

The Human-Elephant Conflict in Southeastern Sri Lanka: Type of Damage, Seasonal Patterns, and Sexual Differences in the Raiding Behavior of Elephants

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Introduction

The conflicts between humans and large fauna for the use of resources have become a major concern in conservation biology (Sukumar 1991; Barnes 1996; Hill 1998; Naughton-Treves 1998; Osborn & Parker 2003; Treves & Karanth 2003). These conflicts are increasing as landscapes continue to be transformed, depleting the amount and quality of resources left for wildlife. Local communities affected by these conflicts bear disproportionate costs in the global enterprise of wildlife conservation and develop negative attitudes towards conservation policies (Newmark *et al.* 1994; de Boer *et al.* 1998). On the other hand, human-wildlife conflicts can be a precursor to the local extinction of the problematic species (Hoare 2000). The Asian elephant (*Elephas maximus*) is a clear case in point.

Asian elephants are endangered (Choudhury *et al.* 2008) due to the rapid decline of their populations in recent decades as a consequence of habitat loss, fragmentation, and the subsequent increase in human-elephant conflict (HEC) incidents (Sukumar 1989). This is particularly true for elephant populations in South Asia, where elephants often live in human-dominated landscapes in close contact with human populations (Leimgruber *et al.* 2003). Elephants have survived in large numbers in these conditions because of their special status in the South Asian culture, where people respect and care for elephants (Erdelen 1988; Bandara & Tisdell 2003; Sukumar 2003). However, these attitudes are eroding under the present levels

of HEC (Fernando *et al.* 2005), and further developments are known to impact negatively on these elephant populations (Sukumar 1991; Williams *et al.* 2001; Fernando *et al.* 2005).

Conservation of elephant populations in South Asia needs thus to emphasize the reduction of HEC (Leimgruber *et al.* 2003), but this is a spiny problem that remains unabated (Barnes 1996; Hoare 2000; Osborn & Parker 2003; Fernando *et al.* 2005). Mitigation management requires sound scientific studies to understand the underlying patterns and processes operating in HEC (Sitati *et al.* 2003) at population level, which are scarce in Asia.

Sri Lanka provides ideal conditions to study HEC. During the 20th century, human population increased dramatically (from four to twenty million people), leading to abrupt losses of forests (from 70 to 20% of the land; Legg & Jewell 1992). Nevertheless, the elephant population is still as high as 2000-4000 individuals (Santiapillai & Jackson 1990; Jayawardene 1994; but see also Blake & Hedges 2004). Many of these animals range outside protected areas, where HEC has escalated in the form of crop raiding and attacks on houses and people. Between 30-50 people and more than 150 elephants die annually in HEC incidents, posing serious problems for the Sri Lankan society. Since poaching for ivory is almost negligible (at difference to other Asian elephant populations, only 7% of males bear tusks; Jayawardene 1994), the HEC is the single main threat for Sri Lankan elephants (Fernando *et al.* 2005).

The official policy in Sri Lanka to reduce the HEC is to confine the elephants within the network of protected areas. For this purpose many elephants have been translocated or driven from conflictive areas into national parks, where electric fences have been erected (Fernando 1993). However, these policies have been rather unsuccessful (Erdelen 1988; Fernando 1993, 1997) and new, scientifically sound, strategies must be considered. Since no systematical study on the characteristics and patterns of the HEC has yet been conducted, we studied HEC incidents in the southeast of Sri Lanka for one year in order to describe the following basic patterns. First, we described the characteristics of the damage produced by elephants. Second, we addressed the temporal distribution of HEC incidents and its causes. The southeast of Sri Lanka is a tropical dry zone with marked seasonality in rainfall and therefore we focused especially on the relation of HEC with rainfall, water availability and the agriculture calendar. Finally, we looked at sexual differences in the raiding behavior of elephants, as pointed out for other populations (Sukumar & Gadgil 1988).

Study area

The southeastern region of Sri Lanka ($6^{\circ}45'-21^{\circ}N$, $81^{\circ}7'-31^{\circ}E$) is part of the dry zone of the country with a bimodal rainfall pattern. The main rainy season comes with the northeast monsoon from September to December. The dry season runs from June to mid-September, with the maximum drought occurring in August and early September. In April and May there is a shorter period of rains (Fig. 2a). The average annual precipitation ranges from 1000 to 2000 mm. The terrain is largely level and natural vegetation is dominated by scrubs and semi-evergreen dry monsoon forests. Water is limited during the dry season and the main sources of water are a few rivers and a series of seasonal and permanent “tanks” (water reservoirs for irrigation purposes).

An extensive complex of national parks, including Yala, Lunugamvehera, and Bundala (Fig. 1), covers an area of more than 1500 km² and constitutes important habitat for elephants in the region. Elephants are abundant both inside and outside the parks. Outside the park complex

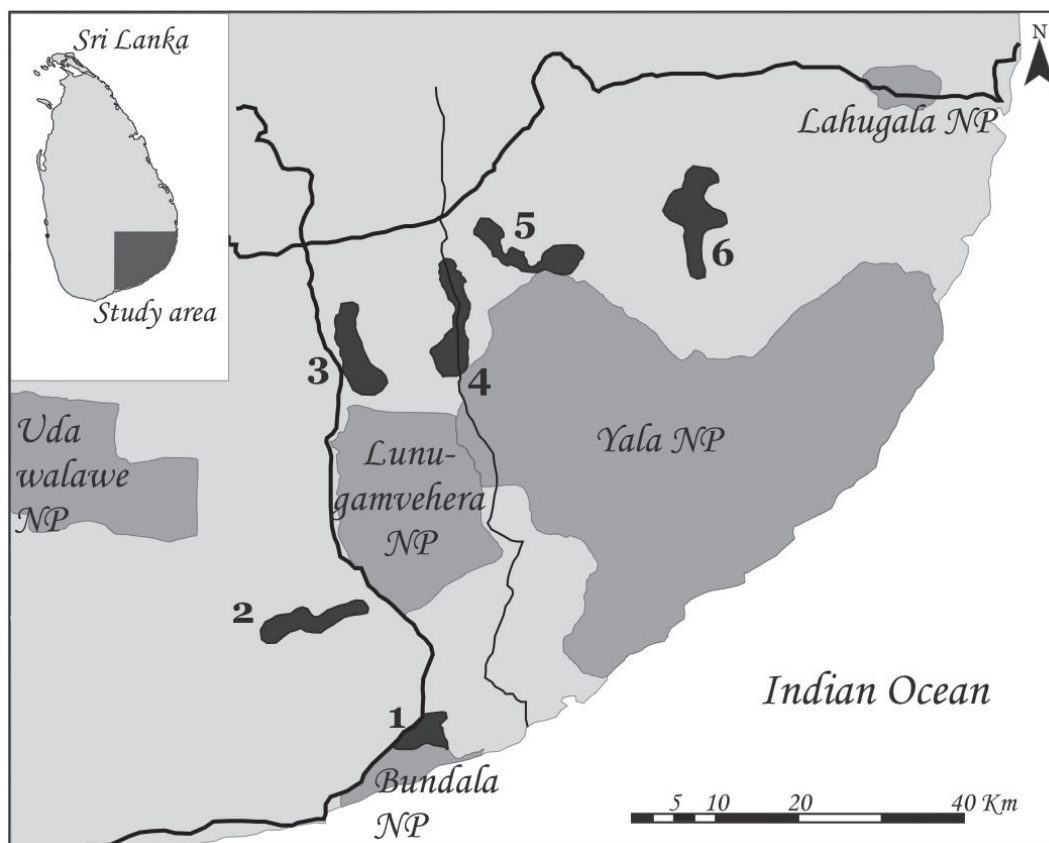


Figure 1. Study area in the southeastern region of Sri Lanka. 1-6 = HEC monitoring areas, NP = National Park, lines = main roads.

human population is rapidly increasing, and elephant habitats are being lost.

Small-scale agriculture is the main economic activity in the region. Banana (*Musa* spp), coconut (*Cocos nucifera*), and sugarcane (*Saccharum offinarum*) as well as some other tree-crops like mango (*Mangifera indica*), jack (*Artocarpus heterophylla*), and tamarind (*Tamarindus indica*) are grown through the year. Seasonal crops are cultivated during the rainy season, including paddy (*Oryza sativa*), maize (*Zea mays*), and several seasonal vegetables (*Phaseolus aureus*, *Vigna catjang*, and others). “Chena”, the local variety of shifting cultivation, is practiced during the rainy season in the forests near villages. This practice creates a mosaic of vegetation of different successional stages inside the forests. Some irrigated paddy fields can produce rice twice in a year.

In order to address the general trends of HEC in this region, we selected six areas located around the park complex (Fig. 1). These areas are old settlements that are currently expanding their limits by forest encroachment for agriculture and settlement. The mean size of our study areas was 43.7 (± 15.6 SD; range 33-72) km². One large-scale sugarcane plantation occurred in the proximity of two of the study areas. There is no detailed information on the elephant population existing in these areas, but during a preliminary survey we could assess the presence of elephants and HEC incidents in them.

Methods

Data collection

We collected data on the agriculture calendar, the water availability, and the occurrence of HEC incidents in the six study areas from June 2004 to May 2005. During the first month only four areas were studied and therefore June was excluded from the temporal analyses.) Six local people (enumerators) were trained and hired on a permanent basis to collect these data. This system allowed us to establish a reliable and independent system to report the HEC (Hoare 1999a; Sitati *et al.* 2003), avoiding the problem

of overexaggeration by farmers (Tcamba 1996; Siex & Struhsaker 1999; Hedges *et al.* 2005).

The enumerators recorded the availability of water and the agriculture calendar in their respective areas. This information was qualitative, subjective (based on their field observations), and recorded on a fortnight basis. Water availability was recorded according to six categories (0 = no water available, 1 = water is available only in permanent tanks or rivers, 2 = low water in seasonal tanks, no flow in streams, 3 = low flow in streams, 4 = medium to high level in seasonal tanks and streams, and 5 = streams and seasonal tanks are at full capacity). A general monthly water availability index was derived as the mean of the monthly water availability in each study area (which was itself the mean of the values for both fortnights). The temporal availability of seasonal crops (rice, maize, and seasonal vegetables) was recorded as “planted”, “early”, “intermediate”, “mature”, and “harvested”. Information about the agriculture calendar was collected for informative purposes and was not included in any analysis.

The enumerators visited the study areas at least twice a week. They were supported by key people at every village who collected information on the occurrence of incidents. The objectives of our study were explained to local communities and their collaboration was requested.

HEC incidents were defined as any incident involving crop damage, house damage, and human threat or injury caused by a single elephant or group of them (Hoare 1999b). All the HEC incidents were visited for verification purposes. Collection of data at each incident was largely based on Hoare (1999b). Data included:

- 1) Time and location: date, time, and GPS location of HEC incidents.
- 2) Characteristics of damage: damage was categorized into: crop, house, and human damages. These categories do not mutually exclude each other within one HEC incident. For crop damages, we recorded crop type(s), growth stage(s), size(s) of the plot

Table 1. Crop damage by elephants.

Crop	No. of attacks	Consumption*	Consumed parts	Growth stage**		
				E	I	M
Banana	318	100	Pith, tender leaves, and rarely fruit	7	38	55
Paddy	176	97	All plant	10	16	74
Coconut	128	100	Leaves and secondarily rachis	22	38	40
Sugarcane	106	82	Culm	16	45	39
Maize	87	91	Cobs and secondarily leaves	6	14	80
Manioc	85	100	Rhizome	9	28	73
Seasonal vegetables	62	93	All plant	7	10	83
Papaya	52	85	Fruit	4	17	79
Tree	41	97	Fruit, bark and leaves	3	14	83
Sesame	27	0	-	11	33	56

* percentage of cases in which damage was caused for consumption as opposed to trampling.

**E = early, I = intermediate; M = mature.

and damage, and plant parts consumed by elephants. For house damages, we recorded the degree of destruction, the materials of the houses, whether people were inside during the attack, and the reasons for the attack. For human attacks, we recorded physical injuries of the victims and the severity. Attacks on humans were also considered to include those cases in which elephants charged or chased people (without physical injury) in incidents isolated from crop raiding or house attacks.

- 3) Elephants: because of the difficulties for farmers to identify correctly sex and age classes during HEC incidents (tuskless males, incidents happening at night) we recorded only the group size of the offender elephants.

Analyses

The relationships between the temporal distribution of incidents, the temporal patterns of rainfall, and water availability were analyzed by the nonparametric Spearman's rank-order correlation. The group size of elephants was compared according to two different factors, type of damage (crop, house, and human) and season (dry, rainy, and post-rainy), using the Kruskal-Wallis test.

Results

Description of HEC incidents

From June 2004 to May 2005, we recorded 975 HEC incidents. Crop damage was the most

common form of HEC, present in 92% of the incidents. Elephants damaged more than 30 different types of cultivated plants of which banana, paddy, and coconut were the most common (Table 1). Consumption was the main cause of damage, and elephants were selective in the parts of crop they consumed (Table 1). Damage due to trampling alone (without any consumption) was less frequent (but see sesame).

Seasonal crops were raided mainly when they were ripe (Table 1). House damage accounted for 10.9% of the HEC incidents (118 houses were attacked). Elephants attacked houses to consume stored foods (mainly paddy), to drink from water deposits (e.g. home wells or water barrels), or — as claimed by some house owners' — to consume salt from kitchens. Several houses were completely destroyed (22.0%) and many more suffered serious damages that could be repaired (49.2%; Table 2). Damages were more frequent on houses made of clay (52.8%) than those of cement (14.2%) or other materials (Table 2). Although elephants attacked houses more frequently when no person was inside (68.6%), attacks with people present inside the house

Table 2. House damages by elephants.

House damage		N	%
Destruction	complete	26	22.0
	partial	58	49.2
	low	22	18.6
	others*	12	10.2
Material	cement	15	14.2
	clay	56	52.8
	other	35	33.0
People inside	yes	37	31.4
	no	81	68.6

*Others include damage on toilets and other external elements.

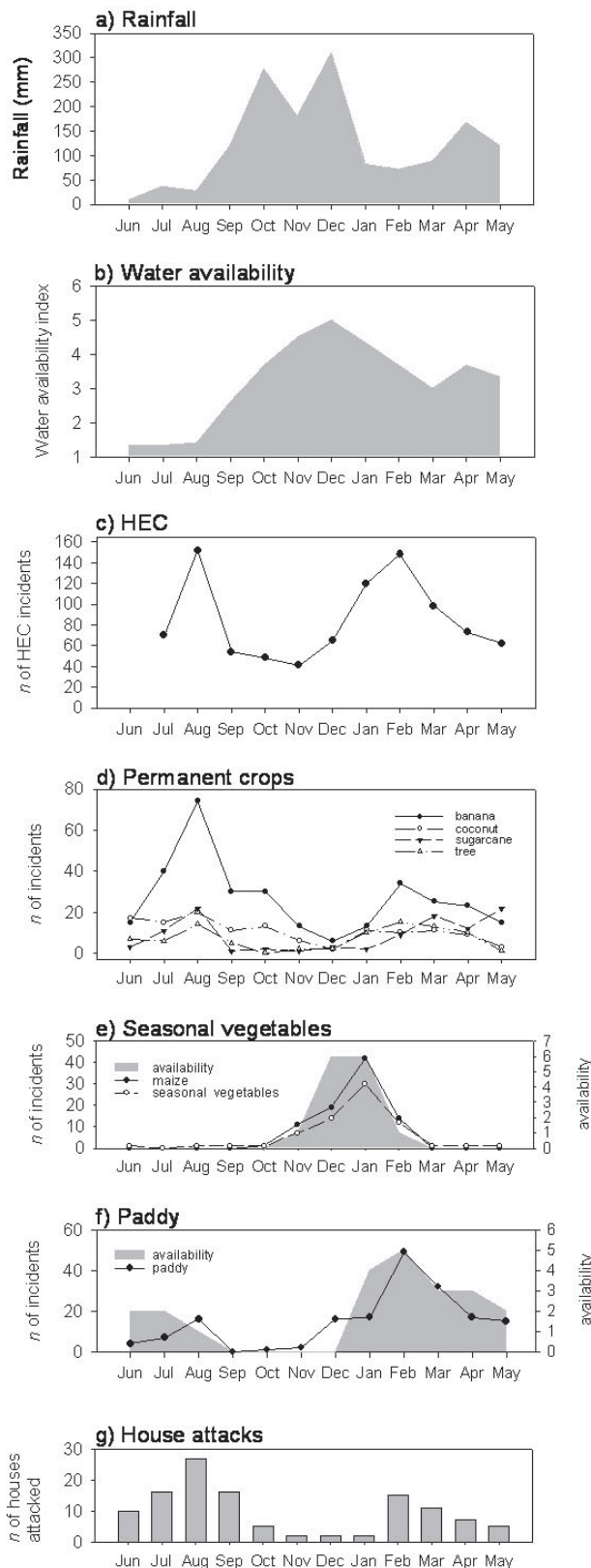


Figure 2. Temporal patterns of HEC incidents in relation to rainfall, water availability, and crop availability. Gray area in (e) and (f) represents the number of areas (0-6) in which a type of crop was recorded as ripe by enumerators. See text for explanation of water availability index.

were also frequent (31.4%; Table 2). Twenty-two (2.3% of total incidents) attacks on humans were recorded, including one death, one permanent disability and 18 charges with no physical injury. These attacks were commonly result of incidental encounters.

Temporal patterns

There was a strong positive correlation between our water availability index and the rainfall ($r_s=0.741$, $P=0.006$, $N=12$), although in January and February the lack of rain didn't translate in an immediate lack of water from rivers and tanks (Fig. 2a, b). HEC incidents occurred year-round but were more frequent during two periods (Fig. 2c): August (in the dry season) and January/ February (after the rainy season). The monthly distribution of incidents was strongly negatively correlated with rainfall, but not with the availability of water (Table 3).

Damages on permanent crops were very high during the dry season, especially on banana, low during the rainy season, and relatively high in February (Fig. 2d). The damage frequencies on banana, coconut, and trees were better explained by water availability than by rainfall (Table 3). In contrast, damages on seasonal crops (Fig. 2e) and paddy (Fig. 2f) occurred after the rainy season. Cultivation of these crops started in October, they ripened in December and January, and were harvested before March (Fig. 2e). Paddy ripened mainly from January and remained longer than other seasonal crops (Fig. 2f). The temporal distribution of damage on paddy, maize, and seasonal vegetables followed their availability as ripe crops (Fig. 2e, f).

Table 3. Spearman's rank-order correlation between raiding frequency and rainfall, water and crop availability.

Incident type	Rainfall	Water
All incidents	-0.745**	-0.257
Banana (permanent)	-0.667*	-0.816*
Coconut (permanent)	-0.606**	-0.694*
Tree (permanent)	-0.626*	-0.755**
Paddy (seasonal)	-0.374	0.161
Maize (seasonal)	0.283	0.820**
Vegetables (seasonal)	0.253	0.830**
House damage	-0.645*	-0.796**

*signi cant at $p = 0.05$; ** $p < 0.01$.

Table 4. Group size of raiding elephants according to type of damage and season.

Group size		Mean	SD	N	Kruskal-Wallis <i>p</i>	d.f.
General		2.37	2.85	915		
Type damage	crop raid	2.46	2.94	845	0.000	2
	house attack	1.55	0.98	38		
	human attack (threats and injuries)	1.05	0.21	22		
Season	dry (July/August)	2.46	2.60	212	0.567	2
	rainy (October/November)	2.46	3.09	76		
	post-rainy (January/February)	2.43	3.22	265		

House attacks showed a bimodal distribution (Fig. 2g). Frequencies of house damages were higher in the dry season than in the post-rainy season (Fig. 2g). Houses were attacked less frequently from Nov. to January, but it is noteworthy that crop raiding was frequent in January (Fig. 2c).

Raiding behavior of elephants

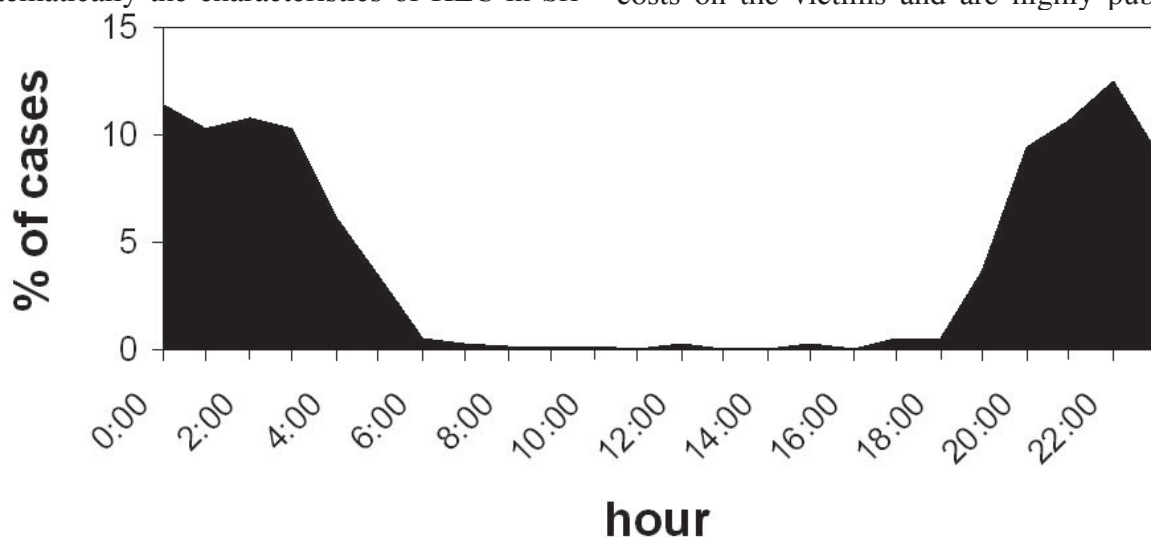
HEC incidents occurred almost exclusively during nighttime (98.3%; Fig. 3). The group sizes of raiding elephants were highly biased to small groups, and 57.4% of incidents were caused by lone elephants (Fig. 4). The group size of raiding elephants did not vary seasonally, but according to the type of HEC incident: average group size was smaller in attacks on humans and houses than in crop raiding incidents (Table 4).

Discussion

Description of HEC incidents

This is one of the first studies to describe systematically the characteristics of HEC in Sri

Lanka. In our study area, crop raiding was the most common type of HEC incident, as in other populations in India (Sukumar 1990; Williams *et al.* 2001), Sumatra (Nyhus *et al.* 2000; Hedges *et al.* 2005), South China (Zhang & Wang 2003) and Africa (Hoare 1999a; Sitati *et al.* 2003; among others). Elephants consume crops as part of their optimal foraging strategy, and the proximate causes that lead to crop (or house) raiding have been well explained by Sukumar (1989, 1990). Attacks on houses and people were frequent in our study area; especially the attacks on houses seem to be much higher than in other populations (but see Hedges *et al.* 2005). It is common to keep rice sacs in the same rooms where people sleep because, to some extent, it reduces the risk of attack by elephants. Elephants probably detect rice and other goods stored inside the houses with their sensitive smell sense and knock down the walls to feed on them. Some farmers suggested that a few elephants might have become accustomed to raiding houses and do it repeatedly. Attacks on houses and people have a high social impact, since they produce high costs on the victims and are highly publicized

**Figure 3.** Time distribution of HEC incidents.

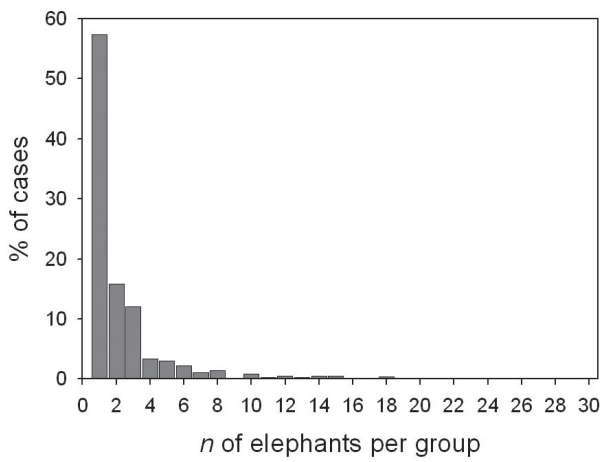


Figure 4. Group size of raiding elephants.

by media. Although farmers in southeast Sri Lanka are mostly Buddhist and very tolerant to crop losses by elephants, tolerance to attacks on houses and people is probably lower. High levels of these incidents may change local people's attitude toward elephants.

Temporal patterns

We have shown that HEC in the southeast of Sri Lanka is a seasonal phenomenon in which rainfall is the main driver for the temporal distribution of HEC incidents. According to the raiding frequency of elephants, the year can be divided into four seasons: the dry season with high damage, the rainy season with low damage, the post-rainy season with high damage, and the transitory season with low damage. These seasons largely correspond with the rainfall patterns.

In order to understand the seasonal patterns of damage by elephants, the attractiveness of crops in relation to wild forage in a particular season, the extent of availability of crops, and the presence of elephants near cultivated areas should be considered (Sukumar 2003). When the attractiveness of crops in relation to wild forage crosses certain threshold — caused either by a decrease in the quality of wild fodder or by an increase in the quantity and quality of crops — we can expect peaks of high conflict like those observed in our study area during the dry and post-rainy seasons. In our study area, the severe drought during the dry season probably led to a drop in the quality of wild forage. In these conditions, the few available crops, as

well as other resources such as food and water stored in houses, would become relatively more attractive to elephants and hence the increase in HEC incidents. With the onset of rains, natural vegetation recovers and damage on crops and houses decreased drastically. The abundant rain from September to December determined local agricultural practices and by January and February (the post-rainy season) most of seasonal crops became ripe. Although rainfall was low in this period, drought was not as severe as during the dry season (e.g. relatively high levels of water flow in streams and tanks; Fig. 2b). We think that the increased attractiveness of crops relative to wild forage in this season was caused by an increase in the abundance and quality of crops, rather than by a drop in the quality of wild fodder. This corresponds with the peaks of damage described for other elephant populations in Asia (Sukumar 1990) and Africa (Bhima 1998; Osborn 2004; Chiyo *et al.* 2005).

Sri Lankan elephants do not undergo seasonal migrations (Fernando, pers. com.), and therefore this factor cannot explain any seasonal variation in HEC as found in other populations (Tchamba 1996). However, we detected some seasonal differences in their local spatial distribution. Particularly, we think that chena cultivation exerted some influence in the distribution of elephants because from October to the end of January the forests around villages were occupied by chena farmers working on and guarding their crops, acting as a barrier for elephant movements toward villages. Once chena was harvested, the result was a mosaic of forest and open patches with low human presence that elephants used extensively, moving closer to villages. From February, there was a sharp increase in the number of raids on paddy, banana, and especially on houses, which we think was partially due to the end of chena activities.

Further investigation is necessary to clarify the details of the relations between the cycles of abundance and quality in natural foods and crops (based on objective and quantitative measurements rather than qualitative data presented here), and their effects on the seasonal changes in crop raiding by elephants in this

region. However, it seems very likely that the mechanisms determining an increase of damage are different in the dry and the post-rainy seasons, which is relevant for the design of mitigation management.

Raiding behavior

Most of the HEC incidents were caused by small groups of elephants, mainly one to three individuals. It is known that elephant males tend to move alone or in small temporal groups (up to five individuals; McKay 1973), whereas females move in family-based larger groups (McKay 1973; Fernando & Lande 2000). Thus, it is plausible that most of the problematic elephants in this region are bulls. Our results coincide with previous studies in the region (Fernando *et al.* 2005), in southern India (Sukumar 1989), northern India (Williams *et al.* 2001), or in African savanna (Bhima 1998; Osborne 1998; Hoare 1999a; but see Sitati *et al.* 2003). These results indicate different behavioral strategies between adult males and female-led herds, with males more ready to assume the risks of crop raiding and attacks to houses and humans than females in a “high risk-high gain” behavior related to their reproductive strategies (Sukumar & Gadgil 1988). The fact that most of the HEC incidents happened at night also supports this. Elephants are active during daytime (McKay 1973). Exclusive nocturnal raiding behavior therefore indicates that elephants do recognize the risk associated to incurring in HEC accidents. Sexual differences were even more accused in attacks to houses and people, involving higher risk than crop raiding. Sexual differences in HEC have consequences for the management of conflictive populations (Sukumar 1991).

Since female herds managed to obtain their resources without frequently feeding on crops, it can be said that crops are not a necessary component of the diet of elephants in the region. It has been suggested that females, initially less prone to assume the risks of conflicts with farmers, might become obligate crop raiders when living in highly fragmented habitats, where resources are more limited and scattered in the human-dominated landscape (Sukumar 2003; Fernando

et al. 2005). This means that the level of HEC in the southeast of Sri Lanka is likely to increase in coming years, as further developments and loss of habitats are ongoing. If such threshold exists, in which elephants become obligate rather than “optional” raiders, conservation of elephants would become much harder once it is crossed, and therefore habitat management should be oriented to avoid these levels of habitat fragmentation and impoverishment.

In the long run, the large extension of the park complex will guarantee the survival of elephants in the southeast of Sri Lanka. However, the elephants ranging outside parks will continue to raid crops and incur into HEC. In order to maintain the peaceful attitude of people toward elephants, as has been done for the last 2000 years or longer (Erdelen 1988), more effective HEC mitigation policies are needed. We encourage the use of (evidence-based) adaptive management strategies that integrate information about the periods and locations in which particular subsets of the elephant population are likely to incur in particular forms of HEC incidents. These management strategies need to be designed at landscape-level and considering the requirements of elephants and local agricultural societies (e.g. Fernando *et al.* 2006).

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