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*Featuring*

# *FOREST NEWS*

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**Cover:** Elephants at sunset  
**Photo:** A. Christy Williams

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*Mother with calves (Photo: A. Christy Williams)*

## **THE FEASIBILITY OF USING MARK AND RE-SIGHT METHODS TO ESTIMATE ASIAN ELEPHANT POPULATIONS**

*by A. Christy Williams*

### **Introduction**

An important objective of the three-year study on elephants and their habitats in Rajaji National Park (RNP) was to estimate the size of the elephant population in the study area. Various mark and re-sight methods were tested, using identified males and female groups in the study area. This paper briefly presents the results of the two methods used to test mark and re-sight methods of population estimation. The two methods described below were not carried out

with as equal effort across all of the forest blocks sampled as hoped for; therefore, the estimates have to be taken more as an index rather than as an accurate estimation. However, it is planned to randomize the sampling design in subsequent studies to come up with more reliable estimates. The main purpose of this paper is to illustrate the potential of using mark and re-sight methods of population estimation, where individual elephants can be identified, using natural characteristics, or marked with a radio transmitter.

## Study area

The study was carried out in Rajaji National Park, the largest national park in the north Indian state of Uttaranchal. Covering 820 km<sup>2</sup>, RNP is an amalgamation of three sanctuaries, i.e., Rajaji, Chilla and Motichur. Seventy percent of the park consists of hilly terrain and the vegetation is mainly dry, deciduous woodland. The intensive study site for this mark and re-sight survey covered about 100 km<sup>2</sup> of the Dolkhand and Chillavally forest ranges in the park.

## Methods

Most male and female elephants can be identified by distinct morphological characteristics such as cuts, nicks, holes in the ears and the shape and size of the tusks of males. The first year of field work enabled the study team to identify certain individual bulls and female groups either by using naturally occurring marks or by radio collar frequency. A total of 9 individual males and 2 female groups were identified in the intensive study area. Whenever elephants were encountered randomly in the various forest blocks, details such as the sex of the animal and whether they had been marked/identified or were unidentified were noted down. This enabled the construction of a capture frequency distribution.

## Results and discussion

### *Craig du'Feu Method*

This is a continuous mark recapture method (Craig, 1953; du Feu, Hounscome and Spence, 1983). Data was analyzed for the period 11 November 1996 to 25 February 1997, because this method assumes a closed population and most animals move into the intensive study area during the winter months (November to March) and move out as the dry season (April to July) approaches.

Each sighting, whether of individual animals or groups, was recorded as one group. A total of 46 such sightings was recorded in the intensive study area, out of which 27 were recaptures. Using this method, the estimated number of groups was 32.06. The 95% Confidence Limit (CL) was 17.1 to 46.8 groups. The average number of elephant sightings was 3.2 animals. This would mean that the

estimated number of elephants in the study area was 103 elephants. The 95% CL gave an estimate of about 55 to 151 elephants using the study area during the sampling period. To test whether the elephants in the study area exhibit equal probability of capture, the observed capture distribution was tested using the G-test to see if it fits a zero-truncated Poisson distribution. The fit was poor ( $P < 0.001$ ), indicating that an equal probability of being captured cannot be assumed. This suggests that the estimate is biased, but it is unclear in which direction. It is our opinion that part of the heterogeneity in capture probabilities was due to the sampling methodology, i.e., efforts in some areas were higher.

### *Ratio method*

In the second method, the ratio of sightings of identified animals to unidentified animals (see Densai, 1987) was calculated for the period April 1996 to April 1997. A total of 66 sightings of elephant groups were recorded during this period. The term "group" is used to include sightings of both individual elephants and female groups. The following data was compiled:

- Total number of female groups encountered = 22
- Total number of female groups that were counted fully = 14 (63.6%)
- Total number of sightings of identified groups = 3 (13.6%)
- Total number of individual animals sighted = 44
- Total number of sightings of individual animals that were identified animals = 28 (63.6%)

We can see from the above data that there is a bias in favor of identifying and counting sightings of individual animals, which are usually males (82% of the sightings [ $n=40$ ] of individual animals). It is more difficult to count or identify female groups in a forested habitat. Another point is that in addition to being easy to count, most (>90%) of the males have tusks which have characteristic individual variations in shape and size and therefore are easy to identify. To adjust for this bias against groups that could not be counted, the study applied the mean group size of 10.1 elephants/female group from fourteen fully counted groups to the eight uncounted groups

and included them in the analyses for the total number of elephants that were encountered. Thus:

- Total number of animals in female groups counted fully = 142
- Total number of animals in female groups after correcting for bias against uncounted groups =  $142 + 8 (10.1) = 223$
- Total number of elephants counted (including groups and individuals) = 266
- Total number of animals counted in sightings that were of marked or identified elephants = 45 (17%)

### Conclusion

The high proportion of recaptures convinced us that the mark-resight method of population estimation should be an appropriate method if the sampling design is proper and the study period is longer than two years. Six radio-collared elephants (four females and two males) and more than 10 identified adult males should give us fairly robust estimates for a population estimated to be around 250 elephants on the western side of the Ganges. The precision will improve as more and more elephants are identified in the study area. In the future we will use estimators which allow for heterogeneity in capture probabilities, like the ones proposed by Minga and Mantel (1989) and Bowden (1993). We are currently carrying out a sample survey, with equal effort in all the areas surveyed. However, a word of caution is that this method will not give you ecological densities, which is of primary importance in many studies.

### Acknowledgements

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## **BLUE BULL (*Boselaphus tragocamelus*) IN LUMBINI - A WORLD HERITAGE SITE OF NEPAL**

by Achyut Aryal

### **Introduction**

Lumbini is the birth place of Lord Buddha and listed as a World Heritage Site. The Lumbini area covers 7.7 km<sup>2</sup> and is administered by the Lumbini Development Trust (LDT). Lumbini is one of the prime tourism destinations of Nepal. The trust maintains various Buddhist temples and other historical places at the site.

Nilgai or Blue bull (*Boselaphus tragocamelus*) is one of the largest Asian antelopes found in the Lumbini area of Rupandehi district. The LDT area provides a significant habitat for Blue bull.

The Government of Nepal protects the country's endangered flora and fauna through legislation and there are various animals in the protected lists. Blue bull is an important wildlife species, but is not a protected species. The Government of Nepal has established protected areas for the conservation of endangered flora and fauna. These flora and fauna are being depleted day by day due to over-exploitation, pollution, habitat destruction, poaching and human and livestock pressure in their habitat (HMG/Nepal, 2002). The population of Blue bull has been declining at a higher rate over the last five years in Nepal and therefore, conservation of Blue bull is a national and global concern (Subedi, 2001). The population of Blue bull is declining from the Terai area due to hunting and habitat destruction (HMG/Nepal, 2002; Aryal, 2004), but not enough studies have been carried out to understand the population trends. Only two studies on Blue bull have undertaken in Nepal (Subedi, 2001; Khattri, 1993).

Rupandehi and Kaplivastu districts are potential Blue bull habitats, but no conservation measures have been taken, hence the higher rate of decline in the population of Blue bull (Subedi, 2001). It is

necessary to identify Blue bull habitats and their carrying capacity. If the population exceeds the habitat's carrying capacity, a translocation program should be initiated to move the animals to other suitable places in the country. This will also help to reduce the crop damage caused by Blue bulls that is experienced by local people.

The present study assessed the crop damage and extent of conflict between local people and Blue bulls, determined the carrying capacity of the LDT area for Blue bull and the population status of Blue bull in the LDT area. Developing natural sites where tourists can observe Blue bull and Sarus crane is a possible option, so there is an urgent need to develop an effective action plan for Blue bull conservation and management in the LDT area. A participatory approach conservation plan is needed for wildlife management (John *et al.*, 1995); therefore, this study proposes a participatory action plan for effective management of Blue bull which would support sustainable tourism and contribute to the local economy of the study area.

The findings of this research would be useful not only for the LDT area, but also for the proper management of Blue bull populations in other parts of the country to ensure their long-term survival in their natural habitat.

The objectives of the study were to:

- estimate the population of Blue bull in the Lumbini Development Trust (LDT) area;
- analyze the carrying capacity of the LDT area for the Blue bull population;
- assess the crop damage caused by Blue bulls and the impact on local livelihoods; and
- develop a participatory Blue bull conservation action plan for contributing to the local

economy and sustainable tourism in the Lumbini area.

### Study area

The study area covered the LDT area and the surrounding Rupandehi district. Of the 7.7 km<sup>2</sup> LTD area, after excluding infrastructure and road areas, only 5.14 km<sup>2</sup> could be considered potential habitat of Blue bull.

### Methods

The study was carried out through questionnaires and direct field observations. Crop damage was measured on the basis of questionnaires and direct field observations in the affected areas. Previous available data regarding crop damage and interviews with 142 respondents from the study area were also considered. The transect line count

method was used for the population count (Sale *et al.*, 1988) and the carrying capacity was calculated on the basis of assessments of food, cover and habitat of Blue bull. The Z test was used for testing the Null/alternative hypothesis. The testing was conducted at a 5% level of significance, with a value of 1.96.

### Carrying capacity

The carrying capacity (CC) of the area for Blue bull was determined from data collected by the field inventory, based on Alberta (2004). The ecological sustainable stocking rate (ESSR) reflects the maximum number of animals [e.g. (ha)/animal unit month (AUM)] that can be supported by the plant community given the inherent biophysical constraints and the ecological goal of sustainable health and proper functioning of the plant community.

### CC-

$$\text{Area (ha) available for Blue bull excluding road, infrastructure, river (A)} \\ \text{ESSR (Ecological Sustainable Stocking Rate).}$$

Where,

$$\text{ESSR} = \frac{\text{Amount of feeding (kg)/blue bull per month}}{\text{Biomass (kg)/ha} * \text{Safe use factor (25-50%)}}$$

Alberta (2004) recommended that utilization levels are generally considered to range between 25 to 50% of total production, depending on the ecological site. These percentages of production use are called *safe use factors*. It is the percentage of the total biomass production of the ecological site that is available for utilization by animals. The safe use factor considers the given inherent biophysical constraints and the ecological goals of sustainable health and proper functioning of the area. The remaining biomass production (carry over) is allocated for ecological maintenance. Recommended safe use values vary according to the ecological site and management. For the study it was calculated as 50 percent.

According to data from the Central Zoo, on a daily average an adult Blue bull needs 14 kg of biomass of palatable species (420 kg per month).

The biomass (kg)/ha is calculated by the weight of the food plant multiplied by the available area

(A). The weight of the food plant was calculated by designing a sample plot (1 m x 1 m) for herbs. Plots measuring 10 m x 10 m were laid out to determine the tree species density (Stromberg, 1995). Simple random sampling was used to determine the biomass of species. Altogether, 42 plots were laid out in the study area. Crown cover and ground cover were also observed. Palatable and unpalatable species were identified with the help of knowledgeable local people and weighed.

### Results and discussion

#### *Population status of Blue bull in LDT area*

A total of 41 Blue bulls were counted in the LDT area: 10 males, 15 females and 16 juveniles. The population density of Blue bull in the LDT area is 8 individuals/km<sup>2</sup>. The sex ratio of male to female is 2:3.

### Population trend

Blue bulls have been recorded in the LDT area since the early 1990s. They are believed to have come from Kakrahawa forest (Indian side), which is approximately 10 km away from the LDT's southern boundary. They followed the path of Kakrahawa forest to Sattabazar Forest and to Kothi river ridge to the LDT area. The initial population was estimated to be around 5-10 individuals. The estimated population had reached nearly 200 in 1997, but this was based on public opinion. According to the local people, the Blue bull population kept increasing until 1999. The increased Blue bull population started to exert tremendous pressure on the adjacent cultivated land, causing crop damage. That situation developed a serious conflict with local farmers. The affected farmers requested the government to control the Blue bulls. In response to this request, five animals were translocated to Banke reserve forest in 1998 (Subedi, 2001). Subedi (2001) counted only 11 Blue bulls in the LDT area, but he used only the Bhairawaha-Taulihawa highway as a transect line and hence fewer animals were counted. According to the local people, during 1998-2000, there was a drastic increase in deaths of Blue bulls, which could have been caused by foot and mouth disease (FMD). Two blood samples were taken during the translocation to Banke forest in 1998, which showed signs of foot and mouth disease (Subedi, 2001). This was not the only the cause of the drastic decline of the Blue bull population; other factors included poisoning, revenge killing by farmers and less available palatable vegetation.

### Habitat structure

The LDT area was covered with plantation forest dominated by Sissoo (*Dalbergia sisso*), followed by Saguwan (*Tictona grandis*), Eucalyptus, Jamun (*Eugenia jambolana*), etc.

Seventy-nine percent of the potential habitat of Blue bull is covered by forest and the other 21% is grassland or open land. During the field survey, all Blue bulls were seen in the forest and not in open land. Generally Blue bulls use open grassland for grazing.

Approximately 43% of the study area had dense crown cover (75-100%), 27% had moderate crown cover (50-75%), 14% had sparse crown cover (25-50%) and the remaining 16% had very sparse crown cover.

During the study period most of the ground layer vegetation was dry and covered with litter. Most of the ground layer was covered with grass species (e.g., *Imperata cylindrica* and *Cynodon dactylon*); about 16% of the area had dense ground cover (75-100%), followed by 44% with moderate ground cover, 29% with sparse ground cover and 11% having very sparse ground cover. From October/November to April/May, ground herbs become dry and hence, this is a food deficiency period, during which time the LDT authority totally bans livestock grazing in Blue bull potential habitat.

### Carrying capacity (CC)

The carrying capacity for a grazing disposition of a given size represents the maximum number of animals that can be sustained without causing a downward trend or without degrading the resources in their habitat. Suggested ecological sustainable stocking rate (ESSR) values provided in the plant community guide are determined from a combination of clipping studies.

In order to sustain the ecological health and function of the plant community, ESSRs are based on a standardized biomass allocation and forage requirements of one Blue bull unit (i.e., 420 kg/month). (Reference: Central Zoo, Kathmandu, 2005).

The LDT area was divided into two parts to calculate the carrying capacity of Blue bull, which were separated by the Bhairahawa-Taulihawa highway. The northern part of the highway is a potential site for the management of wildlife tourism. The carrying capacity of both sites were calculated.

Palatable species preferred by Blue bull were identified with the help of local knowledgeable persons (e.g., shepherds, villagers). Eleven species of herbs/grasses were found in the study area and out of these, 5 species were found to be

palatable species for Blue bull. These included *Imperata cylindrica* and *Cynodon dactylon*.

There were no branches below 7 feet, so the tree biomass was neglected in the calculation of biomass; dry leaves of trees were calculated as unpalatable species.

The carrying capacity of the LDT area north of the highway was as follows:

- Area (ha) available for Nilgai excluding road, infrastructure, river (A): 220 ha
- Amount of feeding (kg)/blue bull per month: 420 kg dry weight
- Total Biomass (kg)/ha: 682.936 kg (dry weight)
- Palatable species spp dry weight: 204kg/ha
- Safe use factor: 50%
- ESSR: 4.11

$$\text{CC- } \frac{220}{4.11} = 53.2 \text{ (=53) individual}$$

The carrying capacity of the LDT area south of the highway was as follows:

- Area (ha) available for Nilgai excluding road, infrastructure, river (A): 294 ha
- Amount of feeding (kg)/blue bull per month: 420 kg dry weight
- Biomass (kg)/ha: 682.936 kg
- Palatable species spp dry weight: 204kg/ha
- Safe use factor: 50%
- ESSR: 4.11

$$\text{CC- } \frac{294}{4.11} = 71.5 \text{ (72) individual}$$

From the above data, the total carrying capacity of the LDT area for the Blue bull is 125 for October-January; the carrying capacity during the dry season will be less. A detailed biomass study should be conducted to identify the carrying capacity in other seasons. Grazing competition from more than 1,000 livestock also reduces the amount of palatable species available to Blue bulls and has encouraged the introduction of unpalatable species in the area, causing the Blue bull to move to private lands in search of food. If livestock grazing pressure is controlled inside the LDT area, the movement of Blue bulls to private lands will be reduced significantly.

#### *Man-Blue bull conflict*

Blue bulls have a direct effect on the local livelihoods of the farmers in lands surrounding the LDT area, as they have always been closely associated with farmlands. Due to the open boundary of the LDT area, Blue bulls frequently visit the farmlands surrounding the LDT area and

destroy large quantities of agricultural crops and vegetables. The area around the LDT was highly affected up to 1 km from the boundary; areas 1-3 km from the LDT suffered medium effects, and areas more than 3 km from the LDT boundary were less affected.

Highly affected VDCs are Tenuhawa, Ekla, Madhuwani and Lumbini Adarsha. A large amount of crop damage has been recorded from Hamamapur, Shivagadiya, Ramawapur, Mahilwar, Padariya, Parsa and some parts of Yakla VDC.

Generally, Blue bull prefers the mature growth stage of different crops (e.g., paddy, maize, mustard, chili, cauliflower, cow-pea, black gram, cabbage, etc), while wheat, potato, radish and pumpkin are preferred in the early stages of growth, and lentils are preferred at all stages. Blue bulls were reported to feed on all the major crops grown in the boundary areas. Apart from agricultural crops, Blue bulls also caused considerable damage to vegetables. According to

the local people, male Blue bulls visited kitchen gardens more frequently than females. The local people claimed that about 5% of the total rice production is damaged by Blue bulls in areas 1 km from the LDT boundary, and 2% was damaged in areas 1-3 km from the boundary.

#### *Impact on the local economy*

Various factors such as seasonal cropping patterns, the absence of strong fencing and the types of crops grown in the field were the main factors governing the extent of crop damage. The types of crops damaged by Blue bulls varies with the season. Generally, damage incurred during the winter months was found to be higher than during the summer. The distance from the LTD boundary to the field also affects the amount of crop damage. There is an inverse relation between distance and crop damage, i.e., as the distance decreases, crop damage increases and vice versa. Crop types also play a significant role in crop damage. Mainly paddy, wheat, mustard, potato, peas and lentils were found damaged in the area. In interviews with 142 farmers surrounding the LDT area, rice/paddy was reportedly one of the most highly damaged crops, with approximately 5% of total production damaged by Blue bull. This amounts to 1,000 quintal, which is equivalent to NRs 900,000 (NRs 1= US\$74). Wheat crops also suffered damages by Blue bulls equivalent to NRs 1,103,595. So it seems that there is a significant amount of crop damage done by Blue bulls, which has an impact on the local livelihood in the areas surrounding the LDT.

#### *Efforts made to minimize crop damage*

Efforts have been made by both villagers and the LTD authorities to minimize crop damage from Blue bull. The Trust erected a brick wall fence along the parsa to the main gate, and most of the LTD boundary was fenced with barbed wire. Unfortunately, there is no fence anymore because the barbed wire was stolen. Local people regularly guard their crops in the field night and day. To deter the Blue bulls, some local farmers used live hedge fences or barbed wire fences around their kitchen gardens, put up scarecrows or used fires to frighten the animals.

## Threats

Some of the threats that Blue bulls face include the following:

- Grazing pressure: Every day more than 1,000 livestock graze inside the park, and constitute the main threat by consuming the food plants of Blue bull and inducing the introduction of unpalatable species.
- Disease transmission: Due to the livestock pressure in Blue bull habitat, there is a high probability of transfer of livestock diseases to Blue bull and vice versa.
- Firewood collection and grass cutting

## Recommendations

- Barbed wire fencing should be erected around the LDT area.
- Livestock grazing and grass cutting inside the LDT areas should be restricted.
- A public awareness program should be initiated to disseminate conservation education to the local villagers about the importance of wildlife resources, and especially about the newly endangered status of Blue bull.
- A detailed biomass study should be conducted to identify the carrying capacity of Blue bull habitat in the dry season.
- Incentives should be provided to local affected farmers in the form of monetary compensation for crop damage, skill development training, income generation training, etc.
- Non-timber forest products (NTFPs) such as Sarpagantha and Mentha should be cultivated in high crop damage areas (1 km from the Trust boundary) as alternative crops which are unpalatable to Blue bulls.
- The LDT should be actively involved in biodiversity conservation activities, such as the restoration of wetlands, regular patrolling, conservation awareness activities, etc.
- Participatory Conservation Action Plan activities must be implemented for better management of Blue bull and other wildlife and to raise the local livelihoods.

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## LOST WITH FIRE

by Manjula Menon

In India, Western Ghats is one of the richest centers of endemism and a region diverse in fauna and flora. A number of programs are currently being implemented for conservation of biodiversity and sustainable utilization in this particular hot spot region – mainly inventories and *in situ* and *ex situ* conservation. The ecosystem is under severe threat from various natural and anthropogenic pressures. One of the greatest pressures is from forest fires. Forest fires are usually the result of three main factors: a heat source, a fuel that burns, and oxygen to propagate combustion. Ignition sources may be natural or human-caused. Fuel refers to the different components of the vegetation layer, both live and dead materials. The effects of forest fires have in turn created a situation that has resulted in severe climatic conditions leading to a significant loss of biodiversity. In recent years, there has been an increase in forest fires due to land use changes and climate warming.

There has also been much concern regarding forest fires at the global level. According to

researchers of the UK-based University of Leicester, the wild fires that scorched parts of Indonesian forests in 1977 spewed as much carbon into the atmosphere as the planet's biosphere absorbs in a year. This led to a sharp increase in global warming during 1998. Forest fires, especially in the Western Ghats, have led to large scale losses of both wild flora and fauna. The tropical dry deciduous forests of Western Ghats are more susceptible to fire than the moist deciduous and dry thorn forests. This can be attributed to the longer dry season of the dry deciduous forests, and hence, larger amounts of dry matter. Studies in Western Ghats have also revealed higher incidences of fire in areas with a high density of *Sorea roxburgii*.

Forest fires also have considerable effects on the faunal species. There have been observations of Indian rock pythons bearing fire scars in the forests of Mudumalai sanctuary. Many insects and birds (e.g., Yellow-wattled lapwing) build their nests on the ground, which in the event of fire could be charred.

Experts viewing NASA's images of air pollution believe that the pollution in the northern and southern hemispheres is due to the burning of fossil fuels and forest fires respectively. The carbon monoxide plumes in the southern hemisphere, especially Africa, can be attributed to forest fires.

Fire is an integral part of the ecosystem. Studies carried out by Pausas and Ramon (1999) have shown that the assessment of forest fires on a local scale is considered a critical aspect of ecosystem functioning, since fire plays a crucial role in vegetation composition, biodiversity, soil erosion and the hydrological cycle.

### Reports of the Forest Survey

Data collected by the Forest Survey of India indicated that the forest area affected by annual fires may be as high as 37 million ha. In India, nearly 600 million rural inhabitants depend on forests for their sustenance and/or their livelihood. This indicates the amount of pressure put on the forest. In response to this pressure, the Forest Department initiated several measures to develop a strategy that would help to conserve the remaining large tracts of natural resources. But the success of any strategy rests with the local people that inhabit the area. Various forest fire prevention committees were formed with the help of the Forest Department, involving the local tribal communities. Each committee was assigned a particular part of the forest for safeguarding from fire. This also provided a means of employment to the local tribals residing within the sanctuary. This action plan was very successful and protected vast tracts of forest, which often suffered the heat scorches of fire, in the year 2002.

Forest fires and indiscriminate grazing are among the most important factors affecting the natural regeneration in the forests and causing its degradation. Some results of the inventories carried out by the Forest Survey of India showed that:

- on an average, 54.7% of the forests are affected by fire;
- 77.6% of the area is subject to grazing incidence; and

- 72.1% of the forest area has no regeneration.

These results further revealed that moist deciduous forests have more incidences of fire, while dry-deciduous and thorny forests are subject to more grazing. According to a Forest Survey of India report, about 50% of the forest areas in the country are fire-prone (ranging from 50% in some states to 90% in others). An IIFN report concluded that 6% of the forests are prone to severe fire damage.

Western Ghats is more prone to forest fires during the period January to May. To control the fires the Forest Departments have set up fire lines of 5-10 m width in areas prone to fire. Forest fire statistics are not reliable because they underestimate the number of fires and the area burned due to the fear of accountability. However, the Forest Survey of India carried out a countrywide study in 1995 that estimated that about 1.45 million ha of forest are affected by fire annually.

Recurrent fires decrease the green cover by preventing regeneration and lead to the slow death of the forest. They also increase erosion and alter the physical and chemical properties of the soil. Two very important species that have been severely affected in southern India by way of human interference and recurrent fires are *Santalum album* – the costliest scented wood in the world – and *Terminalia chebula*, a highly valued medicinal species.

### Effects in the wild

Depending on the size and intensity, a forest fire initiates a chain of ecological successions that may last from a few years to well over a century. A low intensity fire will almost always produce a net benefit to wildlife, provided that it occurs outside of the nesting season. This is because most birds and animals prefer habitat diversity or "edges" and low intensity fires promote edge effects. How different tree species grow also helps determine the fire intensity.

Studies in Indonesia have found that thick bark, like that of Ponderosa Pine and Western Larch, protects against fire because fire can penetrate it

deeply without injuring the cambium. Deciduous trees resist fires better than evergreen trees do, because their foliage contains more moisture and fewer organic compounds than the foliage of most evergreen species, and of course deciduous trees can grow new leaves each year. Disturbances like fires cause gaps in the forest canopy, creating a mosaic with different stages of succession. Succession or regrowth may follow different courses at different times within the same area. For example, a fire following an earlier fire – a double burn or reburn – in the same area may produce a varying mix of species. Many botanists believe that what grows after a fire depends on what species happen to get a head start and crowd out any competitors. After severe fires, only ashes remain on the surface, and the upper mineral soil is cooked and discolored by a chemical change. Counteracting this loss, the ash and charcoal from the burned trees add minerals to the soil, which act as fertilizer.

Studies carried out in California by Fuller (1991) have shown that intense fires can kill soil microorganisms up to a depth of 3 inches, but that they soon recover. The lack of soil microorganisms may account for some of the increased plant growth seen after fires; the plants may grow better because they do not have to compete with soil microorganisms for nutrients. Important soil microorganisms are the nitrogen-fixing bacteria, which are more sensitive to fire than other soil bacteria. By means of a process called nitrogen fixation, these bacteria turn the nitrogen in the air into the nitrogen compounds needed by plants. Because the few bacteria left after a fire multiply rapidly, they can quickly overcome the loss of nitrogen compounds in all but the most severe fires.

Large herbivores such as deer, elk, bison, moose and some rodents (e.g., beavers) can alter the composition of a stand of plants when they browse, particularly when they choose certain plants over others. In this way they can affect fire probability and influence fire behavior. Large herds of grazing herbivores can sometimes reduce the fuel supply.

Earthworm populations are significantly reduced by fire as they live mainly in the humus and

mineral layers; they are more sensitive to the reduced moisture content than to heat from a fire.

### Responses to fire

The immediate reactions of animals to fire are fairly limited. Very large, intense fires can kill all types of wildlife, including such large animals such as elephants.

Birds have to fear only for the safety of their nests and many bird species take advantage of a fire to catch escaping insects that are normally well camouflaged in their habitat. Some raptors momentarily turn into insectivores after a fire passes. Fire may cause some birds to disappear because the amount of litter or the consistency of the forest floor is modified by the fire. Thus, the disappearance of some birds is thought to be due to the reduction in the forest cover due to fire. The number of birds in a forest is always found to be low where there are higher intensities of fire. Reptiles generally have hiding places in wet areas or underground.

The reaction of animals to fire depends on habitat attachment, mobility, ability to find shelter, and sensitivity to smoke and heat. Spider webs have been found in burned over areas the morning after a fire. Snakes usually avoid fire by taking refuge in burrows or rocky crevices. Since most of the area burned is from high intensity fires, while the preponderant numbers of fires are of low intensity, wildlife mortality per hectare is undoubtedly higher than the scientific literature would suggest. Some flying insects are attracted to heat, smoke or burned trees, which increases the population of the insects soon after a fire break. Although there is evidence that some game animals have been killed by fire, and some investigators consider fire capable of killing many wild animals, it is commonly held that vertebrates are rarely killed in fires, since fire is not a direct cause of mortality in vertebrates.

Fire affords better access to food for water fowl by making edible plants available and destroying weeds and undesirable plants.

Studies have shown that coleopterans (fire beetles and firebugs) are attracted by heat. These animals possess infrared radiation-detecting organs that

can locate forest fires at great distances of 100 to 160 km. One of the most remarkable adaptations to a burned environment is the abrupt melanism exhibited by some invertebrates, mainly acridians; this probably acts as a camouflage for escaping predators, especially birds, which have easier access to food when the plant cover disappears.

Many birds and mammals are attracted by fire to feed on fleeing animals. Birds, in particular, show little fear of fire; some are actually attracted by the smoke. These include North American, African and Australian birds such as eagles, vultures, kites and falcons, that hunt small animals fleeing before the fire. African carnivores such as the lion, the leopard and the cheetah hunt alongside fires in savannas. Komarek (1969) notes that various primates such as gorillas, chimpanzees and gibbons are attracted by wild fires and abandoned camp fires. Some investigators reported that wildlife can move more freely to seek their requirements on a burn than was possible before the fire, particularly in areas with heavy undergrowth. The amount of litter and the hardness of the soil may be modified by fire and afterwards by the action of logging and fire fighting equipment. Removal of litter may make foods that were concealed by it available to birds and mammals. Fires rarely burn evenly and they usually result in a larger mosaic of old and new cover. The vast mosaic of forests of different sizes, shapes and edges created by fire provides heterogeneity of environments, thereby benefiting most animals. Seed-eating birds and mammals increase dramatically when a burn yields large amounts of this kind of food. However, severe and repeated burning may reduce the production of grasses, herbs and shrubs and in turn, grazing and browsing wild life.

### **Benefiting the wild**

The hardness of some plants may be greatly increased after a fire. They may become more prolific because of an increased input of nutrients released by ash. This may lead to a qualitative and quantitative increase in the food supply.

Fire improves food quality by increasing the protein and phosphoric acid content of the most commonly

used species. Studies by Miller (1963, 1964) have shown that protein content apparently increased from 5% before the fire to 42% after a fire, and phosphoric acid content increased by 78%. After a fire, infestations of external and internal parasites may be reduced, to the benefit of the host animals. Some investigators have found that certain wildlife species that depend on fire-generated habitat have evolved to exploit burned areas. In order to properly interpret recolonization data, we must consider how long it takes for animals to reoccupy the burn and the factor of mobility.

Representation of all species remained identical in burned and unburned areas, except for earthworms, whose numbers fell sharply, and ants, whose numbers increased. Fewer mammal burrows are seen in burned areas than in unburned ones.

Forest fires frequently cause problems related to insect attacks on trees. Various studies have described the damage done by bark beetles and woodborers. However, prescribed burning can reduce the number of insects of these species or prevent dramatic population explosions.

An increase in nutrients is another common result of fire. The concentration of chemicals rarely attains toxic levels and the effect on productivity is generally beneficial. Thus, increased algae production at the lowest level of the food chain can increase biomass and further diversify the insect larvae population.

Ahlgren (1966) observed the relationship between vegetation and small mammal populations and hypothesized that the main factor in their population variations is food. The number of nests was found to be similar in burned and unburned areas by Kirsch and Kruse (1973), but clutches were found to be more abundant in burns.

Studies on forest fires have reported the loss of nutrients during burning and increased risk of erosion after burning. The effects of fire on animals change over time, but the biggest impact is the modification of their habitat. Animals with flexible habits and diets thrive after fires, and those animals that eat foods found only in mature forests seldom survive. Because fire destroys the sap that keeps bark insects away, these insects soon move

into a burned forest, followed by the woodpeckers and other birds. The woodpeckers increase after a forest fire, but species requiring old-growth forest, like the Great Gray Owl, decrease. Burned forests offer immediate food for some insect pests, whereas others depend on the food that fire provides in the long run.

### Protecting the valuable resources

Forest fires are considered to be a major environmental problem the world over. Protection from forest fires is an interdisciplinary endeavour, which needs to be addressed from both the technological and methodological points of view and necessitates a wide spectrum of various scientific disciplines. (Chuvieco, 1999).

Fire mapping using infrared or similar electronic detection devices is an increasing role for both fixed-wing aircraft and helicopters. Infrared detection devices locate all bodies or objects whose temperature is above absolute zero and emit energy derived from the motion of their atoms in the form of waves. The electromagnetic waves also include visible light and, hence, the infrared waves exhibit many of the characteristics of visible light. Observations from the air need to be validated and checked by field studies, and the data generated from aerial observations must be used in models to provide useful information for operational applications. (Chuvieco, 1999).

Fires should be set at the right time to destroy excess litter and debris. This measure affords good browsing sites, rejuvenates plant life that birds such as grouse feed on, and eradicates plant diseases. (Vogl, 1967). Loss of plant cover due to fire leads to a change in the microclimate, since the temperature increases. The earliest, and probably still the most widely used standard for forest fire control world wide, is the establishment of a goal to burn less than a fixed percentage of the area protected. Successful fire prevention depends on utilizing the three Es – education, enforcement, and engineering – in logical, well planned combinations designed to counteract those fires that cause the most damage within the protection area, and not merely those that result from the most obvious or prevalent causes. (Chandler *et al.*, 1983).

Remote sensing and GIS are helpful tools that provide quick and accurate data acquisition and can describe the forest condition after a forest fire (Sunuprpto *et al.*) The use of advanced information technologies and the collaboration of fire modeling experts, fire managers and remote sensing specialists, can provide alternative solutions to current operational aspects of fire problems, and are certain to be adopted rapidly by fire management entities. (Chuvieco, 1999). Various other fire suppression models are also used to combat the spread of fire in the forest.

In assessing the social and economic impact, fire poses many complex and largely unresolved problems and is the subject of what the forest fire specialists refer to as “fire economics.” The benefits of fire management activities include:

- reduced losses that result from limiting the number and size of destructive wild fires;
- increased forest resource productivity and enhanced environment that result from the use of prescribed fires; and
- successfully monitoring and modifying the suppression of beneficial wild fires. (Jhonson and Miyanishi, 2001).

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## **SAVING THE TIGER: THE NEED FOR "OUT OF THE BOX" THINKING!**

*by Chinmaya S. Rathore*

### **Introduction**

**W**ith shrinking habitats, weak protection and lack of accurate and non-controversial data on tiger populations, it looks like a very bleak scenario for tigers in India. The decline in tiger populations as detailed by the recent tiger statistics released by the Wildlife Institute of India (TOI, 2007) will most certainly spell doom for other animals. Natural ecosystems and populations are governed by a delicate balance that is principally driven by prey and predators operating within the system. The absence of one most certainly means destruction of the other, and activation of a runaway reaction through the food chain. While increased poaching may be a clear and present

danger to tiger populations, the larger threat comes from shrinking habitat. The changes in the forest management paradigm from timber production to habitat conservation also reflect the diametrically changed societal perception of the environment over the last few decades. Society increasingly sees natural forest areas as wilderness refuges in an otherwise man-dominated landscape. Forest areas are now almost like the last wild bastions which are fighting to hold encroaching human armies at bay. As wilderness areas become more threatened, society may increasingly want the State to conserve forests for their biodiversity values alone. The question is whether the State, entrusted with protecting forests, is responsive to making adequate adjustments to its traditional

forest management practices to reflect this changed societal perception? Is there a will to create a long term strategy for habitat management that goes beyond protected areas (PAs)? Should wildlife and biodiversity conservation be an important core value in managing forests outside PAs? The answer to these questions probably holds the key to wildlife conservation in India.

To a large extent, wildlife management in India has been fixated on keystone species and PAs. Areas outside the PA network which are also habitats for many species are generally not managed for biodiversity values. Wildlife values are almost an insignificant part of working plans that outline management prescriptions for these areas. For example, plantation activities undertaken in these areas would most likely not consider planting species that provide food or cover to animals. Values dictating the choice of species could be commercial, for soil stabilization, etc., but rarely for the habitat or as food for wildlife species. Likewise, creating sufficient water holes for animals might not be an important item on the working plan agenda. As part of a long-term conservation strategy, it may be extremely important to initiate programs that provide an increased focus on management outside PA forests for biodiversity values. Unless there is a long-term strategy that aims at conserving and improving habitat outside the PAs, there may not be any real hope for wildlife conservation in India and unwelcome surprises - such as the disappearance of tigers from Sariska Tiger Reserve in 2005 - may occur more frequently.

With the emergence of electronic media that can instantly transmit news around the world, important conservation issues are also being threatened by the 'band-aid syndrome' which is essentially a short duration "accuse-react-forget" loop. There is sudden media hype on a situation where the state is accused of inaction and apathy. This is followed by panic retaliatory firefighting by the official machinery, which usually includes denials and defense. Media then loses interest as it moves to the next big story and all substantive issues are quickly forgotten. The band-aid syndrome metaphorically applies a band-aid on a problem area and then moves on without really treating

the disease. In the process, complex problems that need long-term strategic thought and targeted action are trivialized to a media show. Habitat management and conservation are now becoming the latest victims of this band-aid syndrome.

So what can be done? During the last two years, many opinions have appeared in the press proposing administrative solutions such as hiring young guards, providing potent weapons, better compensation, etc. While not discounting or undermining the need for such measures, this article tries to look at some long-term interventions that may have a more lasting impact on wildlife conservation in the country.

### **Emulating good practices: The GAP Analysis Program**

One of the key features of successful wildlife conservation programs is long-term and holistic planning. Why wait for habitats to degrade or animals to become endangered and then spend millions to conserve them? Would it not be more prudent to read the trends and start conserving what is available in relative abundance. The USGS Gap Analysis program is an excellent example that can be emulated not only to bring in fresh hope for the tiger, but also for a number of other species. The GAP program advocates a proactive approach to biodiversity conservation and aims at identifying areas of high conservation priority. It is essentially a geographic approach to conservation planning which aims to identify conservation 'gaps' in forested landscapes, which are habitat-wise very important for species of interest, but are currently not under protection.

GAP analysis is based on three key principles (USGS, 2005):

- The best time to save species is while they are still common.
- It is cheaper to maintain natural populations, than it is to intensely manage endangered populations.
- While we cannot make a perfect biodiversity model, we can use what we know about the distributions of vertebrate species and vegetation types to assess biodiversity at local, state, regional and national levels.

Using the GAP analysis approach, many areas in the USA have been identified as areas of high conservation value and have received the requisite protection and management interventions that they did not receive earlier. The GAP concept provides a key framework that can provide the building blocks for a long term, non-PA-centric habitat development program. Work of this nature cannot be done by a single organization or institution. It needs a collaborative partnership of many institutions where each partner works on a piece of the jigsaw puzzle. Unfortunately, over the many years of tiger conservation, we have not been able to launch a single multi-stakeholder program of this nature. Overall, we have a very poor funding record of research on tiger ecology, dispersal and habitat utilization. There is a need to invest in research which can provide directions for long-term conservation strategies. Research institutions and forest departments need to evolve a stronger and more trusting relationship in order to make such programs successful.

### **Leveraging the power of community knowledge networks**

The problem of determining the most suitable method for a tiger census has been a subject of debate for a long time now. Critics of the pugmark method currently in use by Project Tiger strongly believe that the current tiger census figures derived using this method are exaggerated (Bagla, 2003). With top technological institutions like the Indian Institute of Technology, and numerous top class software companies in India, could there have been an alternate approach to partner a solution to this problem? Why is it not possible to ask for ideas from the students and faculty of these institutions? Why not build mechanisms that foster knowledge partnerships that bring people of diverse backgrounds together? The police have been using fingerprint identification technology for a long time. Automobile manufacturers use image scanning technology to find defects in parts. Remote sensing scientists analyze satellite images to uncover hidden information. Is it possible to cross-pollinate ideas from diverse expertise domains to solve the tiger census problem? One of the reasons why knowledge communities do not develop is because it is somehow felt that only

the people in charge of a resource can provide solutions to problems in their domain.

When one looks at the evolution of the Linux computer operating system, one marvels at what communities can do if they decide to partner creation and sharing of knowledge. Today, not only is Linux alive and kicking, hundreds of developers across the world write and support open source software for as wide a range of applications as one can imagine. Most of this software is available free to anyone. After the years spent battling with significant problems, there has been no effort to cross-pollinate ideas and bring talented people from diverse fields together to partner solutions. While the world marvels at the power that online communities can wield in a digitally connected world, there is hardly any knowledge networking of this type in the forest and wildlife sectors in India.

### **DNA fingerprinting**

When tiger parts are seized, it is usually not possible to know their origin. If this were possible, seized material could lead investigators to the point of origin. This information could build a picture of areas being targeted by poachers. Every seizure would then not just be a statistic, but would eventually provide very valuable inputs to investigating and enforcement agencies.

DNA printing of hair or blood samples from tigers in PAs can be done and a DNA print database for tigers in each PA can be maintained. This may not be possible for every animal, but can at least be attempted for the breeding stock. If such a database could be developed, the DNA from confiscated body parts could lead investigators back to the locale of the poached tiger and conservation measures could be immediately taken in those areas. DNA fingerprinting has been successfully used in solving the problem of illegal trading of orangutans in Thailand (Nation, 2004). A private safari park owner faced charges when it was discovered through DNA fingerprinting that 12 young apes were not the offspring of the zoo's breeding stock. Orangutans are categorized as endangered species under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), as are tigers. While

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some similar efforts in this direction are underway in India at the Wildlife Institute of India and the National Institute of Immunology, they need the committed support of conservation agencies and forest departments to develop DNA fingerprint databases and to track poachers.

### **PAs must come under the Central Government**

The PAs in India can come under the authority of the Central Government and orders for posting or transfers can be done by the center. This will help to better coordinate conservation strategies, monitor offences, gather and share credible intelligence and equitably prioritize the conservation agenda across parks. It will also reduce regional political interference in park management. It is very much possible to declare all important tiger habitats in India as areas of national and global heritage and bring them under the direct control of a Director of National Parks.

### **Using professional advertising**

Advertising campaigns targeting local communities around forest areas can be undertaken to generate a heightened awareness of the value of forests and wildlife. TRAFFIC USA tried a novel marketing approach to impact the tiger parts trade by shrinking the demand for tiger parts medicines from within the Chinese community in San Francisco. This innovative approach essentially relied on market research to first understand the Chinese belief system. Then they launched a sustained ad campaign using community members to advocate preserving tiger and rhinos as cultural icons (Fox, 2005). This led to a drastic reduction in demand for tiger and rhino part-based medicine within the Chinese community in the San Francisco area. A similar and well structured approach can be tried with local communities around PAs in India to lessen participation in wildlife crime and to develop credible intelligence networks.

### **Using central forces to guard protected areas**

How much power should officers have to deal with wildlife poachers? This subject is as hotly debated the world over as it is in India. There are very valid and convincing arguments on both sides.

Human rights activists have strongly objected to what they term as “coercive conservation.” Herbert and Healy (1999) cite several examples from sub-Saharan Africa, where excessive use of armed force for wildlife conservation has led to many extra-judicial killings. In many such cases it could not even be established if the killed individuals were poachers or villagers. On the other hand, there has been an intense debate as to whether park wardens in Canada should be allowed to carry side arms (pistols, etc). Park wardens strongly felt they should be given the necessary tools to deal with situations of life and death (Canadian Geographic, 2001). However, the Canadian government decided against this and entrusted the enforcement function to the Royal Canadian Mounted Police. This led many wardens to seek alternate employment.

In India, what weapons do the officers who guard forest territory have? Pitted against poachers, illegal timber interests, cattle herders and other intruders, how are they expected to fight and enforce the law? Poaching is an organized big money enterprise and many poachers are equipped with very sophisticated weapons. How are forest guards expected to stop them? Patrolling forest territory and accosting a gang of poachers requires immediate engagement. Can patrolling teams wait for the police to arrive in deep forest areas if they accost fully armed poachers? Why should poachers feel scared to poach? After all who is stopping them?

The answers to these questions are not easily found among the arguments highlighting the pros and cons of providing weapons to the forest staff. But can we leave forest personnel at risk of life and expect them to share the blame when a poaching incident is reported? Many forest personnel have been killed by forest gangs and poachers in the recent past and the state forest departments have felt helpless in dealing with such high risk situations. In 1999, 3 forest personnel of Rajaji National Park were allegedly killed by forest gangs (TOI, 1999). Numerous other incidents of a similar nature have been reported from all over India. What motivation is expected from forest officers when their own lives are at risk?

If providing weapons is not feasible for whatever reason, perhaps something like the Central Industrial Security Force (CISF) be entrusted with the perimeter security of PAs. If steel plants can be protected by CISF, why not PAs? The ecological battalions under the Ministry of Defense being deployed in Assam forests could be another very viable option worth emulating in other areas.

### **Beefing up intelligence networks through community participation**

The intelligence network around most tigers parks is poor and unorganized (WPSI, 2005). Most tiger parts seizures have been made with the help of information acquired by NGOs like the Wildlife Protection Society of India (WPSI), the Wild Life Trust of India (WTI), and the Traffic and Environmental Investigation Agency (EIA) – not through intelligence gathered by government agencies. Intelligence gathering on poaching around PAs and other forests needs to be substantially strengthened.

In the past, there have been initiatives like the Coimbatore Charter of 2001 on Environment and Forests (MOEF, 2001), endorsed by forest ministers and forest secretaries of all states, which pledges to strengthen intelligence networks. This is, however, easier said than done. While the efforts of the Madhya Pradesh Forest Department to establish five wildlife intelligence bureaus (MPFD, 2005) are a step in this direction, they might not yield the desired results. The problem with this arrangement is that in such formal scenarios, intelligence is usually bought – not sought. When money becomes the prime driving force, the information may go to the highest bidder. The content of the information may depend on who the recipient is. Thus, the information could be about poachers for the forest department to use, or it could be about tigers to benefit poachers. The point being that except through sustained outreach programs, where local communities see adjoining forests as livelihood centers, they may not be motivated to volunteer crucial information. If tigers can earn money for local communities, an efficacious and robust intelligence apparatus can be built that will receive volunteered information. For example, eco-tourism can be a key idea to involve local communities, where

tourists arrive to see tigers and locals act as guides, provide food, supply memorabilia, organize cultural programmes and get involved in habitat improvement activities, etc. With such an arrangement, local communities may feel a higher degree of motivation to protect and side with the conservationists rather than the destroyers. Without the real involvement of local communities, intelligence gathering may never provide useful information. It is also worthwhile to note that intelligence that can protect a live tiger is valuable intelligence. Intelligence that recovers dead tigers may not be so relevant. Current hauls of tiger parts have been made using intelligence coming from the poachers end. When we talk of keeping tigers alive, intelligence will have to come from the people's end. It is because of this important difference, that the involvement of local people will be so important.

### **Do we have real management data?**

Developing biodiversity information systems should be a top priority. Good information is the precursor to good management. In spite of the fact that India dominates the global software market, hardly any PA has a visionary information system that can provide accurate, timely and dependable information for conservation management and planning. This situation can be contrasted with a number of other countries that have excellent information infrastructure that forms the backbone of management decision making. It is one thing to have computers, and something quite different to have fully integrated information systems running on them. PAs and other forest areas do not have really good information systems that can be used for decision making. The forest departments should jointly invest in creating an integrated information system software that can be shared by all and can provide seamless integration at the national level. Project Tiger can help fund the development of such software, standardize it, and make it operational across the country. The framework of an integrated information system should essentially not be species-centric, but cover all important biodiversity dimensions. Such information systems should also have information about the surrounding landscape and pressures from human populations.

## Ending mistrust

Whenever tiger deaths are reported from any PA, the causes given by the forest department are hotly contested. For example, in June 2005, a radio-collared tigress with three cubs was found dead in Kanha National Park in Central India (HT, 2005). The forest department claimed that the death of the tigress was due to injuries sustained in a fight with a male tiger. A number of NGO's contested this claim, suggesting that the death was due to the radio collar getting trapped in a bush. It was also claimed by the NGOs that one of the cubs was scorched in a fire started by the forest department; a claim that the department vehemently denied. Whatever the truth, such encounters widen distrust and damage public opinion against the department, even though the department might be doing a good job. Why can't a standard procedure be evolved to document tiger deaths that includes the participation of representatives of NGOs and the press? Why can't the proceedings of recovery and autopsy be videotaped? By observing a predefined procedure involving outside participation, the forest departments can build public trust in their operations.

## Conclusions

The tiger population in India is biologically in its most fragile phase. Adding human costs like poaching, other man-animal interaction pressures and shrinking habitats, makes matters very complex and difficult. The attention that the recent tiger count has generated may probably be the last real chance to effect a major systemic reform that may hold some hope, not only for the tigers, but for other animals also. This requires adopting innovative strategies that go beyond strengthening conventional solutions, which obviously have not produced the desired results over the years. It requires courage to admit failures, resist interference, trust local communities and create knowledge networks that can help evolve and sustain holistic conservation strategies.

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# CHECKLIST AND DISTRIBUTION OF SAURIAN FAUNA IN THE THAR DESERT OF RAJASTHAN

by Sanjay K. Das

## Introduction

The Thar Desert of Rajasthan covers a major portion of the Great Indian Desert (about 62%), which comprises an area of about 191,650 km<sup>2</sup> and spreads over 13 districts of Rajasthan (Gupta and Prakash, 1975; Dhir *et. al.*, 1992; Baqri and Kankane, 2002). It includes Ganganagar, Hanumangarh, Bikaner, Jaisalmer, Barmer, Jodhpur and Churu districts and part of Nagaur, Ajmer, Pali, Jalor, Jhunjhunun and Sikar districts. It is bounded by the Aravali hills in the east, the fertile Indus and Nara valley in the west, the Rann of Kutch in the south, and the semi arid districts of Haryana and Punjab in the north. It lies between 22°30' to 32°05' N latitude and 68°05' to 74°45' E longitude. It is an extension of the Sahara Desert through the Arabian and Persian deserts and continues to the desert portion of Pakistan on its west.

During the post-independence era, vast areas of this natural region have been explored and additions to the saurian fauna have been considerable. Species inventories of a particular region would provide essential data from a conservation and resource management point of view (Oliver and Beattie, 1993). Hence, in the present study an attempt was made to draw up a detailed checklist and distribution of saurian fauna in the Thar Desert of Rajasthan, including distribution in two protected areas i.e., Desert National Park (DNP) and Talchhappar Wildlife Sanctuary (TWS). It also includes comments on species of conservation significance drawn from distributional data. The work of Boulenger (1890); Smith (1935); Minton (1966); Biswas and Sanyal (1977); Murthy (1990); Tikader and Sharma

(1992); Daniel (2002); and Sharma (2002) were consulted during this study.

## Methodology

Intensive field surveys were conducted to search for saurian fauna, during which the visual encounter method of Corn and Bury (1990) was followed.

## Discussion

Twenty-nine species of saurian fauna have been recorded in Rajasthan (Tikader and Sharma, 1992; Sharma, 2002), out of which 25 species are found in the Thar Desert. The Thar Desert supports 86% of the total saurian fauna found in Rajasthan, although it comprises only 62% of the total area of Rajasthan. This supports the studies of Pianka, (1986) and Cloudsley-Thompson (1991), who asserted that saurian fauna attains high abundances in desert environments.

Out of the 13 districts of the Thar Desert, Ajmer district alone supports 12 species of the saurian fauna found in this region. Four of these species i.e., *Cyrtodactylus fedtschenkoi*, *Cyrtodactylus madarensis*, *Mabuya dissimilis* and *Sitana ponticeriana*, are not found in the other 12 districts of the Thar Desert. As only a small portion of this district falls in the Thar Desert (Gupta and Prakash, 1975), we may conclude that these species are not common to desert ecosystems.

The Thar Desert supports 3 endangered and 3 endemic saurian species. If we exclude *Cyrtodactylus madarensis* as being uncommon to the desert ecosystem, then the desert supports only five endangered or endemic species of

conservation significance. From distributional data in Table 1, it is evident that only Jaisalmer district supports all five species. As these species differ greatly in their habit, habitat and basic mode of life, it can be concluded that the habitat heterogeneity of Jaisalmer district is most suited to sustain the species of conservation value found in the Thar Desert of Rajasthan.

Twelve of the 25 saurian species (or 48%) found in the Thar Desert are confined to the two protected areas – Desert National Park and Talchhappar Wildlife Sanctuary. Desert National Park supports all 5 species of conservation significance

Among the five species of conservation significance, the habitat of *B. laungwalansis* should be protected in its natural state, free from any kind of human interferences. Not only is it endemic to the Thar Desert of Rajasthan and Sind (Pakistan), but it also has a restricted distribution, being reported from only a few areas of Jaisalmer district (Das, 2004). Immediate conservation strategies should be implemented to conserve this and other endangered species.

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**Table 1 Checklist and distribution of saurian fauna in the Thar Desert of Rajasthan**

Family/Genus/ Species	Common English Name	Bikaner	Barmer	Jaisalmer	Jodhpur	Churu	Ganganagar	Hanumangarh	Nagaur	Pali	Jalor	Sikar	Jhunjunur	Ajmer
<b>Gekkonidae</b>														
<i>Crossobamon orientalis</i> Blanford, 1875 <sup>*12</sup>	Rajasthan Sand Gecko	+	+	+	+	+	†	-	-	-	-	-	-	-
<i>Cyrtopodion scabrum</i> (Heyden, 1827) <sup>1</sup>	Keeled Rock Gecko	+	-	+	+	-	-	-	-	-	-	-	-	-
<i>Cyrtodactylus fedtschenkoi</i> (Strauch, 1887)	Turkestan Rock Gecko	-	-	-	-	-	-	-	-	-	-	-	-	+
<i>Cyrtodactylus madarensis</i> Sharma 1980 <sup>*</sup>	Luminous Gecko	-	-	-	-	-	-	-	-	-	-	-	-	+
<i>Hemidactylus brookii</i> Gray, 1845	Spotted Indian House Gecko	†	†	†	+	†	†	†	+	+	†	†	†	+
<i>Hemidactylus flaviviridis</i> Ruppell, 1835 <sup>12</sup>	Yellow-Bellied House Gecko	+	+	+	+	+	†	†	+	+	†	†	†	+
<i>Hemidactylus leschenaultii</i> Dumeril & Bibron, 1836	Bark Gecko	†	+	+	-	-	†	†	+	-	-	-	-	-
<i>Hemidactylus triedrus</i> (Daudin, 1802)	Blotched Gecko	-	-	-	+	-	-	-	†	-	-	-	-	+
<b>Agamidae</b>														
<i>Calotes versicolor</i> (Daudin, 1802) <sup>12</sup>	Indian Garden Lizard	+	+	+	+	+	†	†	+	+	†	†	†	+
<i>Trapelus agilis</i> Olivier, 1807 <sup>1</sup>	Brilliant Agama	+	+	+	+	-	+	-	+	-	-	-	-	-

<i>Bufo laungwalansis</i> Sharma, 1978 <sup>*1</sup>	Toad-Agama	-	-	+	-	-	-	-	-	-	-	-	-	-
<i>Sitana ponticeriana</i> Cuvier, 1844	Fan-Throated Lizard	-	-	-	-	-	-	-	-	-	-	-	-	+
<b>Uromastycidae</b>														
<i>Uromastyx hardwickii</i> Hardwicke & Gray, 1827 <sup>**12</sup>	Spiny-Tailed Lizard	+	-	+	+	+	+	-	-	+	-	-	-	-
<b>Scincidae</b>														
<i>Mabuya macularia</i> (Blyth, 1853)	Eastern Bronze Skink	-	-	-	+	-	-	-	-	-	-	-	-	+
<i>Mabuya dissimilis</i> (Hallowell, 1857)	Stripped Grass Skink	-	-	-	-	-	-	-	-	-	-	-	-	+
<i>Ophiomorus raithmai</i> Anderson & Leviton, 1966 <sup>1</sup>	Indian Sand Skink	-	+	†	+	-	-	-	+	-	-	-	-	-
<i>Eurylepis taeniolatus</i> (Blyth, 1854)	Eastern Yellow-Bellied Mole Skink	-	-	-	+	-	-	-	-	+	-	-	-	-
<i>Lygosoma punctata</i> (Gmelin, 1799)	Spotted Supple Skink	-	-	-	+	-	-	-	-	-	†	-	-	-
<i>Ablepharus grayanus</i> (Stoliczka, 1872)	Earless Dwarf Skink	-	-	+	-	-	-	-	-	-	-	-	-	-
<b>Lacertidae</b>														
<i>Acanthodactylus cantoris</i> Günther, 1864 <sup>12</sup>	Indian-Fringe Toed Lacertid Lizard	+	+	+	+	+	†	†	+	-	†	+	-	+
<i>Ophisops microlepis</i> Blanford, 1870	Small Scaled Lacerta	-	-	-	+	-	-	-	-	+	-	-	-	+
<i>Ophisops jerdoni</i> Blyth, 1853 <sup>1</sup>	Snake-Eyed Lacerta	-	-	+	+	-	-	-	-	-	-	-	-	-
<i>Mesalina watsonana</i> Stoliczka, 1872	Long-Tailed Desert Lacerta	-	-	+	+	-	-	-	-	-	-	-	-	-
<b>Varanidae</b>														
<i>Varanus bengalensis</i> (Linnaeus, 1758) <sup>**12</sup>	Common Indian Monitor	+	+	+	+	+	†	†	+	+	-	-	-	+
<i>Varanus griseus</i> (Daudin, 1803) <sup>**12</sup>	Desert Monitor	+	-	+	-	+	-	-	-	-	-	-	-	-

**Ref:** Smith, 1935; Biswas and Sanyal, 1977; Murthy, 1978; Tikader and Sharma, 1992; Anon, 1993; Das, 1994, 2003; Sharma, I. 1996; Sharma, R. C. 1996, 2002; Daniel, 2002; Das *et. al.* 2003; Das and Rathore, 2004; Tikader and Sharma, 1992. **Note:** + Present, - Not present, † Range extension of the species after the present study, \* Endemic species, \*\* endangered species, <sup>1</sup> Present in DNP, <sup>2</sup> Present in TWS, <sup>12</sup> Present in both DNP and TWS

## **EVALUATION OF HABITATS FOR AVI-FAUNA AT SHORKOT PLANTATION (WILDLIFE SANCTUARY), PAKISTAN**

by M. Anwar Maan, A. Aleem Chaudhry and Muhammad Sajid Nadeem

### **Introduction**

Shorkot plantation is an irrigated forest in Tehsil Shorkot, of District Jhang. The area of the plantation is 4,038.8 ha. It is located 5 km from Shorkot Railway Station on the Shorkot Cantt – Shorkot City link road. The terrain is generally flat, with soil formed by river alluvium. The soil is dark brown in color, loamy in texture, highly saline, and waterlogged.

Haveli canal, originating from Trimu–Head works, and Lakhuana disty mark the north–south and south–west boundaries of the plantation respectively. Agriculture fields flank the northern and southern sides of the plantation. The plantation is under various stages of development. Half of the plantation area has relics of natural vegetation. Every year, according to the forest working schedule, the natural area is cleared and planted with *Eucalyptus*.

Visualizing the importance of the plantation for faunistic variety, the plantation was given the status of wildlife sanctuary in 1986 for a period of five years. The period was extended for a further five years up to 1991, and it is still a wildlife sanctuary today.

The area has a semi-arid climate characterized by extremes of temperature, and erratic and irregular rainfall. June–July are the hottest months, while December–January is the coldest period.

The tropical thorn forest, which was the natural vegetation of the area, once supported a rich wildlife fauna, which was either forced to migrate or adapt to new habitats. With the advent of the agriculture era, the natural vegetation of the tropical thorn forest was cleared and an irrigation network was set up. Patches of natural vegetation

were maintained in the form of groves along the irrigation canal and agriculture land. The plantation provides a variety of habitats for wildlife in the form of thick vegetation cover, sparse to thick under-story vegetation, individual trees and patches of natural vegetation.

Over the years, *Eucalyptus* has been planted in regeneration areas. From nursery to mature crop, *Eucalyptus* provides age-grading habitats. It also provides mixed habitat with *Dalbergia*, *Morus* and mesquite.

In Pakistan, very little work has been undertaken on habitat studies and the preferences of bird species for particular habitats. Previous work is mainly confined to species identification. Dr. Salim Ali and Dr. S. Dillon Ripley have conducted extensive bird surveys throughout the Indian sub-continent since 1930.

Khan (1987) observed the bird life of Daphar and Pakhowal irrigated forest plantations in District Gujrat (Mandi Baha-ud-Din). The major contribution to ornithology in Pakistan in recent years has been made by T.J. Roberts (1991–92). However, habitat selection, densities per hectare and the distribution pattern among bird species have not been described. The present study was carried out from July 1989 to August 1996 and describes the preferences of bird species for different sets of vegetation cover (habitat selection), density and distribution pattern. It will provide guidelines for the development of future management strategies for the wildlife sanctuary.

### **Materials and methods**

From the management point of view, Shorkot plantation is divided into blocks, which are further sub-divided into different compartment units. The

forest crop varies within compartments with respect to age and vegetation composition.

The plantation was stratified according to different vegetation composition units. Five strata were identified with mature crops of *Dalbergia-Eucalyptus*, *Dalbergia-Morus*, *Eucalyptus-Dalbergia*, *Eucalyptus* from nursery to ten years of age, and natural areas. Transects 2 km long with variable widths were laid out and studied, recording bird species on both sides of the transects. With the aid of binoculars, the birds were identified according to Ali and Ripley (1987) and Roberts (1991, 1992). Details about the birds identified were recorded on data sheets. The data was analyzed following standard statistical methods (Davis & Goldsmith, 1984; Odum, 1997).

## Results and discussion

The natural vegetation of the area is typical of the central Punjab plains, i.e., tropical thorn forest, with the following species composition: *Acacia nilotica*, *Tamarix aphylla*, *Prosopis cineraria*, *Salvadora oleoides*, *Zizyphus mauritiana*, *Z. nummularia*, *Calotropis procera*, *Capparis decidua*, *Suaeda fruticosa*, *Panicum antidotale*, *Eleusine compressa*, *Cymbopogon jwarancusa*, *Saccharum munja* and *S. spontaneum*, with *Prosopis* that was established later.

*Dalbergia* and *Eucalyptus camaldulensis* were the main plant species planted in the plantation. *Morus* and *Prosopis* were naturally established, forming the understory cover of the plantation. Patches of natural vegetation between different crops have ecotone effects. Water channels attract paddy birds, kingfishers, and water hens, while electricity wires attract perching birds such as swifts, rollers, bee-eaters and doves. The Little green bee-eater, Red turtle dove, Ringdove, Rose-ringed parakeet and Purple sunbird were prevalent in all six of the identified habitat units. Other bird species were more or less distributed according to habitat preferences.

In *Eucalyptus* crops of various ages, 18 bird species were observed during July 1989. During August 1996, 20 bird species were recorded from all stages of *Eucalyptus*. The density of birds per

hectare was rather low during 1989 (7.6) compared to 1996 (16.5). A high bird density was recorded (36 birds/ha) in the *Eucalyptus-Dalbergia* vegetation type. *Eucalyptus* was preferred by 16.9% of the bird population, while 30.7% preferred the mixed crop of *Eucalyptus-Dalbergia*. The distribution pattern was similar in all six vegetation types. The Dispersion Index (31.6% - 35.4%) indicated a distribution of birds of different species in loose groups. The study suggested that mono-crop *Eucalyptus* plantation is not a preferred habitat for birds compared to the mixed cropping system (i.e., *Eucalyptus-Dalbergia*), which provided better habitat for birds.

## Habitats

Mature crops of *Dalbergia-Eucalyptus* provided an extensive and high canopy cover. A total of 15 bird species were observed, with a per hectare density of 5.46 birds. Of the total bird population in the plantation, 7.2 % was distributed in this habitat in groups of various sizes (DI-35.4%).

*Eucalyptus*, from nursery to mature plants, provided a mono-crop, single story cover. Twenty species of birds were present with a per hectare density of 16.9 birds, in loose groups of various sizes (DI-35.3).

The distribution trend in *Dalbergia-Morus* was different. Twenty-seven bird species were recorded in this habitat unit.

The natural vegetation cover maintained its importance as a selective habitat unit. The preference of 31 bird species for this habitat unit shows the importance of natural vegetation in supporting resident and migrant bird species. The *Eucalyptus-Dalbergia* vegetation composition proved equally good for birds, with 30 bird species preferring this vegetation composition.

Habitat preference is subject to change due to the deciduous nature of the vegetation. During winter when leaves are shed, the habitat units lose some attraction for the birds and their preference is diverted to alternate habitats in the farm lands and to remnants of natural vegetation that provide enough cover for the birds.

**Table 1: Distribution of bird species in different habitats at Shorkot plantation (wildlife sanctuary) during August 199**

English Name	Scientific Name	Dalbergia-Eucalyptus	Eucalyptus	Dalbergia-Morus	Eucalyptus-Dalbergia	Uncommanded area	Total
Ashy wren warbler	<i>Prinia hodgsonii</i>				3		3
Black Partridge	<i>Francolinus francolinus</i>				1		1
Black Winged Kite	<i>Elanus caeruleus</i>			1			1
Black Drongo	<i>Dicrurus macrocercus</i>	3		11	2	3	19
Common Babbler	<i>Turdoides caudatus</i>			7	4	2	13
Common myna	<i>Acridotheres tristis</i>		11	5	11		27
Common starling	<i>Sturnus vulgaris</i>			2			2
Pariah kite	<i>Milvus migrans</i>					2	2
Crow pheasant	<i>Centropus sinensis</i>		3	1	2		6
Booted Eagle	<i>Hieraaetus pennatus</i>					1	1
Black bird	<i>Turdus merula</i>			1			1
Fantail Flycatcher	<i>Rhipidura aureola</i>	3	5	5		3	16
Golden backed woodpecker	<i>Dinopium benghalensis</i>	1	2		5		8
Green warbler	<i>Phylloscopus nitidus</i>					10	10
Grey partridge	<i>Francolinus pondicerianus</i>		1		2	1	4
Great reed warbler	<i>Acrocephalus stentoreus</i>		2				2
Golden oriole	<i>Oriolus oriolus</i>			2			2
Hoopoe	<i>Upupa epops</i>	1			2		3
Tailor bird	<i>Orthotomus sutoinus</i>			2			2
House crow	<i>Corvus splendens</i>		5	2	12		19
Indian robin	<i>Saxicoloides fulvicata</i>			1			1
Indian tree-pie	<i>Dendrocitta vagabunda</i>	4	14	12			28
Indian roller	<i>Coracias benghalensis</i>		4	7	11	19	41
Jungle babbler	<i>Turdoides striatus</i>	14	31		37		82
Little green bee-eater	<i>Merops orientalis</i>	1	23	11	60	22	117
Large pied wagtail	<i>Motacilla maderapatensis</i>	1				1	2
Little egret	<i>Egretta garzetta</i>	1					1
Lesser kestrel	<i>Falco tinnunculus</i>		1				2
Pond heron	<i>Ardeola grayii</i>				1	9	9
Cattle egret	<i>Bubulcus ibis</i>					4	4
Common hawk cuckoo	<i>Cuculus varius</i>				1		1
Pied crested cuckoo	<i>Clamator jacobinus</i>				2		2
Indian prima	<i>Prinia subflava</i>					3	3
Pied bush chat	<i>Saxicola caprata</i>		2		4	14	21
Pied King fisher	<i>Ceryle rudis</i>		1				1

House swift	<i>Apus affinis</i>				20	46	1500	156
Red turtle dove	<i>Streptopelia tranquarica</i>	5	8	20	20	40	20	93
Red wattled lapwing	<i>Hoplopterus indicus</i>			2		5	5	1
Ring dove	<i>Streptopelia decaocto</i>			17		18	3	64
Rufous back shrike	<i>Lanius schach</i>	1	25	2		8	5	15
Reed warbler	<i>Acrocephalus scirpaceus</i>						52	52
Rose-ringed parakeet	<i>Psittacula krameri</i>	28	36	41		38	20	163
Shikra	<i>Accipiter badius</i>			1			2	3
Hen harrier	<i>Circus cyaneus</i>						1	1
Sparrow hawk	<i>Accipiter nisus</i>					-	2	2
Long leged buzzard	<i>Buteo rufinus</i>		1					1
Purple sun bird	<i>Nectarinia asiatica</i>	7	17	19		14	12	69
White cheeked bulbul	<i>Pycnonotus leucogenys</i>			1		7	6	14
White backed vulture	<i>Gyps bengalensis</i>					-	2	2
White eye	<i>Zosterops palpebrosa</i>						20	20
White breasted water hen	<i>Amaurornis phoenicurus</i>		5	3			8	16
Streaked weaver	<i>Ploceus manyar</i>						20	20
Indian koel	<i>Eudynamis scolopacea</i>			1		3		4
Red-vented bulbul	<i>Pycnonotus cafer</i>			3		9		12
Common swallow	<i>Hirundo rustica</i>					2		2
No. of species in respective habitats		15	20	27		30	31	55
No. of birds in each habitat type		62	198	201		360	328	116
Surveyed area in hectares		15	15	10		10	21	71
Density of birds per ha <sup>2</sup>		5.46	13.2	20.1		36.0	15.3	16.3
Relative abundance of birds per ha <sup>2</sup> (%)		7.2	16.9	17.2		30.7	28.0	100
Dispersion Index (%)		35.4	35.3	35.3		31.6	31.6	36.8

*D.I. = 100 means random distribution*

*\*D.I. = Less than 100 means group formation  
Greater than 100 means uniform distribution*

The population of resident birds, including scavengers, birds of prey, egrets, partridges, parakeets, king fishers, shrikes, tree pies, Indian rollers and other passerine birds, were consistently associated with their preferred vegetation cover. These bird species have shown little change in their preferences for different vegetation covers.

Habitat disturbances and destruction are important factors that affect the density and distribution of birds. Activities carried out by the Forest Department such as the removal of undergrowth of *Saccharum*, *Prosopis* and grasses, deprive some species of cover, leaving the birds more vulnerable to predation, hunting and netting. Livestock grazing also causes disturbances and hampers the activities of ground nesting birds, particularly during breeding season. The birds are forced to abandon preferred habitat units to adopt less preferred ones.

### Conclusion

The list of 55 bird species indicates a good faunistic variety in the sanctuary area. Management of the area under strict sanctuary terms would dictate wildlife conservation-oriented activities by the Forest Department. Planning is needed to develop mixed cropping systems with fruit plants, which is a preferred habitat for birds, and avoid monocultures such as *Eucalyptus*, which is a poor habitat for birds. Patches of undergrowth vegetation should be maintained for persistent cover. In the regeneration areas, patches of natural vegetation should be maintained to preserve the original vegetation for the resident bird species. The farmers should be encouraged to plant commercial trees on their farmlands. This agro-forestry system will provide alternate habitat units to most of the bird species. Disturbances due to

livestock grazing should be minimized and strict enforcement of laws must be ensured. Water-channels and compartment roads should be maintained properly and developed as micro-habitats. With these efforts, the bird life of Shorkot Wildlife Sanctuary could be further improved.

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# DAMAGE TO AGRICULTURAL CROPS BY MAMMALIAN FAUNA AT THE FRINGES OF LAWACHARA NATIONAL PARK, BANGLADESH

by M.A. Aziz and M.M. Feeroz

## Introduction

Crop raiding by wild animals dates back to the early times in many parts of world. It has become one of the crucial management issues in the arena of wildlife conservation, since in severe confrontations of wildlife with agricultural crops, the loss of properties and lives have taken place. In spite of frequent occurrences of wildlife damage in the country – mostly regarding man-elephant interactions – few of them have been reported (Islam *et al.*, 1999; Miah *et al.*, 2001; Aziz, 2003; Feeroz *et al.*, 2003; Aziz *et al.*, 2006).

Lawachara National Park is one of the country's 16 protected areas and 9 national parks, and the only area that harbors 6 of the 10 primate species that occur in Bangladesh. Several studies have been conducted in the area, but were confined to the primate species only (Feeroz, 1991; Feeroz and Islam, 1992; Hasan, *et al.*, 2005). The present study investigated the crop raiding incidents with notes on economic loss incurred by some of the mammalian fauna of the national park.

## Study areas

Lawachara National Park is located approximately 160 km northeast of Dhaka and 60 km south of Sylhet in the civil administrative units of Kamalgonj Thana, Maulivibazar District, under the forest administration unit of Lawachara, Chautali and Kalachara. It falls under the Maulivibazar Forest Range of Sylhet Forest Division and within the bio-ecological zone of 9b-Sylhet Hills. The national park lies in the West Bhanugach Reserve Forest, a forest planted in the 1950s with an area of about 2,738 ha, comprising three forest beats, namely Lawachara, Chawtali and Kalachara. Lawachara forest beat currently covers an area of 1,250 ha.

The topography of the area varies from medium to steep hilly slopes. Hillocks, ranging from 10-25 m are indiscriminately situated in the forest. There are many streams that carry the rain water flowing through the forest floor. Numerous walkways enable access to move through the forests. There are four forest villages in the area, two of which are located in Lawachara National Park. The south-east, southern and eastern sides of the park are encompassed by tea gardens, while in the north are bare hillocks cultivated by the land owners. Once, the north sides of the bare hillocks were under the reserve and cultivated with pineapple, banana, jackfruits, lemon and some other vegetables as well.

## Study methods

The study was conducted from September 2005 to July 2006, to assess wildlife damages in the northern vicinity of Lawachara National Park. Field visits were made every month, covering all 11 plots of gardens in the northern vicinity of the national park. The wildlife species that were involved in crop raiding were identified by pugmarks, the presence of hairs, quills, scats, teeth marks on the damaged plants, and confirmed by the farmer's observations as well. A questionnaire was also used to interview the land owners and farmers who guard their fields.

To investigate the massive damage of pineapple gardens, 10x10 m quadrates were plotted in the affected areas, which in turn were multiplied by the whole damaged area. Similar quadrates were set up in the intact areas to compare the total number of plants damaged. Direct counts were carried out in the cases of banana, jackfruits and pumpkin damage, while quadrates were employed for lemons. The economic loss was expressed by

the standard market value of the fruit, adding 20% for the costs of cultivation for individual plants.

## Results and discussion

Damages to agricultural crops have been reported and have become a serious management problem involving many wildlife species in different parts of the world (Chalise, 1997; Ghimire, 2001; Miah *et al.*, 2001; Chetry *et al.*, 2002; Medhi *et al.*, 2005; Aziz, 2003, 2006). The present study investigated the agricultural crops damaged by some mammalian fauna in the gardens located close to the national park.

The study revealed that wild boar was the principal crop raider, especially before the budding of the pineapples, and Rhesus macaques raided the crops just before harvesting. Groups (sounders) of wild boars come out of the forest to raid the gardens regularly (mean size=7; range=3-12; N=7), mainly during the second half of the night, causing damage from the seedling stage of the pineapple up until harvesting (March-August). It is during the pre-mature stage of pineapple when most of the damage is incurred by wild boars. The plants are uprooted and the roots are eaten along with the piths, discarding only the serrated leaves. The results showed that the boars preferred pineapple plants of about two months age rather than those just planted, as the former are more healthy, tender and palatable. The frequency of raiding increased with the age of the seedlings. Porcupines also caused some damage by eating and boring the roots of the pineapple plants.

Farmers experience severe economic loss when the boar becomes a nuisance just before the budding of the pineapples, as they have invested much labor and money up to the budding stage. Damage to pumpkins and banana roots by porcupine and wild boar respectively, continues throughout the year.

When the pineapple fruits are mature, rhesus macaques (mean group size=26; range=19-34; N=5) enter the forest-fringed gardens and cause massive damage, as each individual gets a hold of

least one fruit during each raid. The macaques raid the gardens mainly during the daytime during July and August when the fruits are about to be harvested.

Macaques also raid jackfruit crops during April and May, targeting mature and ripe fruits. Sometimes the jackfruits and pineapples are left scratched or half-eaten by rhesus macaques and wild boars during their raids.

Hoary-bellied squirrels visit the lemon gardens throughout the year, boring into mature and ripened fruits. Other squirrels species present in the park (e.g., *Dremomys lokriah*, *Ratufa bicolor*) were not reported to come out of the forest to forage in the gardens.

May-July is the peak time for the Short-nosed fruit bat to forage in banana bunches, although they make visits throughout the year when the plants are flowering. The largest Pteropid of the country, *Pteropus giganteus*, occasionally feeds on the banana bunches. Jackfruit buds have been severely damaged by some squirrel species during January and February, while mature and ripe fruits are targeted by rhesus macaques during April and May.

Farmers must spend a large number of man-hours to keep the overnight raiders away throughout the season. They also invest in batteries for flashlights used in guarding their crop fields at night and incur expenses for other kinds of deterrents. The fact is that man invaded or occupied the wildlife habitats and now the animals are coming back to visit their former ranges as their habitats shrink.

The farmers are frustrated as they must guard their fields overnight throughout the pineapple crop season. The same is true during the daytime for the owners of gardens on the forest fringe. The gardens are planted too close to stop the wildlife residing in the park from joining the raids. To eliminate the problem of wildlife raids, a possible option would be the cultivation of alternative cash crops that are non-palatable to the garden raiders.

**Table 1 List of crops damaged with mammalian species involved**

Crops name	Scientific name	Parts eaten	Species involved
Pineapple	<i>Ananas sativus</i>	Fruits, buds, roots	<i>Ss, Hi, Mm</i>
Lemon	<i>Citrus</i> sp.	Fruits	<i>Ce</i>
Banana	<i>Musa sapientum</i>	Fruits, central piths	<i>Cs, Ss, Hi</i>
Jackfruit	<i>Artocarpus heterophylla</i>	Fruits, buds, seeds	<i>Mm, Ce</i>
Mango	<i>Mangifera indica</i>	Fruits, buds	<i>Mm, Ce</i>
Pumpkin	<i>Cucurbita moschata</i>	Fruits	<i>Ss, Ce</i>

Species code: Mm-*Macaca mulatta*; Ce-*Callosciurus erythraeus*; Dl-*Dremomys lokriah*; Hi-*Hystrix indica*; Cs-*Cynopterus sphinx*; Ss-*Sus scrofa*.

**Table 2 Area-wise crop damage with approximate economic loss**

Plot No.	Area (acres)	Crops cultivated	Major crops damaged	Economic loss (Tk.) (approx.)
1	13.5	<i>As, Ms, Cs</i>	<i>As, Cs</i>	2450.00
2	11.0	<i>As, Ms, Cs, V</i>	<i>As, Ms</i>	14500.00
3	11.0	<i>As, Ms, Cs</i>	<i>As, Cs</i>	23000.00
4	11.0	<i>As, Ah, Cs</i>	<i>As, Ah</i>	10400.00
5	5.3	<i>As, Ah, C, Mi</i>	<i>Ah, Mi, Cs</i>	27000.00
6	15.0	<i>As, Ms, Mi</i>	<i>As, Ms</i>	5200.00
7	15.0	<i>As, Ms, Cs, V</i>	<i>Ah, As</i>	13000.00
8	7.5	<i>As, Ms, Cs</i>	<i>As, Ms</i>	19000.00
9	6.0	<i>As, Ms, Mi</i>	<i>As, Mi</i>	12600.00
10	4.0	<i>As, Cs, Cm</i>	<i>Ah, Cm</i>	6200.00
11	8.0	<i>Ms, Cs</i>	<i>Cm</i>	4700.00

Total economic loss 138050.00 (2125 US\$)

Crop code: As-*Ananas sativus*; Ms-*Musa sapientum*; Mi-*Mangifera indica*; Cs-*Citrus* sp.; Ah-*Artocarpus heterophylla*; Cm-*Cucurbita moschata*; \*Land under the Reserve forests.

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