Application of Technology in Wildlife Sciences

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Photo Credits: CEDT-Camera traps

Contents

Preface

There is a history of using technology in wildlife studies; however, only recently the value of applying technology (camera trap technique in particular) has been very well highlighted. This interest has given rise to initiating many systematic or scientific experiments or studies using technology in wildlife studies. The camera trap technology has considerable scientific, conservation and management advantages for a variety of species, more importantly with a multi-disciplinary team, both the technology design as well as the knowledge of the wildlife species, experimental or conservation needs of both technology and wildlife can be taken care of.

The camera trap technology has been used in variety of species ranging from the largest to the smallest and even elusive wildlife species. Here we emphasize the findings of using camera trap technique for the Asian elephants, an endangered and flagship species of biodiversity conservation. The study results indicate that the technique is usable for population studies of the species. These findings based on 'opportunistic' samplings are comparable with the long-term studies of the species and motivates us to suggest that manpower, resource and time involved in classification of elephants for population studies could be brought down considerably through this technology. The other key gains in using this technique are that, unlike other conventional methods, there is no need for specialists to be present in the field all the time, and all the location and the cameras can be deployed simultaneously in many elephant habitats.

This document presents primarily on an experimental study on using technology in wildlife more specifically in Asian elephant population and demography. Details of survey sites, status of the species in these sites, camera trap equipment, usage possibilities of the same, comparison of results from different studies, identification of distinct or duplications of individuals or groups and other aspects associated to it are discussed.

Acknowledgments

Dr. Arun Venkataraman, Sub-regional Support Officer, CITES/MIKE (Monitoring the Illegal Killing of Elephants) Programme - South Asia, motivated us to process the "opportunistic data". Presentation of this work in the MIKE meeting and discussions with Prof. Anil Gore (Department of Statistics, Pune University) are the motivating factors for this document and other publications related to the work.

"It is risky setting up 'traps' in elephant country", but that was made possible through the excellent field knowledge of the field staff at Bandipur, Mudumalai and BRT. The processing of data was not easy and was time consuming but was done meticulously by Aparna G. Agnihotri, The Nityata Foundation. Special thanks are due to Mr. Gopa Kumar (The Nityata Foundation) for his inputs and Ms. T.N.C. Vidya (CES IISc) for the data of elephants from Mudumalai. Joshua David, Arivazhzgan, Narendra Babu and Ratna Ghosal read through the document and provided useful suggestions.

Abstract

To evaluate the application of camera trap technology in population dynamics studies of Asian Elephant, indigenously designed, cost effective, infrared triggered camera traps were used in the tropical mixed deciduous and high-density elephant habitats in southern India. This has been the first ever such approach for the species; the data collected and processed were "Opportunistic" as usage and placement of the traps were arbitrary, no sampling protocol or design or planning were observed. Usability of pictures was defined through a rating value (0 to 10, 0 to 4 = unusable, 5-10 = usable), which was based on quality, clarity and the portion of the object captured in a given frame. As an initial step, identification of suitable location for the placement of camera trap for the species and the patterns (referred as sequences) through which the "picturisation" takes place were described. In 10 trips, 99 pictures of 330 elephants belonging to 20 sequences were obtained.

The result shows that mean rating of all pictures was 3.36 (N=99, SE=0.16, %CV 5), 80% of the pictures were unusable and only 20% were usable. The picturisation process referred to as a "Sequence" and that ranged from 1 to 25 with an average of 5 pictures (N=20, SE=1.4 & %CV 23) and an average proportion of usable pictures (of all sequences) of 0.26 (N=20, SE=0.09 & %CV 35) and unusable pictures of 0.74 (N=20, SE=0.09 & %CV 12). Using sequences that have usable pictures (45%), 44 distinct individuals were identified and it was found that 38.6% were adult females, 4.5% were adult males, and juvenile males were poorly represented (2%). Results obtained from this "Opportunistic" study were comparable and surprisingly identical to that of other systematic and long-term studies.

The experience suggests the need for redefining sampling effort and parallel survey through camera traps and traditional approaches. The survey does provide some inputs on other aspects related to the use of camera-trap technique for studying the Asian elephants in the forest. The relationship between the applicability of the technique and the type of usable picture captured, time of setting the traps and identification of distinct or duplicates of individuals or groups are also discussed in this document.

Introduction

Camera-traps have been used for documentation of wildlife since the early 1900's (Shiras, 1906). Despite the availability of this technology for more than a century, only recently have there been some attempts to use camera-traps systematically to study wildlife populations (Seydack, 1984; Rappole et al., 1985; Kucera and Barrett, 1993; Mace et al., 1994; Karanth, 1995; Karanth and Nichols, 1998, Carbone et al., 2001). There could be a number of reasons for this. Factors such as availability of this technique, quality of information obtainable, interest or need for testing the technique, cost involved in developing and executing the approach, may have been responsible for this technique not having been used extensively. This technology has a significant scientific, conservation and management advantage for a variety of wildlife species ranging in size from elephants to the smallest mammal or bird (Karanth and Nichols, 1998; Carbone et al., 2001). It aids in appreciating their habitat, population dynamics, activity pattern, and identification of “problem animals” (habitual crop raiders, or human property destroyers or killers, for instance). Problem animals that are very dangerous to approach for observation or animals that are active only during night hours could be identified (through camera-trap-based photographic evidence) and specific understanding or management (capture or relocation) of such animals could be evolved (Varma, pers. obs).

The Asian elephant has been considered as one of most suggestive cultural symbols of the people of Asia and it also stands for the need of safeguarding sufficient natural forest areas, however the survival of the species has been endangered due to number of conservation issues (AERCC 1998). For a meaningful, species and habitat based conservation and management approach there is a requirement of understanding the population status of the species. Several established methods of assessing population densities are available (Burnham et al., 1980; Sukumar et al 1991; Varman and Sukumar, 1995; Varma, 2001). The possibility of using camera-trap technique for population dynamics studies of Asian elephants has never been tested or validated for the species. For elephants, if a “unit”, defined as all or maximum individuals of a group, is photographed through camera-traps, it is possible to identify different individuals based on distinct features. Here we relate our experience in using camera-traps to classify elephants into different age and sex classes for population structure and dynamics studies of the species. Our approach, with a multi-disciplinary team, presents the advantage to incorporate both the technology design expertise as well as the knowledge of the species and its habitat. More importantly, this expertise is available to take care of most of the field or technology based needs at any situation, and it was not developed for any commercial advantage. The idea behind this study was to explore if any useful information could be extracted from the collection of photographs obtained randomly during field testing of the camera trap units. We looked for patterns, if any, that emerges from such pictures, and could be used for quantification. They could also help in evaluating the method and getting insight form proper planning and for devising strategies for further action.

Objectives

In this study a collection of random pictures obtained with camera-traps was used to try to estimate the Asian Elephant population structure (age and sex) in the area under study. The data collected and processed here qualifies to be “opportunistic” as the usage and placement of camera-traps were arbitrary since the purpose was only to test the equipment in the field. Hence this particular analysis is based on no sampling, protocol or design efforts and no particular planning. It is based only on events and may be termed as a random approach. However, if any result emerges through this, it would point to the usability of the camera-trap technique in elephant age and sex classification. If no conclusion could be drawn, this study could still be used for evaluating the plan of setting the cameras, sampling design, protocol and efforts. This has been the first ever such approach and it was carried out in places where density of elephants are known to be reasonably high (AERCC 1998).

Material and Method

Survey sites

The survey was carried out in tropical mixed deciduous forests of Bandipur National Park (BNP), Mudumalai Wildlife Sanctuary (MWLS) and Biligiriranganswamy Temple Wildlife Sanctuary (BRT WLS) under Chamrajnagar Division, of southern India (Figure. 1). BNP lies between 11° 37’ to 11° 54’ N and 76° 07’ to 76° 52’ E and has an area of

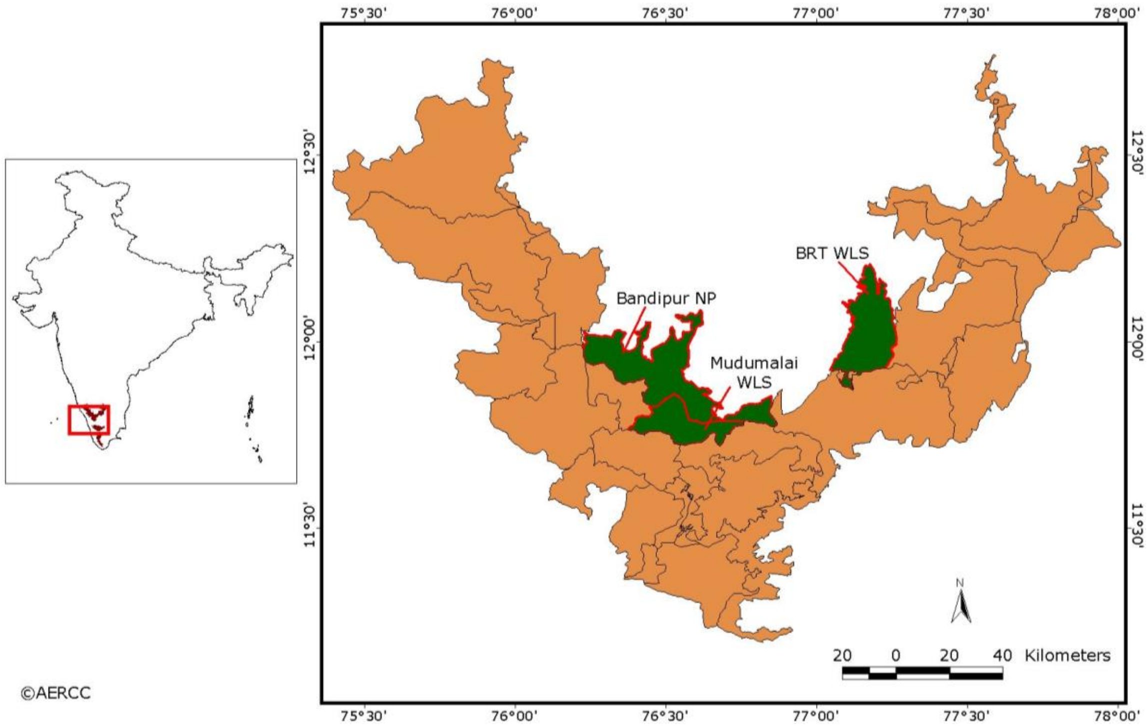


Figure 1: Map showing the location of the three study areas, Bandipur National Park (BNP), Mudumalai Wildlife Sanctuary (MWLS) and Biligiriranganswamy Temple Wildlife Sanctuary (BRT WLS)

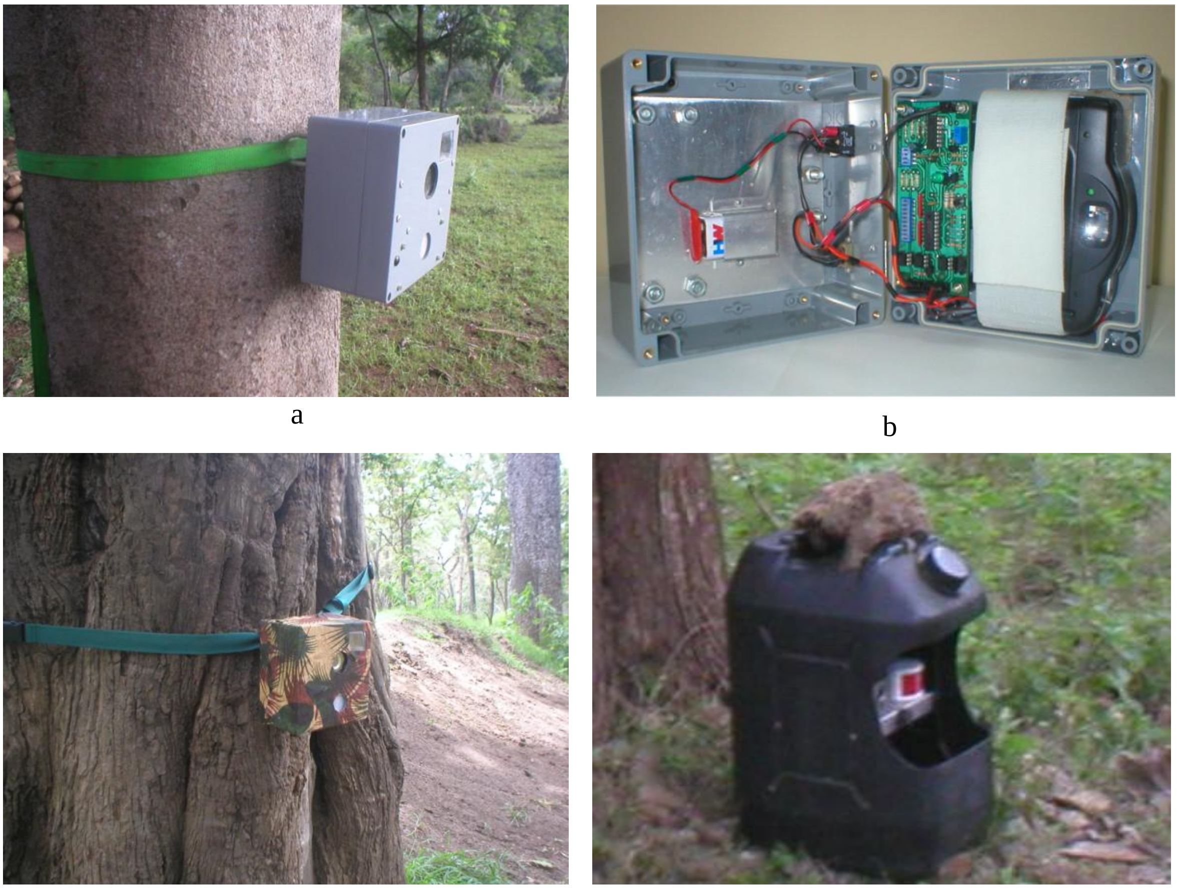
874 km^2 and lies south-west of the Nagarhole National Park, north of the MWLS and west of the Wynad Wildlife Sanctuary. The MWLS is situated in the Nilgiri district of Tamil Nadu and forms a part of the BNP forest complex; the sanctuary lies between 11° 13’ to 11° 39’ N and 76° 27’ to 76° 43’ E and comprise a total area of 312 km^2. BRT WLS lies between 11° 43’ to 12° 08’ N and 77° 00’ to 77° 15’ E and has an area of 510 km^2. Mixed dry deciduous forest types dominate BNP and MWLS. Most of the hills and valleys of BRT WLS are covered with moist deciduous forest type, the foothills and abutting cultivated lands bear dry deciduous and scrub forests, and sub-tropical hill forests are found on hilltops. A detailed description of the geography, vegetation type, fauna and other features of the survey sites is available elsewhere (Krishnan, 1972; Nair et al., 1976; Gadgil and Sukumar, 1986; Sukumar et al., 1992; Ramesh, 1989; Varman and Dange, 1994; Tyagi, 1996; Varma, 2001).

Status of the species

These three regions support a high density of elephants; BNP has an estimated population between 1200 and 1936 elephants (density of 1.37 to 2.2 animals/km^2), MWLS has between 517 and 1059 elephants (1.6 to 3.2 animals/km^2) while BRT WLS has between 691 and 914 elephants (1.4 to 1.8/animals/km^2) (AERCC 1998). These regions are also known for their long-term and well-established studies and surveys on various aspects of the species and habitat (Daniel et al., 1988; Sukumar, 1989; AERCC 1998; Venkataraman et al., 2002).

Equipment

The camera-traps used in this study were developed at the Centre for Electronics Design and Technology (CEDT), Indian Institute of Science (IISc), Bangalore. They consist of a motion detection circuit, a controller and a camera, all three packaged in a weather and vermin proof enclosure (Figures 2a, b, c and d). The motion detection circuit uses a Fresnel lens, a passive pyrolytic infrared detector and the associated amplifier and filter. The detector reacts to any moving body having a temperature different from ambient. The controller receives an input from the detector and then triggers the camera according to settings made by the user. Those settings could be the number of pictures to take for each event, the minimum time between pictures, whether pictures should be taken only at night or only during daytime or at any time, etc



a b c d

Figure 2a,b,c, and d: Types of camera trap used - approaches followed to deploy the equipment (a, c and d) and inside view of the trap (b)

The sensitivity of the detector can be adjusted electronically. In normal conditions, the system detects the motion of a human being up to more than 15 meters. It has also shown to react to a medium size bird (myna) at more than 6 meters. It is therefore suited for a large range of animals, from very small birds to large animals like elephants. The placement of the system and the time at which it is used determine to a large extent the type of animals that are captured.

The cameras used have fixed focal length, usually with relatively wide angle (35mm). The placement of the camera decides the field width. We would recommend 5 to 6 meters to capture single elephants and up to about 15 or even 20 meters to get a comprehensive view of a herd of elephants (10 or more animals). The picture quality is good enough to identify/classify animals at 20 meters during day. For night picture, the flash-reach is a limiting factor. The in-built flash has a reach of no more than 5 to 6 meters, which is only adequate for usage on a trail. We can extend the flash reach up to about 10 to 15 meters by using a slave flash. For this study we used pictures from systems with a regular 35mm roll (argentic) cameras as well as with digital cameras.

The design of the CEDT camera-trap system offers a great amount of flexibility to the users. The present design allows to quickly tailor the system to specific user's requirements by simply reprogramming the controller as per a list of desired specifications. In this case, by working closely with the users the technical team ensured that the system is best suited for their specific requirements.

The uniqueness of these systems lies in their features and the low production cost. The present design has the following features:

- Adjustable detector sensitivity.
- Programmable camera refresh intervals.
- Selectable mode: single, double picture, mini-video.
- Selectable day, night or day-and –night operation.
- Selectable minimum delay between pictures.
- Battery test (battery low indicator).
- Light emitting diode (LED) indicator on front panel for test mode.
- External input / output for advanced applications.
- Splash proof / vermin proof enclosure.
- Simple tree mounting using self-locking strap.
- Simple securing with chain and padlock.
- Simple operation with only two switches (ON-OFF and TEST –TRIGGER)
- Critically, the camera records the time of picture (and usage of flash for digital camera).
- The camera-trap costs around Rs.9, 000 (approx. US$ 200.-) to build with a 35mm argentic camera and Rs.18, 000 (approx. US$ 400.-) with a digital camera (the running costs of which are substantially less).

Usage possibilities of the equipment

Usage possibilities of the camera-trap are outstanding: they can be utilised for individual identification, population density and census estimation of large and small mammals, without human interference in observation. With the technical support of Asian Elephant Research and Conservation Centre (Division of Asian Nature Conservation Foundation), Nityata Foundation and Wildlife Academy of Bangalore, Karnataka and Tamil Nadu Forest Departments, southern India, a few traps have been extensively deployed in variety of forest regions of southern India.

Identification of suitable location

The first concern when using camera-traps is to identify suitable locations for their placement. If the traps are fixed on animal trails (Figure 3a), then only the animals that pass through the trail are captured. In the case of elephants, when a group passes, individuals may go together and the picture may not be usable (Figure 3a) for individual identification. Therefore it is important to place the traps where elephants are attracted for a sizeable duration of time to ensure that individuals or groups can be captured on a number of frames for identification purpose. Suitable locations could be a cropland, human settlements, salt lick or a waterhole. If it were to be a human settlement or cropland, the area could be vast, it may have many entry points, and it may be used only during night time or by specific individuals. On the other hand, elephants are known to spend a reasonable amount of time at each of their visits to a waterhole (Figure 3b). It could be assumed that, at least once in a day (frequency may increase or decrease depending on seasons) all or most of the individuals from a population would visit a waterhole. It has been observed that elephants spend an average of 22 minutes (N = 26, SE = 3.8, %CV 18) at a waterhole during the second wet season (Varma, pers. obs) in Mudumalai Wildlife Sanctuary, and this may increase and decrease during the dry and first wet seasons. These facts point to waterholes as prime location of camera-traps for our study. As mentioned earlier, the photographs used in this study were obtained randomly, without other purpose than testing the camera-traps. It so happened

Figure 3a: Example of camera trap deployed on an animal trail; note not all the animals are not captured

Figure 3b: Elephant captured in a waterhole

that a number of tests were carried out near waterholes, as it was expected to attract visitors. This resulted in a good collection of elephant pictures.

Pattern of elephants visit to waterholes

From these pictures, it was observed that elephants visiting are photographed through a certain pattern. The “picturisation” of a given group of elephants in the field of view of the camera-trap, from the first one entering the field to the last one exiting it, is referred to as a “sequence” (see Figures 4a, b, c and d as an example of a sequence). Each sequence is captured by a set of photographs adjacent in time, even if not equally spaced.

a b c d

Figures 4a, b, c and d: An Example for a sequence in which elephant is seen in a waterhole

For the sequence to be usable for our purpose, it should clearly establish the approximate size of the group (from one to many) and allow classification (sex + age) of a significant percentage of individuals in the group.

In general, such a sequence may start from the time elephants approach the waterhole and ends when they leave. The entry or exit may happen as all members of a unit come or leave together or as individuals, and also with respect to a group, which initiates or leads the entry or exit. Such sequences may provide usable information about the population structure, as explained below.

Usability of the pictures from sequences

The collection of random photographs obtained from the camera-traps consists of 99 pictures of 330 individuals (elephants), belonging to 20 sequences. These pictures and sequences were processed for usability by rating them on a scale of 0 to 10. The rating of pictures was based on their quality, clarity and also position of the elephants in the frame as follows:

- *Quality* refers to how usable a picture is for elephants' age and sex classification (Figures 5a and b) - that implies that all or most of the individuals from a group have been captured by the camera-trap on the given picture.


a


b

Figure 5a and b: Examples of the quality of pictures captured through camera trap

- *Clarity* communicates how good a picture is: whether the animal has been "captured" in good light, if the flash has reached the object, if the picture is focused or not or if it is over or under exposed (Figures 6a and b).


a


b

Figure 6a and b: Examples of the concept clarity

- *Positioning* refers to the occurrence of the animal within an "optimal distance" from the camera, the head and tail of all or most of the individuals being visible (see plates 7a and b as examples of good (7a) and bad (7b) positioning).


a


b

Figure 7a and b: Examples of positioning of elephants captured through the traps

The photographs that get a rating of 5 or above qualify to be usable pictures (see figures 8a, b, c, d, e, f, g and h for ratings assigned to individual pictures). Distinct groups or individuals could be identified from usable pictures of rating 5 to 10 (the picture could be of an entire group or a solitary animal). Even if a picture has good clarity and positioning, it may be unusable if the quality of the information is not adequate. In addition to this, if there are no directly usable pictures present in a given sequence, using all the pictures of that sequence (which could be rating of 1 to 4), we can try to reconstruct the group and identify a maximum number of distinct individuals.

a b c d e f g h

i

Figures 8a, b, c, d, e, f, g, h and i as examples of rating from zero to eight

As mentioned earlier, the information could be related to solitary or group of elephants. The solitary animal could be identified by its age and sex or by adjacent pictures in time showing no other animals. Elephants being social animals they maintain close proximity to each other and individuals within a group cannot be missed. The sizable proportion of the individuals for a given picture could be referred to as a group. Even a small group (e.g.: only mother and calf) can be identified from a picture or a sequence if no part of body (leg, tail, trunk or head) of other individuals is visible in the picture or in the entire sequence. Once all or most of the individuals of the group are identified through discrete recognition, then duplicate pictures can be eliminated.

Results and Discussion

Ratings of the pictures

As a first exercise, an average rating of all individual photographs has been calculated and it was observed that mean rating of the picture was 3.36 (N = 99, SE = 0.16 & % CV 4.75). The frequency distribution of the ratings is presented in Figure 9.

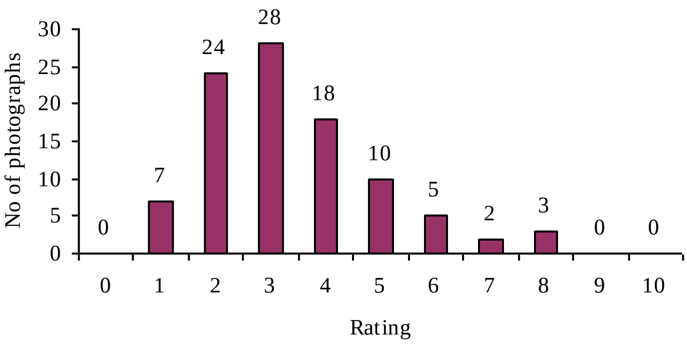


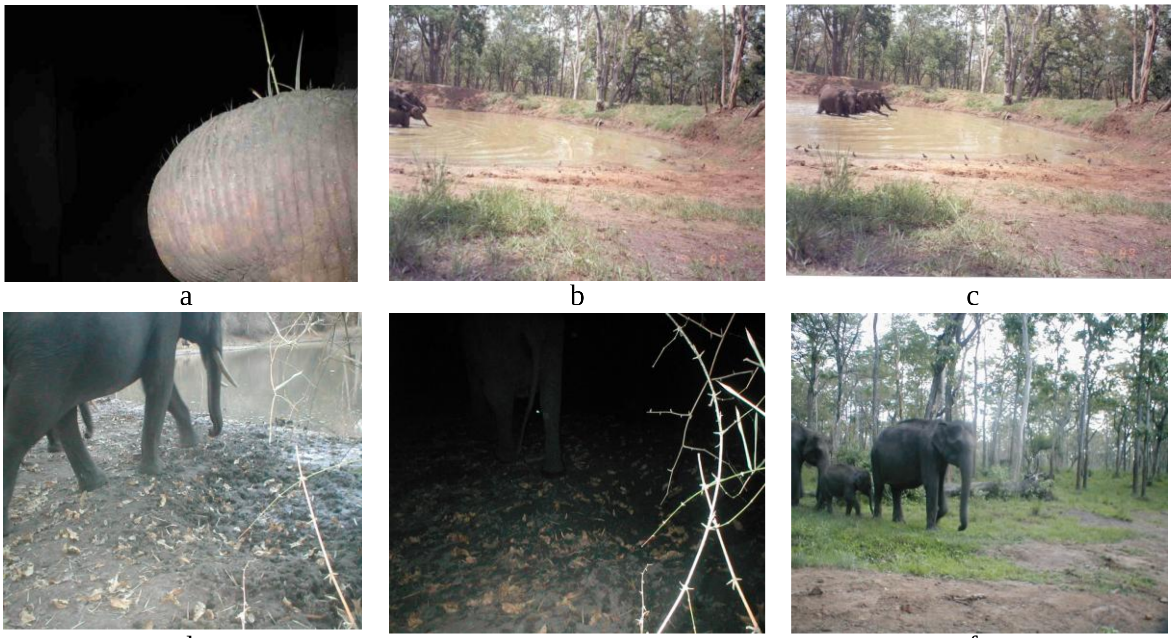
Figure 9: The frequency distribution of the ratings

It was observed that 80% of pictures taken by the camera-trap technique were unusable (ratings from 0 to 4) and only 20 % were usable (ratings 5 to 8). There were no pictures of ratings 9 or 10. No groups qualified for the rating of 8, and it was only solitary adult males that were qualified for that rating. If rating 8 is not considered (as it is only of individual males, but not for groups), only 17% of the pictures are individually usable.

The 99 pictures collected were then brought under 20 sequences (see Figure 10 as an example of such a sequence). The number of pictures per sequence ranged from 1 to 25 with an average of 4.75 (N = 20, SE = 1.4 and %CV = 30). For each sequence, the proportion of usable and unusable pictures was calculated and is reported in table 1.

Figure 10a, b, c, d, e, f, g, h, I, j, k, l, m, n, n and o: Example of one of the sequence with 15 pictures captured by the trap

There is a clear indication that there are more unusable pictures (Figures 11a, b, c, d, e, and f) in individual sequences and also in all the sequences put together. The average proportion of usable pictures for all the sequences is very low (0.26) and the standard error associated with the average is very high (35%). Over all, individual ratings of all the photographs in individual sequences or combination of all sequences showed an overriding role of unusable pictures.



a b c

d e f

Figures 11a, b, c, d, e and f: Examples of unusable pictures

However some sequences did have usable pictures and interestingly, out of 20 sequences, 9 of them (45 %) have usable pictures (sequences no 2, 3, 4, 5, 6, 12, 13, 14 and 20). From these primary usable sequences, distinct individuals were identified (Figure 12a and b) and classified as per their age and sex. Notably, all the usable pictures of sequences come from one region (Bandipur) of the three forests surveyed.

a b

Figure 12a and b: Distinct individuals identified and classified as different sexes

The results presented in Table 2, shows that out of 44 distinct individuals subjected for age and sex classification, 38% are adult females and 4.5 % are adult males. Juvenile males are very poorly represented with only 2%. It is possible that juvenile males are not easily identifiable through camera-trap as they may be concealed under the groups or their tusks are not visible and they may be wrongly identified as juvenile females. Also, the sample size of this survey may not be adequate to conclude anything on juvenile males.

Further, to increase the number of usable sequences, we reprocessed carefully every discarded sequence (sequences with no usable individual pictures) to see if relevant information could be still extracted from them. This time we scrutinized all pictures of each unusable sequence, looking at the possibility of re-constructing a distinct group from them. A very careful scrutinizing allowed us to reconstruct more groups from two sequences previously discarded (sq. no.17 and 19), and thus identify and classify 6 more individuals. The result of this extended approach is reported in table 3.

The results reported in table 2 and 3 do not show much difference for adult females and males, sub adult females and males and calves; however it did make a difference for juvenile females and males. This indicated the need to increase the sample sizes to obtain statistically relevant data, especially for juveniles.

Comparison of results from different studies:
To validate the result obtained by camera-trap survey, they were compared with results of other studies were carried out in Bandipur National Park (Varma pers. obs) and Mudumalai Wildlife Sanctuary (CES 2000) of southern India. Although the sample size of the camera-trap study was very small and the survey itself was opportunistic, the results are surprisingly close (table 4).

This comparison provided valuable inputs; it endorsed our doubt of juvenile males being wrongly classified as juvenile females. The percentage of juvenile females for the camera-trap study is relatively high whereas it is very low for juvenile males. If the frontal position of juvenile males is not visible or the light in the picture is not adequate to distinguish the tusks of juvenile males, they could be wrongly identified as juvenile females; this calls for careful processing of the photographs. As adult male elephants are subjected to poaching pressure (Sukumar, R. 1989; Watve and Sukumar 1997; Ramakrishnan et al., 1998) it is valuable to know the percentage of adult males that are captured by camera-trap survey and validate these results with other surveys, particularly those carried out in the same study area.

From table 4 we can observe that the results regarding the percentage of adult males in the study area (Bandipur) are outstandingly identical. The same table shows both surveys at Bandipur reporting a higher percentage of adult male elephants than was recorded in the Mudumalai survey. It is true that the number of male elephants that could be encountered in Mudumalai is relatively lower than that of Bandipur (Varma, pers. obs and Vidya, pers. comm) and there could be number of ecological reasons or anthropological influences associated with it.

The results and the insights obtained by this technique suggest that this kind of opportunistic survey does provide valuable information. As there was no sampling protocol followed there was uncertainty or scepticism and discomfort in processing the data; however, the results of the survey do imply that the technique is usable for population studies of species like elephants. The results also advocate the need for accepting the concept of “optimal sampling effort” for elephant age and sex classification studies. It is known that conservation priorities are not only determined by efficient and reliable methods but also by cost or sampling effort and rapid assessments of given species and their habitat (Silveira et al 2003).

If the results of age and sex classification of 44 individuals through camera-traps are comparable to those of classification of 142 or 2756 elephants by direct observation, it suggests that manpower, resource and time involved in classification of elephants could be brought down through optimal sampling efforts. Our experiences do suggest the need for increasing, or redefining the sampling effort and calculating the cost involved in terms of equipment, field trips and other expenses for the camera-trap surveys. It would also be interesting to carry out parallel surveys through camera-traps and traditional approach; this would enable a comparison of results.

Other findings and suggestions:

The survey did provide some valuable information about other aspects related to the use of camera-trap technique for studying the Asian elephant. It was observed that sequences play a very important role in determining the usability of pictures; it is essential to know the pattern of sequences and then develop a strategy associated with it. It was observed that elephants might visit a given water hole in the following patterns:

- Same group or individual elephants may visit the same waterhole at different times,
- Same group or individual may visit different waterhole on the same day,
- Different groups or individuals may visit the same waterhole on the same day, different waterholes on different days.

To obtain relevant data, it is critical to avoid duplication in all these situations. This can be arrived at by proper planning of the camera-trap survey and careful interpretation of the resulting photographs.

The number of individuals captured in a frame depends on the number of individuals entering or exiting the waterhole at a given time (Figure 13a, b, c and d), and the manner in which they proceed; individuals of a given group may enter or leave together or come as a sub-group or as solitary individuals.

a

b

c d

Figure 13a, b, c and d: Examples of number of individuals entering or exiting the waterhole

If pictures are taken continuously, while capturing the events, and if there is differentiable distance between each individual or a sub group in given group, then the identification (age and sex class) or individual recognition process (distinct identification marks) is easy. However as elephants maintain a close proximity to each other, individual differentiation will always be challenging.

There could be some confusion when groups break into small units (Figure 14 a, b, and c) and rejoin later or if already there is a group in the waterhole and another group or sub-group visits the same waterhole. In such situations, individuals of these groups could get mixed with the group already present and would cause uncertainty in the usability of the pictures. However, through the study, a distinct pattern emerges; it starts with a few individuals entering the waterhole, and later a larger number of individuals enter the water while closely grouped. It is possible that juvenile or sub adult male enter the waterhole after a gap of time, as was observed from the time lag between photographs.

a b c

Figure 14a, b and c: Elephant groups breaking into small units

Setting up a camera at a waterhole

After selecting a waterhole (Figure 15a) setting traps in an appropriate place is another important decision. For our purpose, camera-traps should be fixed in locations where animals enter or exit the waterhole (Figure 15b). If there are more than one entry points for a given waterhole, then two or more camera-traps may need to be set up.


a b

Figure 15 and b: Research team members looking for signs of waterhole usage and entry and exit points of elephants

Another crucial factor that would decide the applicability of this technique is the type of usable pictures captured by the method. As mentioned earlier, the usability of picture varies based on factors like:

- The occurrence of the animal in the set up frame.
- The distance of the animal from the camera.
- The positioning of the animal, the picture covering the entire body of the animal from head to tail.

The distance between camera and subject is critical; if too close or too far, it would be difficult to interpret the photograph. Hence, one should aim at positioning the camera-traps at an optimum distance from the expected path of the elephants to obtain usable pictures. With reference to the positioning (also related to the optimal distance from the camera), a good side view is desirable. A frontal view of the animal may not always be usable, but when close enough to the camera it may be adequate to identify its age and sex.

Time of setting the traps

The timings of the captures have to be taken into account. This can be broadly classified into morning, afternoon, evening and night. Unlike daytime, night time photography is more challenging (Figure 16a and b). If we intend to document elephants visits at night, it might be essential to use additional slave flashes to extend the flash reach. If equal sampling effort for both day and night is available, it is possible to know the time in which elephants frequent the waterholes. During this survey most camera traps had been setup for periods of more than 24 hours at any given location, corresponding approximately to equal day and night sampling efforts. From the pictures obtained it is clear that more elephants are seen in the daytime at waterholes.

a

b

Figures 16a and b: Challenges experienced with night time photographs

If this is confirmed by further experiments and observations, and if there is no distortion in the class of elephants visiting the waterholes at night compared to day, it could be sufficient to record daytime visits. This would allow the use of simple traps without extra slave flashes.

Identification of distinct or duplications of individuals or groups

For proper data interpretation it is critical to avoid duplication when classifying individuals or groups from photographs. Number of duplicates or distinct units with respect to an individual or a group of elephants can be sorted out based on a qualified identification exercise, where many factors can be taken into consideration like:

- The number of individuals.
- The number of individuals in each age class.
- The identification marks of individuals to develop distinct individuals or groups.

Further, while processing the pictures, one can consider the following scenarios for construction of groups and identifying individuals from two or more groups visiting waterholes:

Scenario 1: Same day, different cameras placed at different locations, far apart:
In such a case, photographs taken by each camera will belong to distinct individuals or groups.

Scenario 2: Same day, same location, same camera, photographs taken at different times.
Here the time lag, group size and distinct individuals play a role in the identification of the distinct groups and individuals.

Scenario 3: Different days, different cameras at the same or different locations.
Here, there is need for a protocol to avoid any confusion or mixing of data (photographs) and that calls for having a code name or number of each camera-trap, each place and each photograph. Details of the location of camera fixed or removed have to be mentioned.

It is only by carefully scrutinising and interpreting all photographs with those criteria in mind that one can extract meaningful information from them.

Conclusion

The analysis of a collection of photographs obtained randomly while testing camera-traps has shown good potential to use such technology for the study of the population structure of the Asian elephant. The results obtained in such an "opportunistic" manner compare very closely with similar classifications worked out at much greater effort with traditional means. This suggests that the camera-trap technology, combined with a very good knowledge of the species, could be a very useful tool for population study. With proper design, strategy and planning, one could obtain very useful data with relatively low effort and investment. The other important advantage of the technique is that, unlike other methods, specialists would not need to be in the field for extended periods of time at all locations. The initial camera tests and subsequent analysis of the photographs obtained have brought to light a number of criteria regarding the optimum placement and operation of the camera-traps for such specific study. It clearly established that the technology needs to be tuned to the specific requirements of a given research activity.

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Table 1: Proportion of usable and unusable photographs for each sequence

Sequence Code	No. of pictures	Usable	Unusable
1	1	0	1
2	25	0.24	0.76
3	7	0.14	0.86
4	4	0.5	0.5
5	13	0.15	0.85
6	15	0.2	0.8
7	2	0	1
8	1	0	1
9	3	0	1
10	2	0	1
11	1	0	1
12	1	1	0
13	2	1	0
14	4	1	0
15	2	0	1
16	2	0	1
17	3	0	1
18	2	0	1
19	4	0	1
20	1	1	0
Mean	4.75	0.261	0.739
SE	1.40	0.091	0.091
CV %	29.6	35.0	12.4

Table 2: Classification (age and sex) based on 9 primary usable sequences out of 20 (45%):

Age & sex Classes	AF	A M	SAF	SAM	JF	JM	Calf	Total
Number	17	2	6	3	9	1	6	44
Percentage	38.6 %	4.5 %	13.6 %	6.8 %	20.4 %	2.3 %	13.6 %	100 %

AF: Adult Female, AM: Adult Male, SAF: Sub-Adult Female, SAM: Sub-Adult Male, JF: Juvenile Female, JM: Juvenile Male

Table 3: Classification (age and sex) based on 11 extended usable sequences out of 20 (55%):

Age & sex Classes	**AF**	**A M**	**SAF**	**SAM**	**JF**	**JM**	**Calf**	**Total**
Number	20	2	6	4	9	3	6	50
Percentage	40 %	4 %	12 %	8 %	18 %	6 %	12 %	100 %

AF: Adult Female, AM: Adult Male, SAF: Sub-Adult Female, SAM: Sub-Adult Male, JF: Juvenile Female, JM: Juvenile Male

Table 4: Comparison of results of different studies of classification of elephant by age and sex

Regions	Source	Number of elephants classified	AF	AM	SAF	SAM	JF	JM	Calf
Bandipur	Camera trap	44	38.6 %	4.5 %	13.6 %	6.8 %	20.4 %	2.3 %	13.6 %
Bandipur	Varma 1998-99	142	39.4 %	4.2 %	18.3 %	13.8 %	8.4 %	9.2 %	7 %
Mudumalai	CES 2000	2756	38.7 %	2.2 %	15.0 %	6.4 %	14.2 %	11.0 %	12.4 %

AF: Adult Female, AM: Adult Male, SAF: Sub-Adult Female, SAM: Sub-Adult Male, JF: Juvenile Female, JM: Juvenile Male

Appendix 1:

Poster Presentation of usage of camera traps for elephants at the Elephant Research Symposium in Fort Worth, Texas (USA) December 3-5, 2004. Organised by the International Elephant Foundation and the Fort Worth Zoo

Title: Trapped elephants: A study evaluating the camera trap technique and comparison of the results with the direct observation method for population dynamics studies of (*Elephas maximus*) in southern India.

Abstract

We update our experience of evaluating the camera trap technique in population dynamics studies of Asian Elephant. Our earlier work emphasized more on the applicability of the technique and here the focus is towards comparing the results (of the camera trap method) with that of direct observation method. The camera trap method results are based on 99 pictures of 330 elephants originating from 20 sequences, and usability of these photographs were rated (0 to 10, 0 to 4 = unusable, 5-10 = usable) by quality and clarity of the pictures, in addition to the position (of the object - elephant). From 20 % usable pictures, 44 distinct individuals of elephants were identified. The results indicated that 14 % to be calves, 20 % juvenile females, 14 % sub-adult females, 39 % adult females, 2% juvenile males, 7% of sub –adult females and 5 % were adult males. The result of only 44 distinct individual classified is comparable with the results with sample sizes ranging from 103 to 2756 animals classified by direct observation method. The comparison revels that the technique underestimated juvenile males and overestimated juvenile females. However if these juvenile classes are brought under one category, the results are closer to the direct observation method. Through this, we reinforce our earlier findings of usability of the technique for Asian elephant.

Keywords: Asian elephants, population structure, camera trap, direct observation method, sample size.

TRAPPED ELEPHANTS

Surendra Varma,[1,2] *Andre Pittet*[2,3] *H.S. Jamadagni*[2,3,4]

A study evaluating the camera trap technique and comparison of the results with the direct observation method for population dynamics studies of Asian elephant (Elephas maximus) in southern India.

BACKGROUND

We update our experience of evaluating the camera trap technique in population dynamics studies of Asian elephant. Our earlier work emphasized the applicability of the technique and here the focus is towards comparing the results of the camera trap method with that of direct observation method.

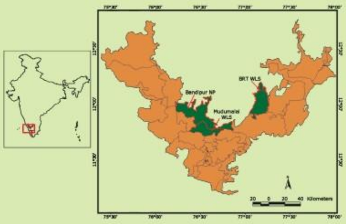
SAMPLING APPROACH

Based on NO sampling
'Protocol'
'Design'
'Efforts'
'Planning'

Could be called only as EVENTS and "may qualify" as a complete RANDOM approach.

ELEPHANTS CAUGHT IN "TRAPS"

The survey was carried out in tropical mixed deciduous forests of Bandipur National Park (BNP - 11° 37" to 11° 54" N and 76° 07" to 76° 52" E), Mudumalai Wildlife Sanctuary (MWLS - 11° 13" to 11° 39" N and 76° 27" to 76° 43" E) Biligiriranganswamy Temple Wildlife Sanctuary (BRT WLS - 11° 43" to 12° 08" N and 77° 00" to 77° 15" E).



Traps were placed where elephants are attracted to a "maximum duration of time" and individual or groups can be captured "more number of times".

The camera trap method results are based on 99 pictures of 330 elephants originating from 20 sequences.

Usability of photographs were rated (0 to 10, 0 to 4 = unusable, 5-10 = usable) by quality and clarity of the pictures, in addition to the position of the subject - elephant.

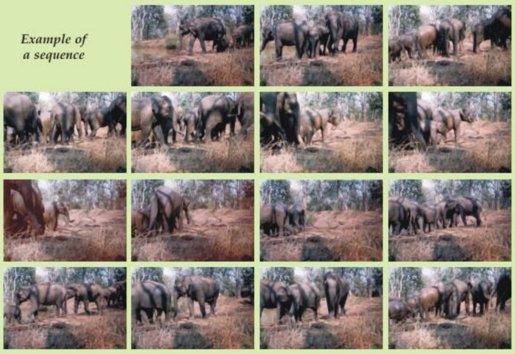
Quality: Refers to how useable a picture is for elephants' age sex classification - all or maximum number of individuals is captured.

Clarity: Communicates how good a picture is; whether the animal has been "captured" in good light and if the flash is reaches the object (elephant).

Positioning: Occurrence of the animal within an "optimal distance" from the camera and the head to tail of maximum individuals being visible.

Sequence: The "picturisation" of a given group of elephants in the field of view of the camera trap, from the first one entering the field to the last one exiting it.

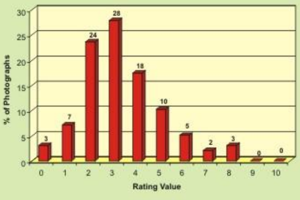
Example of a sequence



RESULTS:

Mean rating of all Photographs

N	99
Mean	3.36
SE	0.16
%CV	5



Combination of pictures rated 2 & 3 : 54%
Usable pictures : 20%
Not usable : 80%

Average of the proportions of usable and unusable photographs for all sequences.

	Usable	Unusable
Mean	0.21	0.78
SE	0.08	0.09
CV %	37	10


Example of unusable picture


Example of usable picture

From usable pictures, 44 distinct individual elephants were identified of which, 14 % were calves, 20 % juvenile females, 14 % sub-adult females, 39 % adult females, 2% juvenile males, 7% sub adult males and 5 % adult males.

COMPARISON

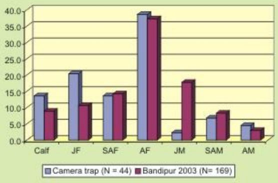
Findings were compared with different studies using direct observation method. These comparisons were from:

- ☆ One compact geographical unit with large forest complex and high elephant density
- ☆ Same study site as this and
- ☆ Site with similar habitat type.

COMPARISONS OF RESULTS FROM OTHER STUDIES

Sl. No.	AF	AM	SAF	SAM	JF	JM	Calf	NC	Location	Source
1	38.6	4.5	13.6	6.8	20.4	2.3	13.6	44	***	Camera Trap
2	39.4	4.2	18.3	13.3	8.4	9.15	7	142	Bandipur	Varma '98-'99
3	39	2.1	15.3	5.9	13.1	12.8	12.1	2576	Mudumalai	Vidya '99

AF: Adult Female, AM: Adult Male, SAF: Sub-Adult Female, SAM: Sub-Adult Male, JF: Juvenile Female, JM: Juvenile Male
NC: No. of Animal Classified



In all these combinations of comparisons, out of 7 age and sex classes, the results of camera trap method matches with 4 (57%) age and sex classes of direct observation method.

INSIGHT

The population structure result obtained from the classification of only 44 distinct individuals photographed (by camera traps) is comparable with the results with sample sizes ranging from 169 to 2756 animals classified by direct observation method.

The results obtained in such an "opportunistic" manner (photographs were obtained randomly while testing camera traps) compare very closely with similar classification worked out at much greater effort with traditional means.

This suggests that the camera trap technology, combined with a very good knowledge of the species, could be a very useful tool for understanding population structure.

Our experience do suggest the need for redefining the sampling effort and calculating the cost involved in terms of equipment, field trip and other expenses for the camera trap surveys.

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Surendra Varma has been studying large mammals for the last 13 years, particularly the last 6 years concentrating on various studies and survey on Asian elephant in south India, northeast India, Myanmar and Vietnam. He is a member of IUCN/SSC Asian Elephant Specialist Group and Research Officer working for the Asian Elephant Research and Conservation Centre (AERCC, a division of Asian Nature conservation Foundation - ANCF), Bangalore, south India.

André Pittet and H.S. Jamadagni are both electronics engineers. One of their key interests is the application of technologies to wildlife studies and conservation. Since 2001, together with their team at CEDT, they designed, developed and field tested a number of camera-traps. For this, they work in close collaboration with species specialists and researchers.

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Camera-traps have been used for documentation of wildlife since the early 1900's. Even with the availability of this technology for more than a century, only in recent times have there been some effort to use camera-traps systematically to study wildlife populations. The possibility of using camera-trap technique for population dynamics studies of Asian elephants has been tested for the species. This document relate the experience in using camera-traps to classify elephants into different age and sex classes for population structure and dynamics studies of the species.

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