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Identifying Elephant Movement Patterns by Direct Observation

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Introduction

Conservation of Asian elephants (*Elephas maximus*) is a national priority in Sri Lanka. Due to crop raiding, property damage, human injury and death caused by elephants, their conservation is also a major socio-economic and political issue. Elephants have comparatively large home ranges, and in Sri Lanka, 70% of elephants live outside Department of Wildlife Conservation protected areas (Fernando *et al*. 2008a). Some elephant home ranges lie completely outside, some partially, and others completely within protected areas (Fernando *et al*. 2008a).

Development activities like irrigation and infrastructure development and management activities targeting human-elephant conflict mitigation such as electric fences, undertaken without consideration of elephant movements may cause loss and fragmentation of elephant habitat (Fernando *et al*. 2008b). Range loss or obstruction of elephant movement causes increased human elephant conflict as elephants are forced to move into new areas, or utilize richer sources represented by crops in order to compensate. Where they cannot compensate adequately it leads to increased elephant morbidity and mortality, especially in the case of herds (Fernando 2006; Fernando *et al*. 2008b). To minimize detrimental effects of development and management on elephants and human-elephant conflict, knowledge of existing elephant home ranges and movement patterns is critical.

Our study site was located in southern Sri Lanka (Fig. 1). It was bounded by the coast in the South; Udawalawe-Thanamalwila road to the North, Thanamalwila-Weerawila road to the East - which separated the Lunugamvehera National Park from the study area; and the Sooriyawewa-Hambantota road on the West. The southern part of the study area consisted of the Bundala National Park and adjoining Wilmanne Sanctuary, and hereafter is referred to as the 'Bundala area'. The study area North of the Bundala area is hereafter referred to as the 'Mattala area'. Elephant habitat in the Bundala and Mattala areas were approximately 50 and 300 km^2 respectively. Bundala and Mattala areas were separated by the Hambantota-Weerawila road (Fig. 1), which was mostly bordered by dense human settlements and permanent cultivations.

Rapid and large-scale development of the area is ongoing, with an international port and airport, and agricultural, industrial and infrastructure development. Many of the roads in the area, including the Hambantota-Weerawila road are to be upgraded to highways. A planned railway track running through Hambantota to Kataragama in the East will cut through the study area. In addition, an electric fence is planned around the Bundala National Park and Wilamanne Sanctuary to prevent elephants from venturing into adjacent developed areas.

Currently over 300 elephants are found in the study area. If elephants use both Mattala and Bundala areas, specific measures would need to be taken in conducting development and management activities, to allow elephants continued access from one area to the other.

In this study, our primary objective was to assess whether elephant home ranges encompassed both Bundala and Mattala areas, which would entail their crossing the Hambantota-Weerawila road. A secondary objective was to evaluate the use of individual identification as a technique for obtaining information on movement patterns and home ranges. The study was based on individual identification of elephants at locations in Bundala and Mattala areas. Data from individual identification was compared with that from 6 radio-collared elephants.

Methods

Study area

Natural vegetation in the study area consisted mainly of scrub with some patches of mature tropical evergreen forest, and sand dunes and associated vegetation on the coast. A few lagoons lay along the coast. Small to medium sized irrigation reservoirs with the paddy fields cultivated under them lay scattered across the landscape. The study area was surrounded by dense settlements and large tracts of paddy cultivated under the Udawalawe and Lunugamvehera mega-irrigation projects. Some villages lay within the study area. Chena cultivation was conducted by villagers and led to a patchwork of regenerating scrub in different successional states.

Individual identification

Asian elephants have easily identifiable and variable morphological characters (Ilangakoon 1993; Ardovini *et. al.* 2008), which enables reliable and comparatively easy individual recognition. As elephant social structure consists of group living adult females and young, and solitary adult males (Fernando & Lande 2000), we limited our identification to adults. An adult female was defined as any female that had developed breasts, had a calf or was post-reproductive. An adult male was defined as a male that was larger than an adult female. The main characters that were used for individual identification were:

- Sex: male/female
- Ear (R & L):
    - folds (primary and secondary)
    - extent of fold, folded in or out
    - lobes – shape
    - de-pigmentation, tears, holes
- Tail:
    - presence or absence of hair tuft
    - relative length of front & rear hair tuft

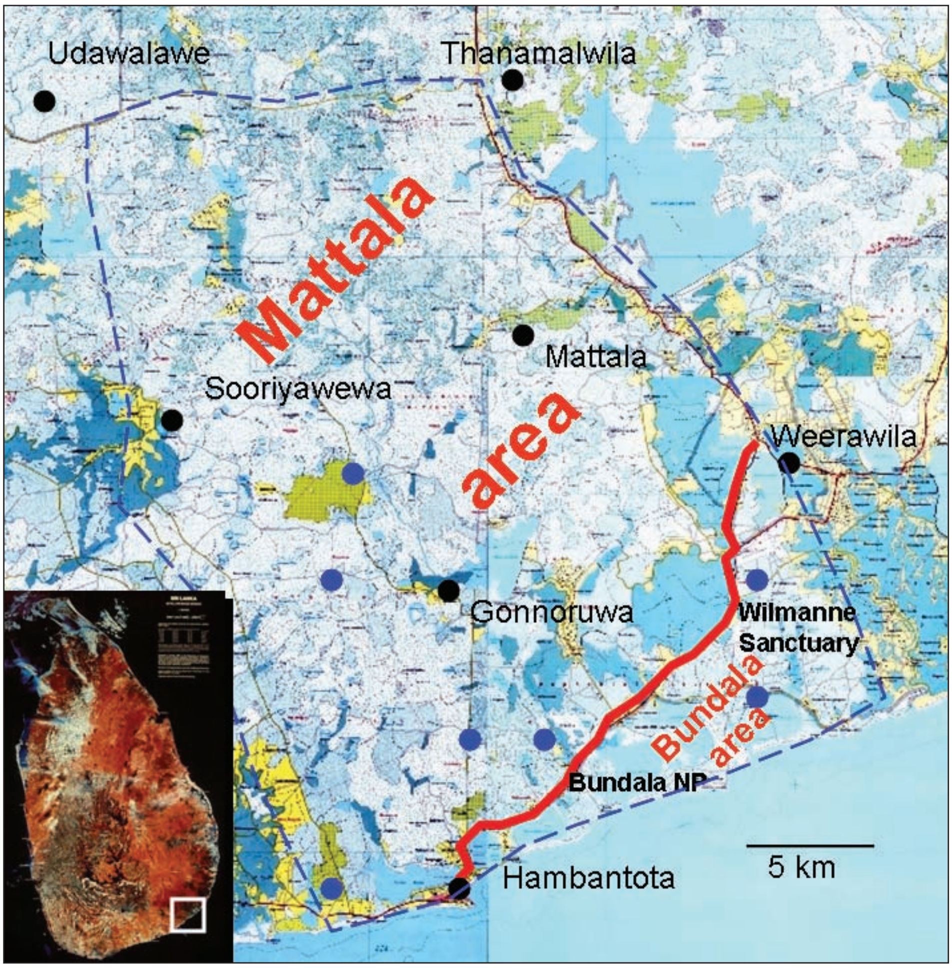

Figure 1. Map of the study area. Blue broken line = study area; thick red line = Hambantota-Weerawila road; black circle = town; blue circle = sampling location.

Figure 2. ID pictures of an adult female sighted in the Mattala area (left) and Bundala area (right).

- Shape of spine
- Tusks/tushes (R & L):
    - presence/absence
    - size (relative)
- Body: - lumps and de-pigmentation

Data was collected from a total of 29 days of elephant sightings (10 days in the Bundala area and 19 days in the Mattala area), between May 2008 and August 2010. Observations were made at five locations North of the Hambantota-Weerawila road for the Mattala area and two locations south of it for the Bundala area (Fig. 1). Encountered elephants were photographed using a Canon Digital SLR Camera with a 75-300 zoom lens.

Digital pictures were sorted and analyzed visually using Picasa 3. Individual elephants were identified, a picture collage created with Picasa for each individual as a reference, and the individual given an identity (Figs. 2&3). Newly photographed elephants were compared with the reference catalogue and if no match was found, added as a new individual.

Radio-tracking

From June to September 2009 five adult females (Sakuntala, Sapumali, Uma, Valli, Wanamali) and one adult male (Thaga) were fitted with GPS collars in the Mattala area, to assess the impact of management actions on elephants. The collars were programmed to collect GPS locations every 4 hours (at 1:30, 5:30, 9:30, 13:30. 17:30 amd 21:30 local time). The data was downloaded via satellite or SMS.

Data analysis

Data from individual identification was entered and sorted in MS Excel 2003. Significance between observed groupings was tested with Mann-Whitney U tests implemented in Excel using the Excel add-in program statistiXL 1.8. Data from the GPS collars were plotted on 1:50,000 toposheets using ArcMap (Esri ArcGIS) software and evaluated visually.

Results

Individual identification

A total of 103 elephants, consisting of 26 adult males and 77 adult females were identified. On average an elephant was observed 1.61±0.99 times. Sixty one (59.22%) elephants were sighted only once (Fig. 3). The highest number of times an individual was re-sighted was a female that was seen 7 times. Only 11 (10.68%) elephants were encountered more than twice (10 females, 1

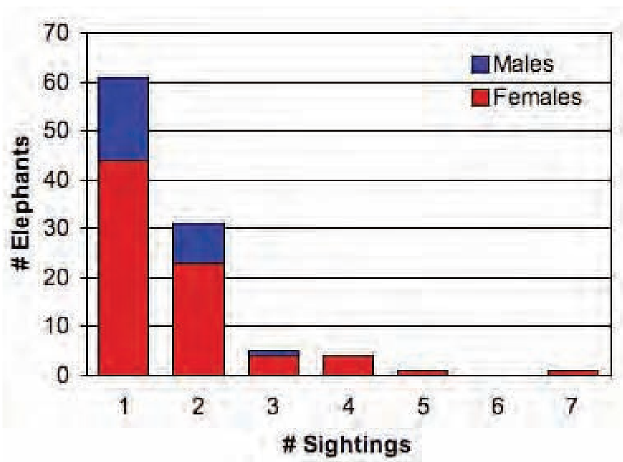

Figure 3. Sighting frequencies of identified individual elephants in the study area.

male). On average, each male was seen 1.38±0.57 times and each female 1.69±1.09 times, which were not significantly different from each other.

A total of 80 elephants were identified in the Mattala area (17 males, 63 females) and 31 elephants in the Bundala area (10 males, 21 females). On average individual elephants in Mattala were observed 1.61±1.08 times and in Bundala 1.19±0.40 times, which were not significantly different from each other. One male (3.80%) and 7 females (9.09%) were observed in both Mattala and Bundala areas. The 7 females using both areas belonged to two herds.

Radio-tracking

All six elephants were collared in the Mattala area. The three elephants that were collared in the southern part of the Mattala area were observed to also use the Bundala area (Fig. 4). The home ranges of the three that were collared in the more northern parts of the Mattala area did not extend to the Bundala area.

Of the elephants that used both areas, adult female 'Sapumali' crossed the Hambantota-Weerawila road after midnight on 16th July 2009. She stayed in Bundala for two days and one night before returning to Mattala after dusk on 17th July 2010. This was Sapmuali's only visit to Bundala during the 263 days (June 2009 to March 2010) the GPS collar was working. The adult female 'Wanamali' crossed over to Bundala around midnight on 25th October 2009. She only spent the day in the park

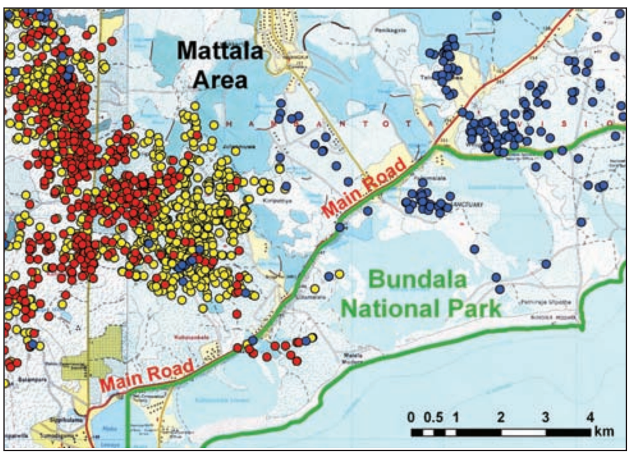

Figure 4. The coloured dots represent GPS locations for collared elephants. Yellow = Sapumali; Red = Wanamali; Blue = Thaga.

and went back to Mattala the following night. In 500 days of tracking (September 2009 to January 2011), this was the only trip she made to Bundala.

The male 'Thaga' was collared in the Mattala area and was tracked for 196 days, when his collar ceased functioning. He was collared during musth. Twenty one days after collaring, at the end of the musth period, he moved into the Bundala area where he spent most (83%) of his time. During the time he spent in Bundala he did one five day trip to the Mattala area and 29 nocturnal visits across the Hambantota-Weerawila road, lasting less than 12 hours.

Sapumali and Wanamali belonged to the same female group. During the identification sampling, Sapumali and Wanamali were sighted 4 times each and Thaga twice in the Mattala area. None of the collared elephants or any other females from Sapumali and Wanamali's group were detected in the Bundala area in the identification sampling.

Discussion

While the greater number of elephants individually identified in the Mattala area is partly explained by the greater sampling effort there, the number of elephants identified per day of sampling was also greater in Mattala (4.2 and 3.1 elephants/sampling day, in Mattala and Bundala areas respectively). Therefore, the data suggests a larger population of elephants in the Mattala area, which is consistent with expectations from the extents of elephant habitat in the two areas.

Overall, re-sightings of elephants were comparatively low and no significant difference was observed between males and females or between Mattala and Bundala. The low re-sighting frequency suggests that a large number of elephants were present in the study area and that the home ranges were much larger in comparison with the area sampled. The greater percentage of females identified is likely to reflect a female biased sex ratio, possibly due to higher mortality of males from conflict with humans, rather than any influence of sexual dimorphism in behavior, on sighting frequency.

Elephant movement between Mattala and Bundala

Our data on individual identification and radio-tracking clearly demonstrated the use of both Mattala and Bundala areas by female and male elephants.

Individual identification found a higher percentage of females than males using both Mattala and Bundala areas. This may in part reflect elephant social organization, as females are not independent units but are clustered into groups, whereas males move as individual units. However, it may also represent greater use of both areas by females. The elephants that were detected to use both areas through individual identification were observed well inside the Bundala area, indicating significant use of the Bundala area by some herds and males, that also used the Mattala area. As females represent elephant herds, preserving connectivity between the two areas could be critical for the survival of herds that use both areas.

The greater percentage of identified elephants only seen in the Mattala area suggested that home ranges of some elephants may lie wholly within the area, which was confirmed by the radio tracking. As the extent of elephant habitat in the Bundala area was approximately 50 km^2 it is unlikely that there are many elephants especially females, whose home ranges lie entirely within the Bundala area. The radio tracking data suggests that even herds that do not have home ranges split between Mattala and Bundala areas may undertake occasional incursions from Mattala to Bundala. Such incursions may indicate access of critical resources such as water at the height of the dry season. Radio tracking data from the male Thaga, who took cover in the Bundala area during the day and ventured across the Hambantota-Weerawila road in the night, may indicate crop raiding.

Management implications

It is likely that human-elephant conflict in the area will increase as a result of development, due to loss and fragmentation of elephant habitat, greater presence of people in the area and associated increase in human-elephant encounters. If development also results in obstruction of movement between segments of elephant range or blocking access to essential resources, their impact on conflict escalation would be far greater and out of proportion to the actual extent of habitat lost. Ideally, from an elephant conservation and human-elephant conflict mitigation point of view, development activities should not be conducted in elephant range. However where such activities are essential, their proper design, taking into consideration the ranging patterns of elephants can minimize their detrimental effects.

Our data clearly demonstrated that elephants used both Bundala and Mattala areas. If movement between the two areas is cut off, elephants in neither area could compensate by extending their range in another direction, as there are no 'vacant' elephant habitats. As the current areas occupied by elephants are hemmed in by developed areas, loss of range would compel elephants to raid cultivated crops in order to compensate, leading to severe escalation of human-elephant conflict. Therefore, in planning development activities, ensuring the preservation of connectivity between the two areas for elephants, is critical for preventing increase in human-elephant conflict and conserving elephants. In the construction of a railway line and upgrading of the Hambantota-Weerawila road to a highway, and construction of any other highways that divide elephant habitat, incorporation of 'overpasses' or 'underpasses' in their design to allow elephants to cross from one side to the other would be an option (see Mount Kenya Trust 2011).

Similarly, construction of an electric fence on the boundary of Bundala National Park would prevent elephant movement between Mattala and Bundala. Such an action would compel the elephants that lose part of their range to challenge the fence, greatly increasing the chances of fence breaking by elephants. If they fail to breach the fence elephants that previously used both areas would suffer high morbidity and mortality, as elephants are unable to compensate for the sudden loss of a large portion of their home range (Fernando 2006; Fernando *et al.* 2008b).

Therefore, in designing a perimeter fence for Bundala National Park and Wilmanne Sanctuary, care should be taken to preserve access to the Mattala area but prevent access of developed areas by elephants.

Individual identification as a technique for assessing elephant movement

Individual identification indicated that at least two herds had home ranges that lay across Bundala and Mattala areas. Only two of the five females collared in Mattala visited Bundala and that too only very briefly, which indicated occasional incursions rather than regular use of the Bundala area by some herds. Individual identification sampled a wider cross section of the population than possible through radio tracking and provided better population level information at a much lower cost.

Individual identification failed to detect the use of Bundala area by Thaga. The radio tracking data showed that the Bundala area was his non-musth home range. However, he did not frequent the locations sampled in Bundala. Greater sampling effort and more even spread of sampling locations over the study area could rectify such deficiencies. Even at a very high sampling effort, individual identification is unlikely to detect movements such as those of Sapumali and Wanamali who only made very brief visits to Bundala. Therefore in comparison to radio tracking, information obtained from individual identification had lower resolution and power of detection.

Our study demonstrates the usefulness of individual identification in establishing elephant movement between two areas. While radio tracking provides more detailed movement information, it may not always be an option due to constraints of funds, time, logistics and technical capacity. We conclude that individual identification is a simple, non-invasive technique that can be used to assess elephant movement, albeit with some limitations. Additional population and demographic data obtained from individual identification can complement techniques such as radio tracking and is of value for research and management.

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