Research Article *Gajah 42 (2015) 7-14*

Camera Traps Unveil Enigmatic Crop Raiders in Udawalawe, Sri Lanka

Ashoka D. G. Ranjeewa[1]*, Y. J. S. Tharanga[1], G. H. N. A. Sandanayake[1], B. Vijitha Perera[2] and Prithiviraj Fernando[3]

[1]*No. 1/657 Thanamalwila Road, Udawalawe, Sri Lanka*
[2]*Department of Wildlife Conservation, Battaramulla, Sri Lanka*
[3]*Centre for Conservation and Research, Rajagiriya, Sri Lanka*
**Corresponding author's e-mail: dga.ranjeewa@gmail.com*

Abstract. We studied Asian elephants (*Elephas maximus*) entering three villages bordering the Udawalawe National Park, Sri Lanka, by placing camera traps on road openings of the boundary electric fence of the park. We identified 35 individuals that crossed the fence, all of which were males. Identified individuals were of differing age/size classes and the majority were solitary. Elephants left the park at dusk and retuned at dawn. Individual variation was observed in method and time of fence crossing. Elephants showed localized movement over the small area of the study. Our results suggest a high degree of crop raiding by males in the area and underscore the failure of current management activities in preventing human-elephant conflict.

Introduction

Human-elephant conflict (HEC) is the primary threat to the survival of Asian elephants (Fernando *et al*. 2012). Elephants have a distinct social structure with group living females and solitary males, with adult males being the main contributors to HEC (Sukumar & Gadgil 1988; Chiyo & Cochrane 2005; Fernando 2011). Crop raiding is the principal proximal cause for the conflict between humans and elephants. Elephants raid crops primarily at night (Sukumar 1989; Graham *et al*. 2009). However, all males in a population do not raid crops (Williams *et al*. 2001; Chiyo *et al*. 2011b).

Most HEC studies are based on damage evaluation through questionnaire surveys or examining pre-existing records (Fernando *et al*. 2005; Santiyapillai *et al*. 2010; Ekanayaka *et al*. 2011). A few studies have used new technology such as radio collars (Fernando *et al*. 2008; Graham *et al*. 2009) and DNA analysis (Chiyo *et al*. 2011b).

Patterns of HEC may vary between locations (Hoare 2001) and by individual elephant. Individual identification of 'problem-elephants' can provide information useful in understanding HEC and determining location specific and effective mitigation actions. Due to the difficulty in locating and observing elephants at night, it is challenging to identify crop-raiding individuals by direct observation. Thus, important aspects such as the demography of crop raiders, number of raiders and individual patterns of crop raiding, remain largely unknown.

In this study, we used infrared night vision camera traps to identify individual elephants entering three villages bordering the Udawalawe National Park, Sri Lanka.

Methods

Study area

The study area encompassed the villages of Pokunuthanna, Neraluwa and Dahaiyagala, situated at the northern border of the Udawalawe National Park (UWNP) in southern Sri Lanka. Distance between the villages were: Pokunuthanna and Dahaiyagala 3 km, Pokunuthanna and Neraluwa 1.5 km, Dahaiyagala and Neraluwa 2.7 km. UWNP covers 308 km^2 with a boundary of approximately 100 km. It is contiguous with

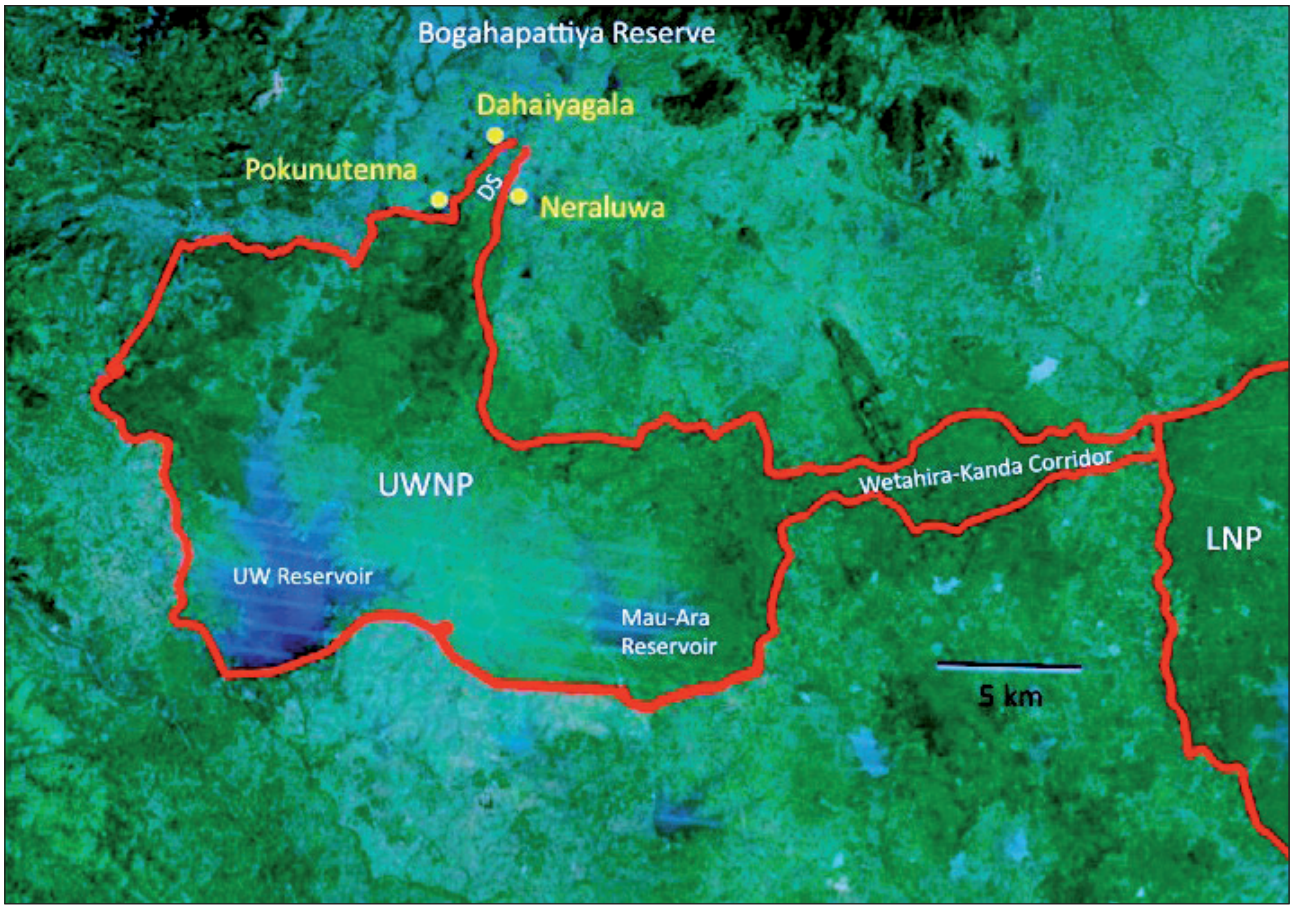

Figure 1. Map of Udawalawe National Park and study area. Red line: electric fence on park boundary. LNP: Lunugamvehera National Park. DS: Dahaiyagala Sanctuary.

the Dahaiyagala sanctuary and Bogahapattiya Forest Reserve in the north and Wetahira-Kanda corridor and Lunugamvehera National Park in the east (Fig. 1). It is used by around 1000 elephants of which around 250 are mature males (de Silva *et al*. 2011). Elephant habitat extends beyond the park boundaries to adjacent conservation and non-conservation areas.

The mean annual temperature is approximately 32ºC and the average annual rainfall is about 1329 mm. The main rainfall occurs from October to December during the northeast monsoon and some rain is received via the southwest monsoon from March to April. Two cultivation seasons "Maha" and "Yala" follow the rainfall.

The major crop in the area was paddy. Banana, coconut, mango, manioc, papaya and vegetables were also cultivated. Villagers guarded their crops using tree huts, shouting, fire crackers, hanging electric torches, and by setting up bonfires and locally made electric fences.

An electric fence built by the Department of Wildlife Conservation was located on the boundaries of the UWNP and the Dahaiyagala sanctuary (Fig. 1). The fence separated the protected area from the three study villages and lay through small forest patches in some places. Several public roads crossed the fence through the Sanctuary area. The fence had five openings related to roads, guarded by detachable electric wires.

Data collection and individual identification

The study was conducted from March 2014 to January 2015. Data was not collected during the months of September, November and December due to logistic issues. Within the study period, the cameras were deployed on a total of 38 nights. Four night vision camera traps were used. The cameras were stationed close to one of the three villages on each night of data collection. Fence road openings (Fig. 2) and elephant trails within 200 m of fence road openings, were selected

Figure 2. Road fence opening at Pokunuthanna.

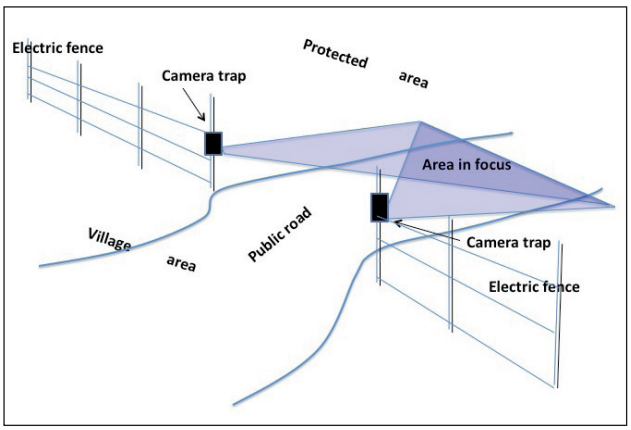

Figure 3. Camera trap setting at fence openings.

to set the camera traps. Two camera traps were set covering the fence opening (Fig. 3) and the other two camera traps were set on nearby trails. Camera traps were not set during the day as elephants did not cross the fence during daylight hours.

Camera traps were fixed at a height of 4-5 feet from the ground, facing the park, to capture frontal views of elephants leaving the park (Fig. 4). At 24:00 h, one camera was turned around to face the village, to capture returning elephants. Camera operation mode was set to take day and night pictures. A series of three consecutive still photos and a 15 second video clip were captured at each trigger. A one second interval was set between each photo, video and trigger. The cameras were in operation from 17:30 h to 6:30 h. In addition, observations were conducted from a vehicle about 80 m away from the fence openings, which also served to prevent the cameras from being stolen.

Individual elephants were identified using morphological criteria (Moss 1996; de Silva *et al*. 2011). Three age/size classes were defined for males as mature-adult, young-adult and sub-adult. Identification of mature- and young-adults was based on secondary sexual characteristics (Fernando *et al*. 2012), and sub-adults on assessed height in addition (shorter and less developed secondary sexual characteristics than young-adults). Individuals detected ≥5 times were used to study individual variation in crossing the fence and those seen ≥3 times were used to assess locational preference. Capture histories were constructed from camera trap data and observations. Date, time, method of leaving and returning, individual identity, sex, age class, group size and the village name were recorded for each capture. Elephants captured within 10 minutes of each other and moving in the same direction (in or out of the park) were considered to be associating as a group.

Method of exiting and entering the park was classified as 'opening' when an elephant crossed the fence at an unguarded road opening, as 'breaking' when the fence was crossed by bringing down fence posts or stepping on the wires. If an

Figure 4. Examples of elephants captured by the camera traps.

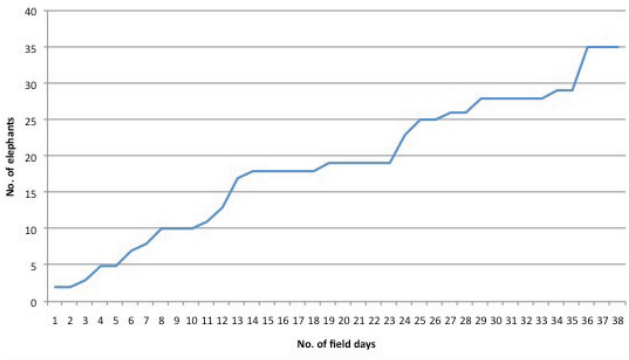

Figure 5. Cumulative number of identified individuals.

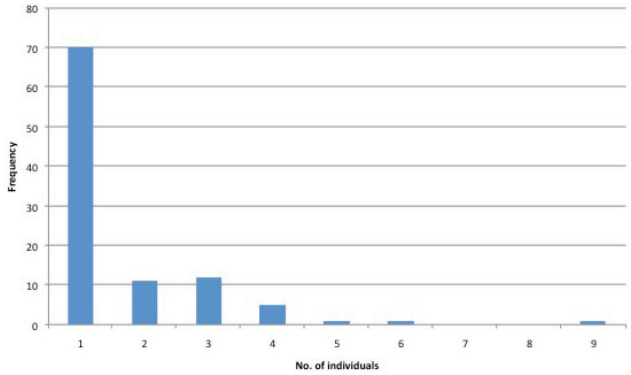

Figure 6. Group size and frequency of elephants crossing the fence.

elephant was captured only on exiting, method of entering was recorded as unknown and vice versa.

Results

Elephants were observed on 33 out of the 38 nights of data collection. A total of 192 elephant crossings were recorded with an average of 5 ± 5.33, ranging from 0 to 22 crossings per day. All crossings were by males. A total of 35 individuals were identified, of which 21 were mature-adults, 5 young-adults and 9 sub-adults. The cumulative number of the identified individuals showed continued increase throughout the study period (Fig. 5). Of elephants crossing the fence, 69% were solitary individuals and group sizes of associating individuals ranged from 2 to 9 with a mean of 3.16 ± 1.46 (Fig. 6).

Timing of leaving and returning

The earliest time elephants exited the park was 17:55 h and the latest time of entering the park was 6:06 h. The peak of elephants leaving the park was from 18:00 - 21:30 h (86%). The peak period of returning to the park was 4:00 - 6:30 h (86%) with 43% of crossings between 5:00 - 5:30 h. Elephant crossings were minimal between 23:30 - 2:30 h (Fig. 7).

Methods of leaving and returning

Elephants used several methods to cross the fence (Fig. 8). On 88% of occasions, individuals did not return from the point they exited the park that night. Of the individuals crossing the fence, 23% left the park by 'breaking', 49% through 'openings' and 28% were classified as 'unknown'. When returning, 11% entered the park by 'breaking', 32% through 'openings' and 57% were 'unknown'.

Individual variation

Six males consisting of five mature adults and one sub-adult crossed the fence five times or more. They crossed the fence a total of 60 times, with a

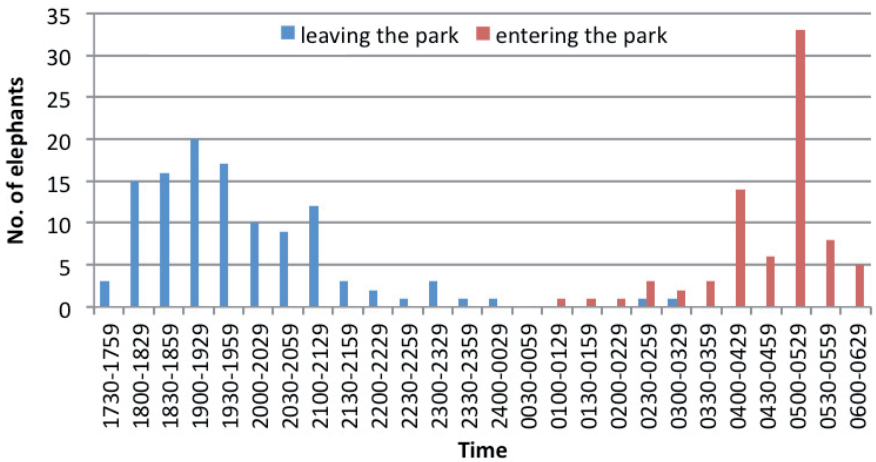

Figure 7. Elephant crossings against time.

Table 1. Method of leaving and returning to the park by selected males, as a % of total exits and entries of each individual.

	Exiting park			Entering park		
Elephant ID	Opening	Breaking	Unknown	Opening	Breaking	Unknown
M153	67	33	0	0	0	100
M155	75	8	17	58	0	42
M166	83	0	17	67	0	33
M286	27	36	36	36	36	27
M1004	40	60	0	20	0	80
M1015	66	17	17	33	0	67

mean of 10.00 ± 4.871 (range 6-17) crossings by an individual (Fig. 9, Table 1).

Thirteen individuals crossed the fence three or more times. They made a total of 70 crossings with an average of 5.38 ± 3.176 (Range 3-12) crossings by an individual. M155, M1000 and M1012 were observed at Dahaiyagala in 92%, 100% and 100% of crossings respectively. M286 (92%), M1003, M1004 and M1011 (100%) were only seen at Pokunuthanna. Six out of the eight males found at Pokunuthanna were also seen at Neraluwa and the other two also at Dahaiyagala. Two males were recorded at Neraluwa and Dahaiyagala. M1015 was seen at all three villages.

Discussion

We found that only males crossed the fence to enter the study villages. As the villages were situated next to the park fence and crop raiding was common, it can be assumed that the males crossed the fence to raid crops. Our results are consistent with previous studies on African elephants (Chiyo & Cochrane 2005) and Asian elephants (Fernando *et al*. 2005; Ekanayaka *et al*. 2011) that found only males raided crops. Crops have higher nutritional value than wild fodder (Sukumar 1989). Our findings support the hypothesis that despite high risk, males raid crops to increase body size, thereby enhancing reproductive success (Sukumar & Gadgil 1988; Chiyo *et al*. 2011a).

We identified 35 crop-raiding males, which amounts to 15% the total number of males previously identified by de Silva *et al*. (2011) in the UWNP. A study using molecular and observational techniques in Amboseli National Park, Kenya estimated that one third of the males engaged in crop raiding (Chiyo *et al*. 2011b). The cumulative number of identified males did not reach an asymptote during our study, indicating that the total number of crop raiders within the study area was higher than what was recorded. Therefore, the proportion of raiders in the Udawalawe population is likely to be much higher than in Amboseli.

Figure 8. Methods used by elephants to cross the fence. Left: Pushing a fence post. Middle: Stepping on fence wires. Right: Through unguarded road opening.

Our study was confined to 3 road openings in relation to 3 villages, and covered approximately 6 km of the park perimeter fence. There are approximately 52 villages around UWNP and the perimeter fence is around 100 km. Crop raiding is experienced in almost all villages around the park. While road openings on the fence were limited, elephants broke the fence all along its length. We also observed elephants crossing the park fence on most days of observation, throughout the year. Therefore, our study underscores the very high prevalence of raiding in the area.

We observed elephants crossing the fence to be mainly solitary, together with a few bull groups.

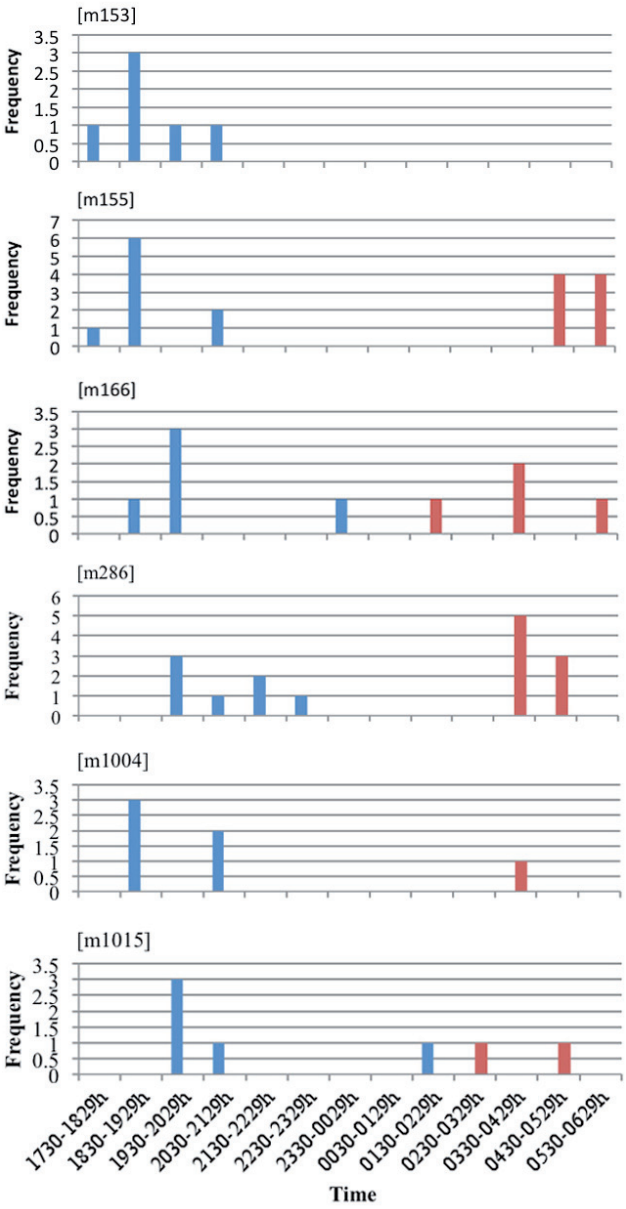

Figure 9. Times of individual elephants leaving (blue) and returning (red) to the park.

A similar pattern was observed in Hasanur in southern India, where raiding by single bulls was the most common but groups of up to four males came together for raiding (Sukumar 1989). Sukumar (1989) also recorded a higher grouping propensity during the night, with only 7% of bulls observed to be in groups during the day and 43% during the night. An observational study by McKay (1973) found 18%, 19% and 38% of males to form diurnal bull groups in Yala, Gal-Oya and Lahugala National Parks respectively in South-east Sri Lanka. Nettasinghe (1973) recorded a bull group of eight at Thamankaduwa area in north-central Sri Lanka. We found 30% of the males identified in our study to associate in bull groups. The group of nine observed by us is the largest bull group recorded in Sri Lanka to date. Therefore, our study found a comparatively high tendency for bull group formation, which is likely to be related to the raiding behaviour of the observed individuals.

We detected all three age-classes of males crossing the fence to and from the villages. Thus it is likely that the number of 'problem elephants' (Fernando 2011) in the area will increase in the future as more young elephants take up raiding.

Timing of leaving and returning to the park.

We found that elephants left the park at dusk and returned at dawn. In southern India males entered crop-lands between 19:00 h to 22:00 h and returned before sun rise (Sukumar 1989). A study in Laikipia plateau, Kenya, found elephants raided crops during the night and that they moved more rapidly when in human dominated areas (Graham *et al*. 2009). In North-western Sri Lanka, de Silva & de Silva (2007) found that feeding hours shifted to the late evening or night in areas with high habitat disturbance. The preference for entering human areas and presumably raiding crops during hours of darkness as observed by us and other studies, could be related to minimizing detection hence risk.

Methods of leaving and entering

Only a small proportion of males used the same point for exiting and returning to the park. We

found that the majority of males left the park through road openings but their return was not detected. This could be due to returning through another road opening or by breaking through the fence at a different site, or not returning but moving-on. As elephants sometimes broke the fence even when they could exit the park through an opening, and the fence was broken regularly along its length at multiple points, most elephants that exited the park could have returned by breaking the fence at another point. Our results suggest that the electric fence on the park boundary was ineffective in preventing males from exiting the park, hence it didn't stop the crop raiding.

Individual variation

Intra- and inter- individual variation was observed in times of exit and re-entry, hence amount of time spent outside. While the times of exit and re-entry by a particular individual varied between dates, some individuals appeared to favour particular time periods. Such variation could be due to different extents of crop raiding and risk taking by different males but could also be related to experiences on a particular night and crop guarding by villagers.

Individual males showed variation in the method of crossing the fence with M155 and M166 mostly using openings and the others showing an irregular pattern. Individual variation in methods of crossing the fence suggests that individuals varied in their ability and/or preference. As elephants have high memory capacity and can learn from each other (Savage *et al*. 1994; McComb *et al*. 2001; Byrne *et al*. 2009), such variation maybe related to past experiences and associations.

We found a high degree of preference for particular villages by specific individuals, with only one of 13 elephants observed at all three villages. As the three villages were within an area of about 5 km^2, our results suggest localization of crop raiding males at a fine geographic scale. While we do not have the information to determine cause, such localization could be related to variation in resource (crop) availability and degree of crop protection hence risk, together with home range boundaries, competition between individuals and variation in risk taking.

Conservation importance

Our study demonstrates that night vision camera traps can provide accurate individual identification of problem elephants and can provide information on the demography, number of raiders, patterns and timing of the movements of such elephants. Such data enables managing 'problem elephants' without negatively impacting non-raiding individuals.

The main management actions for HEC mitigation in Sri Lanka and across the range are translocation, elephant drives and constructing electric fences. In addition to the general failure of translocation in mitigating HEC (Fernando *et al*. 2012), our findings indicate that translocation is impractical in our study area, as a large number of males caused problems. Elephant drives would also be inappropriate and ineffective, as only males raided and they crossed the fence at will. Therefore, the most effective HEC mitigation measures for the area would be community based methods, centred on small 'exclosure' electric fences, rather than the extensive 'enclosure' fence on the park boundary.

Acknowledgements

We thank the Department of Wildlife Conservation of Sri Lanka for permission to conduct the study and the Rufford Foundation for financial support.

References

Byrne RW, Bates L & Moss CJ (2009) Elephant cognition in primate perspective. *Comparative Cognition & Behavior Reviews* **4:** 65-79.

Chiyo PI & Cochrane EP (2005) Population structure and behaviour of crop-raiding elephants in Kibale National Park, Uganda. *African Journal of Ecology* **43:** 233-241.

Chiyo PI, Lee PC, Moss CJ, Archie EA, Hollister-Smith JA & Alberts SC (2011a) No risk, no gain:

Effects of crop raiding and genetic diversity on body size in male elephants. *Behavioral Ecology* **22:** 552-558.

Chiyo PI, Moss CJ, Archie EA, Hollister-Smith JA & Alberts SC (2011b) Using molecular and observational techniques to estimate the number and raiding patterns of crop-raiding elephants. *Journal of Applied Ecology* **48:** 788-796

Ekanayaka SKK, Campos-Arceiz A, Rupasinghe M, Pastorini J & Fernando P (2011) Patterns of crop raiding by Asian elephants in a human-dominated landscape in Southeastern Sri Lanka. *Gajah* **34:** 20-25.

Fernando P (2011) Managing 'problem elephants'. *Loris* **25(6):** 32-36.

Fernando P, Leimgruber P, Prasad T & Pastorini J (2012) Problem-elephant translocation: Translocating the problem and the elephant? *PLoS ONE* **7:** e50917.

Fernando P, Wikramanayake E, Weerakoon D, Jayasinghe, LKA, Gunawardene M & Janaka HK (2005) Perceptions and patterns of human–elephant conflict in old and new settlements in Sri Lanka: insights for mitigation and management. *Biodiversity and Conservation* **14:** 2465-2481.

Fernando P, Wickramanayake ED, Janaka HK, Jayasinghe LKA, Gunawardene M, Kotagama SW, Weerakoon D & Pastorini J (2008) Ranging behavior of the Asian elephant in Sri Lanka. *Mammalian Biology* **73:** 2-13.

Graham MD, Douglas-Hamilton I, Adams WM & Lee PC (2009) The movement of African elephants in a human-dominated land-use mosaic. *Animal Conservation* **12:** 445-455.

Hoare R (2001) Management implications of new research on problem elephants. *Pachyderm* **30:** 44-48.

McComb K, Moss C, Durant SM, Baker L & Sayialel S (2001) Matriarchs as repositories of social knowledge in African elephants. *Science* **292:** 491-494.

McKay GM (1973) The ecology and behaviour of the Ceylon elephant in southeastern Ceylon. *Smithsonian Contrib. Zool.*, **125:** 1-113.

Moss C (1996) Getting to know a population. In: *Studying Elephants*. Kangwana K (ed) African Wildlife Foundation, Nairobi. pp 58-74.

Nettasinghe APW (1973) *The Inter-Relationship of Livestock and Elephants at Thamankaduwa Farm, with Special Reference to Feeding and Environment*. M.Sc. thesis, University of Peradeniya, Sri Lanka.

Santiapillai C, Wijeyamohan S, Bandara G, Athurupana R, Dissanayake N & Read B (2010) An assessment of the human elephant conflict in Sri Lanka. *Cey. J. Sci. (Bio. Sci.)* **39:** 21-33.

Savage A, Rice JM, Brangan JM, Martini DP, Pugh JA & Miller CD (1994) Performance of African elephants (*Loxodonta africana*) and California sea lions (*Zalophus californianus*) on a two-choice object discrimination task. *Zoo Biology* **13:** 69-75.

de Silva M & de Silva PK (2007) *The Sri Lankan Elephant: Its Evolution, Ecology and Conservation*. Wildlife Heritage Trust Publications.

de Silva S, Ranjeewa ADG & Weerakoon D (2011) Demography of Asian elephants (*Elephas maximus*) at Uda Walawe National Park, Sri Lanka based on identified individuals. *Biological Conservation* **144:** 1742-1752.

Sukumar R (1989) *The Asian Elephant: Ecology and Management*. Cambridge University Press, Cambridge.

Sukumar R & Gadgil M (1988) Male-female differences in foraging on crops by Asian elephants. *Animal Behaviour* **36:** 1233-1235.

Williams AC, Johnsingh AJT & Krausman PR (2001) Elephant-human conflicts in Rajaji National Park, northwestern India. *Wildlife Society Bulletin* **29:** 1097-1104.