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SUMMARY

A total of 213 Assamese macaques (*Macaca assamensis*) were encountered in 9 groups within the total area surveyed of 113 km² at Langtang National Park. The group density was found to be 0.0790 groups / km² with a population density of 1.8691 individuals/ km² and a mean group size of 23.66 (Range 13-35) individuals. Group size showed a great intraspecific variance among populations of this species in the area. Since larger groups prevailed in group encounters, further research should be attempted to explain whether the high predation pressure or between or within-group competition is responsible for large group size of Assamese macaque in the area. Age-sex composition of the macaque comprised 31% adult females, 16% adult males, 18% sub-adults, 16% juveniles and 19% were infants in the study area. The adult sex ratio and the recruitment rate were found to be 1:1.92 and 0.61 respectively. The estimated crop damage from 75 households was about Rs. 150,000 per annum with the average of Rs. 2,000 per household. Presence or absence of macaque damage is significantly related to the distance of the farm from the forest ($\chi^2 = 30.9$, df = 2, $P << 0.05$). Therefore the crop-raiding incidents were highly clustered near the forest. The costs of crop protection per household ranged between Rs.500-1500 per household per year, which comes to Rs. 37,500- 112,500 for 75 households. It was found that Assamese macaques spoiled more crops than they actually eat; juveniles and infants in particular brought about damage during play on the ground. The major crops: maize, potato wheat, buck wheat, millet, and others were found to be raided by Assamese macaque in the area. Among these, maize cobs were found to be highly preferred (62%) followed by potato tubers (23%). The most commonly used crop protection strategy was constant vigilance during crop seasons used by 60 % of the farmers in the study area. This severe localized crop damage results from the negative attitudes of the local subsistence farmers with respect to food security towards this species and makes it more vulnerable. Besides this most common form of human-macaque conflict, other threats come from expanding human populations and encroachment upon Assamese macaque habitat particularly due to rapid logging for timber to manufacture tourist lodges and hotels and to fulfill the demand of firewood in these harsh areas. Agricultural crop and livestock depredation by wildlife results in disputes between the park authorities and the local people. Potential solutions recommended here emphasize the need for the Park administration to either accept responsibility for the protection of crops and livestock from the park’s wildlife or to take measures immediately to minimize them and increase the level of tolerance of the local people for sustainable conservation. Additionally, the sharing of park revenues with local people may also help to lower conflict levels and change the perceptions of locals towards park wildlife. Site-specific conservation measures with development and distribution of outreach materials to local stakeholders should be carried out to foster interest from locals in primate conservation.

**Key Words:** *Macaca assamensis*, Population, Langtang National Park, Crop-raiding, logging, Park revenue, Conservation
INTRODUCTION

Two species of macaques have been reported from Nepal; Rhesus macaque *Macaca mulatta* (Zimmermann, 1780), and the Assamese macaque *Macaca assamensis* (McClelland, 1840) among which the latter one is the less well reserached nonhuman primate of Nepal (Chalise, 2000a) and is categorized as ‘Vulnerable’ in the 2007 IUCN Red List of Threatened Animals. The Assamese macaque (*Macaca assamensis*) of Nepal is fully protected under NPWC Act 1973. Assamese macaques are distributed in Nepal, Sikkim, Bhutan, Assam, northern Myanmar, northern Thailand (Fooden, 1982; Chalise & Ghimire, 1998; Chalise, 1999) and Yunnan, southern China (Zhang et al., 1981). A discontinuous distribution pattern is characteristic of Assamese macaques including Thibetan macaques (*M. thibetana*) (Wada et al., 1987) and stump-tailed macaques (*M. arctoides*) (Fooden et al., 1985). The macaques inhabiting forests were markedly disturbed by the over-utilization of forests by humans who cultivate crops in fields, cut tree branches as food for domestic animals and collect firewood. As a consequence, the proportion of forest area to the total area of Nepal (43%; 63,000/147,181 km²) in 1978 had decreased to 37% (55,000 km²) in 1985 (Ministry of Forest and Soil Conservation, 1988). There are currently few primary forests remaining, and only small secondary forests or scrub are distributed throughout the majority of Nepal. Since 1978 forest deterioration has continued. The taxon is designated as threatened due to its restricted distribution of less than 22,000 km², an estimated area of occurrence of about 914km² with continuing decline in area, decreasing quality of habitat, and declining population (Molur et al., 2003). As a result, macaque distribution has become fragmented and shrunken by the forests’ deterioration. Because of their distribution patterns, Assamese macaque populations would have been more influenced by forest habitat deterioration compared with rhesus macaque populations. The isolated distribution of the Assamese macaque seems insufficient for maintaining a viable population in Nepal. There have been few studies to determine the minimal viable population size necessary for the conservation of not only Assamese macaques, but also *Macaca* in general (Wada, 2005). A species’ viability must be measured by evaluating population dynamics and environmental effects (Fa & Lind, 1996). Given its restricted extent of occurrence, increasing threats to the individuals and habitat, and decreasing numbers in fragmented patches, the Nepal Assamese macaque population is categorized as ‘Endangered’ (Molur et al., 2003). Likewise the National Parks and Wildlife Conservation Act of 1973 lists the Assamese macaque as a protected species and appendix II of
CITES. Of equal concern is the fact that these animals are considered as a crop-raiding pest in Nepal (Chalise, 2001) and, as such, conflicts between local people and the macaque are on the rise. This, in turn, presents an additional threat to the survival of the macaques. Given the decreases in natural habitat and population numbers along with increasing threats due to retaliation for crop raiding, there was a critical need to evaluate the population status of Assamese macaques in Langtang National Park and help with generating solutions to deal effectively with the human–macaque conflict. The aim of this study therefore was to assess the Assamese macaque population in Langtang National Park. This comprehensive work included population surveys, analysis of socio-ecological factors and identification and recommendations for the site-specific conservation measures for this species in the area.

METHODS

Study Site

Map: Langtang National Park showing the Assamese macaque survey trails

Langtang National Park (Longitude 85° 33' 98.4" E, Latitude 28° 12' 47.4 " N) is in north-central Nepal on the Tibetan border. With altitudes varying from 800 m to >7200 m, habitats range from
subtropical forest to perpetual snow (Sayers & Norconk, 2008). The Langtang National park was established in 1976 by the Government of Nepal and in 1998, an area of 420 km², in and around park was declared as buffer zone. LNP is the second largest Mountain National Park of Nepal, and covers 1710 km² in three districts: Rasuwa, Nuwakot and Sindhupalchock of Bagmati Zone of Nepal (Chalise, 2003).

**Preliminary Field Survey**

A preliminary field survey was done in the month of October 2007 to understand the geophysical and climatic conditions. Survey process included the collection of information in discussions with park authorities (warden, rangers and game-scouts) of Langtang National Park, local people and officials of INGOs and NGOs working for the conservation of Sacred Himalayan Landscape through community participation. Study area was visited on foot, animals were observed using 10 x 50 mm binoculars and behavioral data collection methods were practiced. A total visually accessible area of 113 sq. km was selected in two dimensions with help of topomaps (scale: 1:50 000), without taking contours into account for the survey.

**Population Status**

A population study of a wild primate typically involves a considerable investment of time and resources i.e. money, equipment and labour (Ross & Reeve, 2003). But only investing these resources may not be sufficient for the survey of primates in such mountainous topography which makes most of the systemic survey methods impractical. So, a total count was carried out from all the accessible trails present in the the survey area. Assessing age required study of the age classes used by previous researchers and some practice (Ross & Reeve, 2003). So in this study we followed Chalise (1997) to distinguish the age and sex of the macaques and practiced with experts in the field. The macaque groups in LNP were comparatively more stable and less persecuted by human beings making group size estimation and composition more accurate. The birth rate was estimated for each group as the number of infants per adult female at the time of the survey.

**Total Count**

Population surveys throughout the study area (113 km²) were carried out from all the accessible trails. The trails were walked slowly at c. 0.5 km/hr, covering a distance of 6 km per day. Observers paced along trails stopping every 500 meters to search the area for 1/2 hour by applying both visual and auditory cues simultaneously. The topography of the region makes it
difficult to undertake systematic surveys. When macaques were encountered, the following data were recorded: locality and its coordinates, detection time, duration of observation, activity and age-sex composition of the group. Age and sex were categorized properly with the help of a spotting scope. Counting was repeated 3 times to minimize the bias in distinguishing age and sex of the groups. Population density \( (D_2) \) was calculated from the group density \( (D_1) \) as: 

\[
D_2 = D_1 \times \text{mean group size},
\]

where \( D_1 = \text{number of identified groups/ area surveyed} \). All areas were surveyed starting at 06:00 and finishing at 18:00.

**Questionnaire Survey**

Direct questionnaires were used because the mountainous topography and the land use patterns of the study area made alternative methods impractical. After visiting the 120 farms in the study area, 75 households were surveyed in Ramche, Syafru and Timure VDC of Rasuwa district whose farms were found to be damaged by the macaques. The survey focused in estimating the crop damage per household yearly and getting the information on the methods of deterrence applied by the farmers in the area.

## RESULTS

### POPULATION STATUS

**Group and Population density**

A total of 213 Assamese macaques were encountered in 9 groups. The mean group size was 23.66 individuals. The group density was 0.0790 groups / km² with a population density of 1.8691 individuals/ km².
Age-sex composition
This comprised 31% adult female, 16% adult male, 18% sub-adults, 16% juvenile and 19% infants in the study area (Fig. 1).

Adult Sex Ratio
The adult sex ratio (male to female) observed in the area was 0.52 (52 males per 100 females) i.e. 1:1.92.

Birth Rate
Birth rate in this study was 0.61 (61 infants per 100 females).

Group size and distribution
The group size recorded at the highest elevation of 2420 m asl in Lama Hotel consisted of 13 individuals. The group size recorded at the lowest elevation of 1,300 m asl in Ghurtabensi consisted of 23 individuals. The largest group size was recorded at an elevation of 1,710 m asl on a bank of the Bhotekoshi river near Timure and consisted of 35 individuals. The smallest group of 13 individuals was recorded at the Lama Hotel at an elevation of 2420 m asl (Fig. 2).
THREATS TO MACAQUES

1. Human-Assamese macaque interaction (Crop-raiding and its consequences)

Presence and absence of macaque damage (Crop vulnerability)

Macaque damage scores from the 120 farms surveyed were recorded as present or absent to see if there was significant difference between farms with distance from forest (Near <100m, Average 101m-500m and Far >501m) using Chi Square test. Presence or absence of macaque damage is significantly related to the distance of the farm from the forest ($\chi^2 = 30.9$, df = 2, $P << 0.05$). Damage is present in more farms near to the forest than for those at average distances or far from the forest (Table 1).

Table 1 Cross tabulation for presence of macaque damage against distance of farm to forest

<table>
<thead>
<tr>
<th>Macaque Damage</th>
<th>Distance to Forest</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Near &lt;100m</td>
<td>Average 101-500m</td>
</tr>
<tr>
<td>Absent</td>
<td>Observed</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Expected</td>
<td>24</td>
</tr>
<tr>
<td>Present</td>
<td>Observed</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td>Expected</td>
<td>40</td>
</tr>
<tr>
<td>Total</td>
<td>Observed</td>
<td>64</td>
</tr>
</tbody>
</table>

Local women with raided maize cobs

Researcher (left) with raided maize cobs
Economic loss
In this study, the kind of loss, direct or indirect brought about by Assamese macaque raids were estimated. It was found that they damaged most agricultural crops to a considerable extent. It was found that Assamese Macaques spoiled more crops than they actually eat; juveniles and infants in particular brought about damage during play on the ground. The estimate of damage was assessed on the basis of the information gathered from the owners (households) of 75 farms where there were the presence of macaque damage out of 120 farms. The calculated crop damage from those 75 households was about Rs. 150,000 per annum with the average of Rs. 2,000 per household. The costs of crop protection ranged between Rs.500-1500 per household per year, which comes to Rs. 37,500- 112,500 for 75 households. Besides this direct loss, they also caused indirect loss by feeding upon the flowering and fruiting trees, which reduces fruit production considerably.

Crop Preference
All major crops maize, potato, wheat, buck wheat, millet was found to be raided by Assamese macaques in the area. Among these, maize cobs were found to be highly preferred (62%) followed by potato tubers (23%), millet (7%) and buck wheat (6%) (Fig 3).
Combination of crop field, village and macaque habitat

**Crop protection strategies**

To protect crop fields and orchards from wildlife including the macaques, farmers use many methods. These methods include patrolling and guarding the fields by farmers including their children, Scarecrows, tin-box, stones and catapults, keeping dogs, fencing with thorny twigs etc. The most commonly used crop protection strategy in guarding their fields was constant vigilance during crop seasons. This method was used by 60% of the farmers in the study area. 20% of field owners use scarecrows. Few farmers (about 15%) use dogs for protection to chase the macaques away, while the remaining 5% of farmers use tin-boxes and catapults to chase the macaques from the crop fields (Fig. 4).

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**Fig. 3** Percentage crop damage by Assamese macaque

**Fig. 4** Different crop protection strategies used by farmers in LNP
Along with all the above methods, all farmers commonly use thorny twigs and branches of different trees and shrubs at the periphery of their farm. Despite all these measures of crop protection macaques do manage to invade the crops.

II. Loss of Habitat

As the human population and tourism increases, so does the need for materials and space; areas required for habitation and land use are expanding at alarming rates. Consequently, people are rapidly encroaching and destroying primate habitat for their own needs. Non-human primates are just one of the many creatures that are threatened by human sprawl and resource exploitation. The following are typical ways that humans are causing loss of crucial habitat for monkeys in the study area:

Agriculture and Livestock

Agriculture practices and livestock grazing had a significant impact on primate habitat in the area. The demand of agricultural products such as crops and livestock for the increasing populations, clearing forests for animal husbandry and shifting cultivation has been occurring in the area. This has been speeding up erosion processes and degrading away forests that provide the only known homes for many species of wildlife including primates. Much of this was at the expense of the primary habitat for indigenous primates and poses a serious threat to the species.
Logging and Firewood collection

Wood products, specifically hardwoods and other woods of the area are in great demand for constructing houses, small huts, tourist hotels and other purposes. Because the primates were found in forested areas, the impact from logging on these species is particularly high. Illegal logging still occurs in the area though designated as protected National Park. Illegal clearing of timber in the protected area will be devastating to surviving primate populations. Firewood collections increasing day by day from the nearby forest area to fulfill the demand for fuel to cope in such harsh area have been damaging macaque habitat.
The creation of roads in previously undisturbed areas has caused direct loss of habitat, erosion, pollution, and the threat of easy access by poachers, farmers, and illegal harvesters of plants and animals, as well as the increased chance of disease transmission, introduced predators, and fire. All this enhanced activity heightens threats to primates and other animals. The Pashang Lamhu Sherpa Highway with numerous bends in such hilly area has crossed and fragmented the potential habitat of the primates including that of the Assamese macaque. In the adjoining sides of this highway, landslides have worsened the remaining habitat and deserted the forests and productive crop-fields every year. The squeezing of the primate natural habitat by such activities has forced them to invade the orchards and farms in the area and made them more vulnerable.

DISCUSSION

Hanya et al. (2003) stated that a “group” should be modified to reflect the normal group spread of the species and defined a group only by distance, and did not distinguish situations when macaques belonging to different social units (troop) stayed within 500m each other. We also followed Hanya et al. (2003) for defining the group to estimate the group density though this shortcoming may have caused an underestimation. Intensive study may be required to avoid this underestimation. The group density of Japanese macaques estimated as 1.43 and 0.737 groups/km² in the disturbed area and undisturbed area by the method of combining point census and group follows within a census area of 7 km² in the western area of Yakushima, an island in southern Japan (Hanya et al., 2003) whereas in the present study the group density of Assamese macaque was found to be 0.0790 groups/km² by applying a method of total population count within a census area of 113 km² Hanya et al. (2003), in the same study, population density was calculated to be 22.9 and 11.8 macaques/km² in the disturbed and undisturbed areas respectively with the mean group size of 16 whereas in the present study, the population density of Assamese macaques was found to be 1.8691 macaques/km² with the mean group size of 23.66. The altitude of census area was 700-1300 m asl in the study of Hanya et al. (2003) and 900-2500 in the study of Chalise (1997) whereas the altitude of census area was 1200-3300 m asl in the present study. Mehlman (1989) reported that a semi-isolated study population of 162 Barbary macaques (six groups) inhabiting the Ghomaran fir forests of the Moroccan Rif mountains had a density of 6.73 individuals/km². The adult sex ratio was 0.725, and immature comprise 46 - 9% of the population. Group size ranged from 12 to 59 individuals, with a median value of 24.
Southwick et al. (1964) reported two troops of Assamese macaques in Darjeeling and estimated group size of 10-25 and the adult sex ratio 1:1.7. Foden (1982) recorded 11 Assamese macaques’ troops and observed troop size varies from 10 to 50 individuals in Kanchanaburi, Thailand whereas we recorded 9 Assamese macaques’ troops and observed troop size varies from 13 to 35 individuals in Langtang National Park. Aggimarangsee (1992) observed two semi-tame colony of this species with 29 and 27 individuals and the adult sex ratios of those colonies were about 1:1.7. The adult sex ratio of Assamese macaque troops observed in this study i.e. 1:1.92 is apparently similar to that of the above stated in the study of Southwick et al. (1964) and Aggimarangsee (1992) i.e. 1:1.7 and in the study of Chalise (2000b) i.e. 1:1.9. Macaques live in multi-male, female-kin bonded groups and ratios of males to females range from 1:1.2 (Macaca radiata) to 1:9 (Macaca nemestrina) (Feeroz 1996) which is also justified with my present study in which the adult sex ratio was found as 1:1.92 with the reasonable recruitment rate of females though slightly more than half i.e. 0.61 (61 infants per 100 females). These findings support that the Macaca assamensis also live in multi-male and female-kin bonded groups like as other macaques.

Barbary macaques in the Djebela, Morocco were extremely wary of humans and generally fled once sighted (Waters et al., 2007). A total of nine groups and 89 different individuals were counted in that study and the overall average group size was 9.9 (range 3–19). Wangchuk (1995) calculated the population density of Golden langurs using line transect method covering the area of 58.5 km² was found to be 2.1 langurs/ km² and in the present study, the population density of Assamese macaque was found to be 1.8 individuals/ km². Environmental constraints and human interference might affect group composition and group size of the macaques (Machairas et al., 2003). In fact there are altitudinal demographic differences between the encountered populations in Langtang National Park. Small group size (13) observed in Lama Hotel (2420m asl) might be attributed to minimize the foraging costs and predation pressure. However, such an effect is probably confounded with relevant effects imposed by the patchiness of resource distribution that in turn may affect group size itself. Abundance, distribution and quality of food affect group size (Wrangham, 1980; Mehlman, 1989; Menard & Vallet 1997). According to Dunbar's Model (1988), group size in primates is optimized to maximizing net reproductive rate, in relation to the
availability - dispersion of food and predation risk. As predation risk is concerned, group size is less important in terms of detection than avoidance of predation (Dunbar, 1988). If early detection is the main anti-predatory strategy as in Macaca sylvanus, then group size can be kept small to comfort food availability (Van Shaik & Van Noordwijk, 1983) as in the Assamese macaque in this study which was found in the group size of 13 individuals at 2420m altitude where they have to face with sparsely distributed and low quality feeding resources and no alternatives as in lower altitudes for crop-raiding. It could be argued that the presence of Himalayan Semnopithecus entellus in the area might be another reason for squeezing the group size in the area because it can neither expand its upper limit of altitudinal distribution as by Himalayan Semnopithecus entellus (which is found up to 3800m in Langtang National Park: Pers. obs. in 2006 and Pers. comm. with Prof. Dr. Randall C. Kyes and Assoc. Prof. Dr. Mukesh K. Chalise in 2007) nor can adapt with lower inter and inter specific groups in terms of foraging competition.

The Assamese macaques were distributed between the altitudes of 1300m-2420m asl in LNP in contrast with the Arunachal macaque which is unique in its altitudinal distribution, occurring largely at altitudes between 2000-3500m asl (Kawamoto et al., 2006) whereas Fa (1984) recorded the distribution of the Barbary macaques within the altitudinal range of 600m-2300m in Morocco and Algeria with the population density of 2-36 individuals/ km². The Assamese macaque group recorded at the altitude of 2420m during our study period in LNP is the highest upper altitudinal limit of the species ever recorded in Nepal till now. Chalise (2007) reported that the primate species Assamese macaques and langurs are dwellers of riverside forest area as it provides succulent herbs and other food items including insect larvae which are consistent to the present study since most of the groups of macaques encountered near the trail route along the water resources Trishuli, Langtang Khola and Bhotekoshi river. Possibly, they prefer the open area with fewer disturbances for either precluding or minimizing predator pressure during their activity period though it has to be confirmed in a future study. Animals will choose to live in those places where they will have the maximum chance of survival or reproductive success (Partridge, 1978). Distribution of species in different habitats may not follow directly from habitat preference or choice; inter- and intraspecific competition can exclude animals from preferred habitats and force them into less suitable areas (Partridge, 1978). Barbary macaques
remain in zones which humans have been unable to use or reach (Fa, 1984) in contrast with the Assamese macaque in Langtang National Park but are not provisioned by locals and tourists.

We found that presence of macaque damage was associated with the distance to farm from the forest which is similar to the study of Priston (2005) who had studied crop-raiding by *Macaca ochreata brunnescens* in Sulawesi, Indonesia. When farmers have opportunities to claim financial compensation for crop damage, there is the potential for primates to be ‘blamed’ for damage that may be over and above the damage these species actually inflict (Naughton Treves, 1997; Siex & Struhsaker, 1999; Chalise, 2000b). Therefore, in this study, we had given no signs for compensation to the farmers from the concerned authorities before taking the response about crop loss from them; their estimation about crop damage may be somewhat reliable. In this study, the loss was directly converted into Nepalese Rupees which was equivalent to about Rs. 2000 per household in the study area. The costs of crop protection ranged between Rs.500-1500 per household per year, which comes to Rs. 37,500-112,500 for 75 households. Besides this direct loss, they also caused indirect loss by feeding upon the flowering and fruiting trees, which reduces the fruit production considerably. Chalise (2000b) collected information on crop raiding by interviews with the villagers in Lakuwa village of MBCA and reported that Rhesus and Assamese macaques were the most frequent crop raiders and langurs visited the fields least. He found that Assamese macaques were worse than Rhesus macaques. He estimated 39696.65 kg of the agricultural product in Lakuwa village with 80 households, was lost by the wild animals with 496.21 kg for each household; that is, 67.38% of cereals and 32.62% of tubers and fruits and among the crop losses due to the wild animals, monkey species took part in 55% damage. He stated that they raid the maize fields most heavily - 29%, then potatoes- 23% (tubers also), rice- 13%, fruits- 12% and kodo- 12%. The tubers and fruits come to 35% of the total loss and all the cereals combined made 65% loss in Lakuwa village. The most heavily damaged crops were maize, potato, wheat, buck wheat and millet, in common with other studies. Farmers were accurate in their reports of preferred crops by macaques. It was found that they persisted in growing maize, despite its vulnerability to crop damage. Hill (1997) reported that maize was a staple and preferred crop and was less vulnerable to other forms of damage. Chalise (2000b) reported that cereals, fruits and tubers are the most preferred and vulnerable for raiding by
macaques in MBCA which is similar to this study. Khatry (2006) also supports that maize is the prominently vulnerable crops for raiding by primates.

Human activity on the farm, including regular patrols, caused macaques to spend more time loitering on the boundaries of farms and reduced party sizes. Of the deterrents used a combination of ‘physical and noise’ methods proved most likely to prevent further raiding, when carried out by men (Priston, 2005). Studies of elephant have shown that if the risks to elephants of raiding can be increased from the moment that they come near the farm, they are less likely to raid. Thus as soon as elephants are sighted, people shout, whistle, and chase them to deter them (Cited in Priston, 2005). The same kind of activities was successful against macaques in LNP. This study showed that 60 % of the farmers were found to guard the fields by themselves, 20 % were using scarecrows, and 15 % were using dogs and remaining 5 % used tin-boxes and catapults for scaring and driving the macaques from the crop fields. Often farmers would wait until macaques were actually in their farm before they did anything to try to deter them. If, on first sighting the macaques, farmers make noise, threw stones and chased them away from the surrounding area it may prove successful in deterring them. Chhangani & Mohnot (2004), in a study in and around Aravallis of India, calculated the percentage of crop protection methods by farmers as 60% guarding fields, 20% throwing stones, 15% using dogs and 5% others including dangerous methods like single shot gun, potash bomb and high voltage electric current with which animals are usually killed or seriously injured. Bagale (2003) found guarding overnight as an effective crop protection technique in Lumbini area in order to protect their crops from Nilgai *Boselaphus tragocamelus*, a nocturnal crop raider. In this study, we found guarding fields as most employed crop protection technique in Langtang from Assamese macaque, a diurnal crop raider. Though the Guarding/Chasing is the most effective method of deterrence in which mainly the women and children engage, it is time expensive and keeps people away from other activities (Southwick & Siddiqi, 1977; Bell, 1984; Southwick & Lindburgh, 1986; King & Lee, 1987; Pirta *et al.*, 1997; Sekhar, 1998; Knight, 1999; Hill, 2000) especially consumes the time of educational activities of children in such remote areas which further move the poor people backwards through long lasting impacts. So the loss is invaluable in comparison with time rather than economy. Farmers in LNP reported that loss of crops, loss of food, loss of money and loss of time (via time spent guarding fields) were problems associated with crop-raiding by macaques.
Loss of time was the most frequently cited problem, followed by crop loss. Crop loss, of course, actually encompasses two of the other problems, money and food (Priston, 2005).

**CONSERVATION MEASURES**

**I. Involving local people in conservation**

Langtang National Park is the second largest Himalayan National Park in the country, located in the Central Northern part which is famous for its rich floral and faunal diversity, both in terms of species richness and endemism. The forests of the Park are important catchments for many rivers (Langtang river, Bhotekoshi river, Trishuli river, Melamchi river and Indrawati river) and streams. People living inside the Park put pressure on the resources of the Park. A long-term effort in involving local people in conservation should be carried out in the area. Attempts should be made by educating, motivating and involving people under the eco-development strategy with aims to bring a reduction in the dependency of local people on the resources of the Park and thus lead to habitat improvement, watershed development and overall conservation. Locals residing in and around Parks feel neglected and lack awareness about the efforts being made and the need and urgency of such efforts towards conservation and wildlife protection. This is one important reason that makes conflict resolution between the Park authorities and the local people very difficult. The Park authorities have failed to seriously attempt the involvement of local people in conservation planning and management taking their concerns into mind and trying to solve the issues through better management options derived through consultations and consensus building. The ongoing debate about the justification, planning and management of Parks between wildlife conservationists and human rights advocates overlooks the fact that both wildlife and local communities are today equally threatened. Reconciliation between the two is possible if local communities and government agencies evolve a partnership in conserving the habitats with critical support from NGOs and independent researchers. Though we were unable to engage in such activities through this small survey project, at least we encouraged and suggested the park authorities involve the locals in conservation of the park resources.

**II. Community Outreach and Conservation Education Programme**

Educating and motivating the locals along with encouraging them in alternate income generation activities to forest dependents in the community and improving their skills and knowledge for the
new way of living; developing suitable biomass in and around the target villages (fire-wood, fodder, small timber and fruit trees) and encouraging reduction in the use of firewood, increasing the efficiency of energy use, motivating people to use alternate energy materials and methods may help in off taking the pressures on the forest resources. To create awareness about the value of the Park and the need to conserve, we conducted such small activities in the area. We visited the local schools inside the Park area and took the conservation education class focusing students on future conservation activities for safeguarding their own natural resources for their green future. Our knowledge also shared with teachers and community members through discussion meetings. All the involved members were supplied with small leaflets that described the importance of primates and other wildlife of the park.

Discussion with local people  Conservation education for students

III. Sharing of Park Revenue

Revenue-sharing as the most important advantage of people living in and around a National Park helps reducing human-wildlife conflict and minimizing impediment local support for the Parks. By channeling tourism revenue to local residents, conservationists hope to offset wildlife costs and improve local attitudes toward conservation. To date tourism revenue-sharing (TRS) programmes in different parts of the world have met with mixed success. Conservation is only possible when the local people realize the ownership over the park resources though indirectly. The park-people conflict mostly arises around the world on the issues of park revenue sharing that came from tourism and other natural resources of the park and Langtang National Park can’t remain untouched from it. Thus sharing of Park revenue among the local communities in the
form of eco-development programmes reduces resource dependency on forests of the Park, and thus leads to habitat improvement and conservation. Realizing these facts during our study period and literature from experiences in African countries, we suggested four key components of successful revenue-sharing programmes: long-term institutional support, appropriate identification of the target community and project type, transparency and accountability, and adequate funding. With firm institutional support and realistic expectations, TRS can play an important role in improving local attitudes towards conservation.

**CONCLUSIONS**

This study indicates that Langtang National Park is the prime habitat of Assamese macaque but the eco-war with local farmers in the form of unacceptable crop-raiding has been made this animal more vulnerable. A total of 213 Assamese macaques are recorded which living in 9 groups in the LNP. The group density is found to be 0.0790 groups / km² with a population density of 1.8691 individuals/ km² and the mean group size of 23.66 individuals. The age and sex of the species comprised 31% adult female, 16% adult male, 18% sub-adults, 16% juvenile and 19% are infant in the entire study area. The adult sex ratio and the birth rate are 1:1.92. and 0.61 respectively. The calculated crop damage from 75 households estimated about Rs. 150,000 per annum with the average of Rs. 2,000 per household. Damage is present in more farms near to the forest than for those average distances or far from the forest. Thus macaque damage is more likely to occur in farms closer to the forest. The major crops found to be raided by Assamese macaque in the area are maize, potato, wheat, buck wheat and millet. Among those maize cobs are highly preferred (62%) followed by potato tubers (23%), millet (7%), buck wheat (6%) and others 2% by macaques. They spoiled more crops than they actually eat; juveniles and infants in particular brought about damage during play on the ground. The costs of crop protection per household ranged between Rs.500-1500 per household per year, which comes to Rs. 37,500-112,500 for 75 households. The most effective crop protection strategies adopted by the farmers is guarding their fields by constant vigilance during crop seasons. The crop loss has the potential to be a significant problem for subsistence farmers. Human-wildlife interaction is fast becoming recognized as one of the major problem facing conservation today. Interactions tend to result in human ‘victory’ over animal ‘combatants’ which are either excluded from traditional areas of use or eliminated altogether. This eco-war is subsumed under the concept of ‘conflict’ which only human can ultimately win (Lee, 2004). For species and habitats to be conserved effectively,
this conflict must be addressed (Priston, 2005). Although the areas where the species is found are protected, further work will be crucial to safeguarding the species (Waters et al., 2007) in Langtang National Park. The crop raiding by Assamese macaque is the major cause of conflict between Assamese macaque and human. For species and habitats to be conserved effectively, this conflict must be addressed. Developing a management plan needs to be done in the context of direct interaction and engagement with farmers and not in academic isolation (Priston, 2005). Locals should be encouraged for the replacement of other suitable crops that likely not preferred (repellent crops) by primates. Future study should be focused on the identification of these repellent crops for monkeys but should be palatable for human-beings and cattle. The locals should be encouraged for the proper guarding of crop fields without persecuting the macaques. Further study should be focused on inter-specific resource competition and spatial analysis between Himalayan Semnopithecus entellus and Assamese macaques as they occupy the same habitat. Future study should also be focused on the effect of both within and between the group competition since they shape the group size and their fission and fusion with respect to seasonal availability of feeding resources and social behavior as in most of the macaques. Locals should be made aware about the role of primates in the ecosystem and the possibility of primate tourism as in the most of the African countries which could be an alternative source of income for subsistence farmers.

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