.

Activity	All	Males	Females	Statistics
Feeding	82.2 (5.0)	86.8 (4.7)	81.6 (7.7)	$F = 48.80$, $df = 1$, $P<0.001$
Moving	9.5 (4.0)	4.7 (4.4)	10.2 (6.5)	$F = 77.13$, $df = 1$, $P<0.001$
Drinking	1.7 (0.6)	2.0 (1.3)	1.7 (1.3)	$F = 4.93$, $df = 1$, $P<0.05$
Resting	6.6 (2.1)	6.5 (2.1)	6.5 (3.6)	$F = 0.02$, $df = 1$, $P=0.892$

(grass family-21 species) and Euphorbiaceae (spurge family-11 species).

Elephants consumed mostly twigs, young leaves and sometimes bark (Fig. 2) from the Moraceae, Fabaceae, and Euphorbiaceae taxa. Fruit, primarily figs (Moraceae: *Ficus* sp.), was rarely consumed (Fig. 3). The leaves and, petioles of palms including spines, were eaten. Typically, entire grass clumps were consumed. Bamboo species (*Schizostachyum* sp. and *Gigantochloa* sp.) were commonly eaten, comprising 19% of the total diet, and 33% of the elephant browse diet (Fig. 4).

Foraging ecology

Elephants tended to browse (56.3%) more than graze (43.1%). Bamboo, shrubs, young trees, rattan (Fig. 5) and liana were typically browsed, whereas grass species, mainly in the Poaceae family, dominated the grazed plant taxa. Elephants tended to browse more during the wet months ($F = 6.35$, $df = 13$, $P<0.05$) versus the dry months when they tended to graze ($F = 6.62$, $df = 13$, $P<0.05$). Further, browsing increased with increasing rainfall ($r_s = 0.58$, $df = 13$, $P<0.05$).

Discussion

During daytime foraging, the captive elephants were active >90% of the time. This contrasts with wild elephants, which apparently are more active at night than during the day (e.g., Grassman *et al*. 2006). Feeding was the dominant (82%) elephant diurnal activity for Seblat elephants, similar to that reported for African savannah elephants (*Loxodonta africana*; 70%-75% feeding; Lindsay

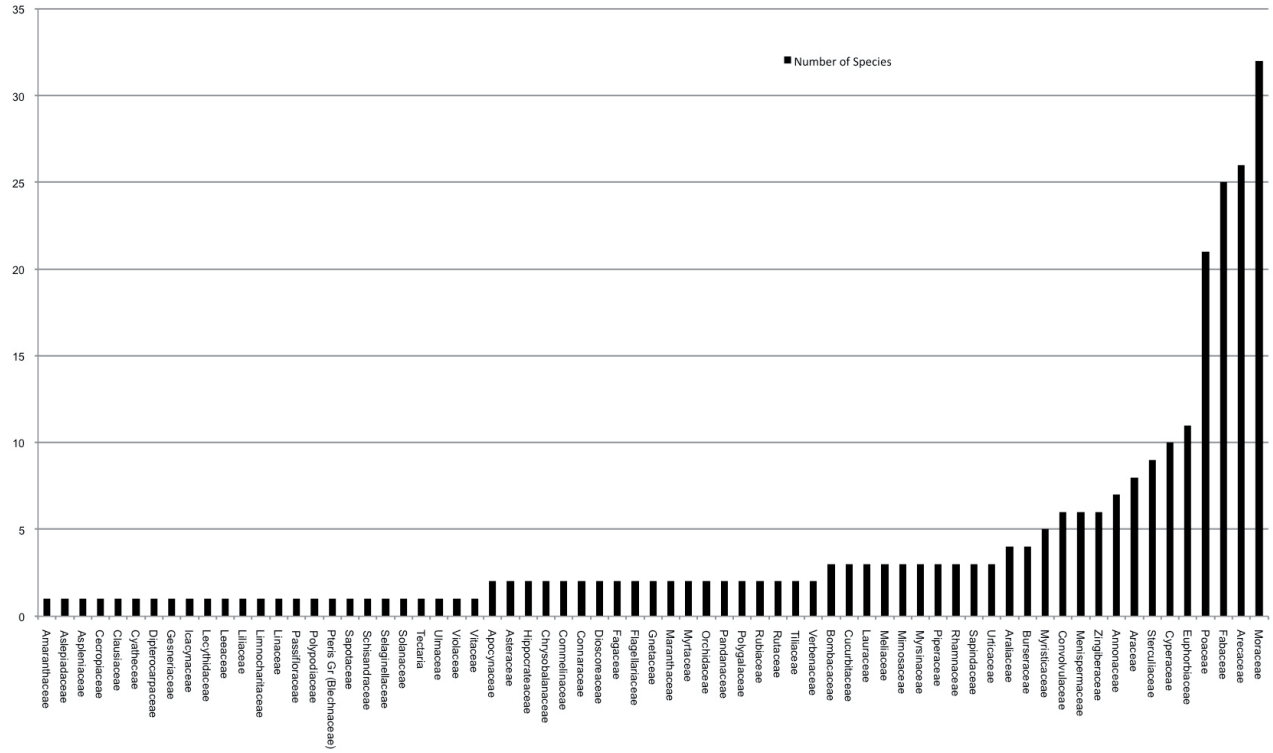

Figure 1. Numbers of plant species by taxonomic family consumed by 14 elephants at SECC, April 2007 to August 2008.

1994), and other Asian elephants (up to 91.1%; McKay 1973). The higher feeding time by male elephants probably was consequent to their larger size (~10%) and concomitant higher basal metabolic rate (Kleiber 1947). In Kenya, Lindsay (1994) also reported that the basal metabolic rate of adult male elephants could reach 1.5 times higher than for adult females.

The five plant taxa families (Moraceae, Arecaceae, Fabaceae, Poaceae and Euphorbiaceae) most frequently eaten by Seblat elephants were also reported as important in diets of elephants in Asia and Africa (Buss 1961; MacKay 1973; Guy 1976; Olivier 1978; Short 1981; Sukumar 1989; Chen *et al*. 2006; Campos-Arceiz *et al*. 2008). Elephant diet may be influenced by plant abundance, availability and palatability, but curiously, the same five plant families most frequently consumed by elephants are also important in the diets of other animals such as orangutans (Russon *et al*. 2009), hornbills (Kinnaird *et al*. 1996) and many ungulates (Schaller 1998; Baskin & Danell 2003).

The tendency of elephants to browse more than graze is probably related to the high availability and nutritional value of browse plants in Seblat. Lowland rainforest dominates Seblat and grassland habitat only occurs in small patches within the forest. Additionally, feeding behaviours of other large herbivores maximize their nutritive value while reducing the ingestion of secondary chemical compounds (Bryant & Kuropat 1980). This condition may occur for Seblat elephants where bamboo, with its low

Figure 2. Adult male feeding on tree's bark.

Figure 3. Adult female elephant feeding on figs fruit in the forest floor.

tannin levels (Easa 1989; Shuguang *et al*. 2009), is important in elephant diets.

In contrast to India and Africa where elephants tend to switch their foraging strategy from mostly browsing during dry seasons to grazing during the wet seasons (Barnes 1982; Sukumar 1989; Lindsay 1994), Seblat elephants tended to browse more during the wet season even though grass was seemingly more abundant in the dry season. The pattern in Seblat may be related to higher protein content and fatty acids reported in browse versus grass species during the wet season (Dougall & Scheldrick 1964; Field 1971).

Elephants at the SECC compensate for night-time confinement by increasing activity during the day, appear to have normal dietary intake, and thus seem well-adapted to captive management. Although selectively logged 20 years ago, the SECC and the surrounding forested areas appear to provide adequate nutritional quality for supporting elephant reproduction and growth. Thus, secondary forests of similar age should be considered suitable habitat in conservation planning for Sumatran elephants, and habitat management in other disturbed elephant habitats should focus on restoring/providing plants important in elephant diet.

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Figure 4. Adult female feeding on bamboo.

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Figure 5. Adult female feeding on rattan.

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