Biological Forum – An International Journal **7**(2): 930-943(2015)

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Determining the Interrelationship between Macaque Population and Land Cover/ Use Type in Delhi, Using Line Transect Method

Pritha Acharya*, Ambrina Sardar** and Santanu Ray***

**Amity Institute of Environmental Sciences, Amity University Uttar Pradesh, Noida, (UP), India*
***Amity Institute of Environmental Sciences, Amity University Uttar Pradesh, Noida, (UP), India*
****Professor Ecological Modeling Lab, Department of Zoology,*
Visva-Bharati University, Shantiniketan, (WB), India

(Corresponding author: Ambrina Sardar)
(Received 09 October, 2015, Accepted 01 December, 2015)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Movement ecology has now become a significant topic for discussion. With the changing environment and climatic conditions, there are several factors that work for the movement of all type and size of organisms. These changes in animals are sometimes observed positive and sometimes it is negative in terms of their behavior and intra-specific interaction. The following study investigates the impact of changing land use pattern in relation between green cover and migratory ecology of monkeys, to understand the factors that affect their ecological movement and behavioral aspects. The research work also comprise of the analytical study of the approaches that were used for the sampling and study of monkeys. The project has a progressive look and is based on both comparative and a collection of secondary as well as primary data. It identifies the concepts that could be applied to the migration of the monkeys into the urbanized areas. The study also establishes the facts that determine parameters that might play a leading role in their movement, based on conduction of surveys of certain sites. The deduction of conclusion is based on identifying the reasons causing movement, discovering any change in the behavior which is causative of the movement and finally linking them to develop a conceptual framework that explains the entire process of movement.

Keywords: Movement Ecology, primates, man-monkey conflicts, behavioral ecology, urbanization, line transect method

INTRODUCTION

Land cover is a term used for the physical materials present on the surface of the Earth, it states how much region is covered with vegetation, wildlife, agriculture etc. whereas, land use defines the purpose the land serves, or how people are using that land. The land may be a wildlife habitat, recreation ground, urban gardens, agricultural farms etc. Ecological movement or movement ecology is that branch of ecology that deals with the concept of movement of individuals as well as a collection of individuals. According to Ran Nathan (2008), movement ecology is a scientific paradigm, which places movement as the focal theme. It aims at developing theories regarding the movement of organisms, thus helps in understanding the cause, and consequences of all the phenomena related to movement. Ethology or behavioral ecology is a part of ecology that deals with the behavioral responses of animals.

A. Indian primates

Monkeys belong to the infraorder Anthropoidea, and are divided into two types: the old world monkeys and the new world monkeys. The old world monkeys are restricted to Asia and Africa and mainly consist of rhesus monkeys, langurs, gibbons etc. whereas the new world monkeys are restricted to central and south America and include the species namely capuchin, spider monkeys, marmosets etc.

Photo by: Dr. Pradeep Kumar

India is known to be the home for 13 species of primates. Out of 13 species, three species viz. *Rhesus macaques* (*Macaca mulatta*), Bonnet macaques (*Macaca radiata*) and Hanuman Langurs (*Trachypitheus entellus*) are known to be most problematic to humans and have maximum instances of man-monkey conflict. The rhesus macaques are the main trouble makers. Rhesus macaques (*Macaca Mulatta*) are highly intelligent and seek for even the smallest of opportunities to exploit any situation. Rhesus monkey, (*Macaca mulatta*) are found on such a broad geographical area that it is difficult to concisely summarize the type of habitat of rhesus macaques populate (Kumar and Chopra, 2012). They become highly aggressive and may even attack humans when feel threatened. The Bonnet macaque (*Macaca radiata*) is less aggressive compared to Rhesus monkeys but cause damage to crops, vegetation and trees. These are not very well adapted to city life. The Hanuman Langurs (*Trachypitheus entellus*) are largest amongst the three, and are primarily tree dwellers and mainly cause damage to crops. Because of their large size and hairy appearance, they are feared by the Macaques and are even used to scare off the Rhesus Macaques. In Delhi NCR, the Hanuman Langurs are employed by the offices and the RWA as a measure for controlling the trouble faced by the people through the monkeys. In order to understand, why monkeys are migrating more and more toward the urbanized areas, and to resolve the conflict between monkeys and humans, we first need to understand, the demands of the species. Rhesus macaques live in troops, each troop consists of 20-200 members. According to John (2013), "The troop is at the very heart of monkey society." Each troop is led by an alpha male, and an alpha female. The females outnumber the males with a ratio of 4:1 and separate hierarchies exist in case of both males and females. Of the major diurnal activities viz., rest, move, sit, social groom, self groom, play and feed (Ahsan & Khan 2006).

Conflicts and issues related with monkeys. When a species constructs its niche in urban areas, its aggressive behavior is likely to increase due to competition for food and space and high density (Camperio-Ciani, 1986 and Dutta, 2012). However, all primates do not have the same capacity to become urbanized (Sharma, 2006).

Human–wildlife conflicts have increased since the last few decades. Perhaps to develop strategies for conflict management, the pre requisite is to understand the drivers. Due to increases in human populations and rapid urbanization, the existing forested areas are still facing continuous threats of degradation (Hasan *et al* 2013).

The effects of habitat and gender are not significant, but residency significantly affected the intensity of human-monkey conflict (Chauhan and Pirta 2010). Recently, human-wildlife conflict has increased alarmingly and in the absence of an appropriate management plan this problem is only going get worse in future. Today, crop raiding monkeys are the biggest and most urgent issue troubling farmers in Himachal Pradesh (Singh & Thakur (2012).

Since people are a part of all the conflicts, social methods are essential for finding the solutions.

Meta-analysis is one way to determine the commonality in pattern of variables (driving people's attitudes, sharing areas with damage causing carnivores, elephants, primates and ungulates) present across a wide range of contexts. Categories and sub categories and indexes were developed (from the publications) to describe relative frequency relative significance of categories and degree of accuracy between use and significance. Tangible costs and tangible benefits thought to be the main drivers of attitudes were respectively, two and three times more non-significant than significant. Moreover research has focused on the concept of Reconciliation, i.e., a friendly reunion between former opponents, as a mechanism of nonhuman primates for conflict resolution. According to the Valuable Relationship Hypothesis, reconciliation restores the disturbed relationship between former opponents and, consequently, occurs more often between individuals with more valuable relationships. The Uncertainty-Reduction Hypothesis emphasizes the function of reconciliation to reduce anxiety and uncertainty in the recipient of aggression following a conflict. The study of post-conflict emotionality facilitates the integration of these two hypotheses (Aureli, 1997).

According to Kanskey & Knight (2014), socio demographic variables such as gender, education and wealth are also used to determine attitudes in primates. Poor understanding of the ecological and social underpinnings of this human–wildlife conflict hampers effective conflict management programs (Bagchi and Mishra 2006). Thus to guide future attitudes and development of species plans and policies transparency in concept is required. In a case study on the migration and avoid breeding by male monkeys, Melnick *et.al.* (1984) have collected the demographic record of seven groups including 292 individuals, for a period of 42 months. These groups were not found to inbreed as it was observed that they were genetically very similar when the blood sample analysis was done.

Melnick *et.al.* (1984), ascertain that "high gene flow between groups and avoidance of consanguineous mating throughout the population is consonant with behavioral observations of male-limited natal group emigration, relatively short non-natal group male tenure, and seemingly random distribution of male migration."

Felsenstein, 1985 reported that the species which are closely related genetically are likely to response in a similar manner to human threats. Brum *et al.* (2014), another research states that the species which are phylogenetically closer are more susceptible to the extinction due to their similar response to anthropogenic threats. In contrary to this unrelated species react differently to the anthropogenic threats. High human population densities in Asia lead to a direct conservation conflict between human populations and wild species, which result in increased hunting pressure (IUCN, 2013). Chapman and Peres (2001), Harcourt and Parks (2003) and Mittermeier *et al.* (2012), reported that the primates are mainly threatened by habitat destruction, hunting (for food and other purposes) and live capture for export or local trade. Felsenstein, (1985), (2014) used Bootstrap techniques for the phyllogenetic studies. The phylogenetic hypothesis by Perelman *et al.* (2011) was taken as the base for the analyses of 416 primate species, from 72 genera, and the branch lengths in MYA. The result of the study shows that all the lineages occurring in America and Madagascar are exclusive to their regions, while Africa and Asia shared three families (Hominidae, Lorisidae and Cercopithecidae). Considering that regions vary greatly regarding their bio-geographic history and the intensity of land transformation, and have distinct primate assemblages. According to Lehman & Fleagle (2006) and Ellis *et al.*, (2010), primate lineages responded differently to human land uses and their responses differ with the variations between regions. America showed strong association between land use and phylogenetic primate composition compared to other regions. Africa showed least infact no association between primate clades and land use; the reasons being because human pressure occurs at finer phylogenetic scales, or even operates at species level. Madagascar showed negative relation with Primate Lineages and wild land cover. According to Lehman and Fleagle (2006), the slash and burning practice in Madagascar has fragmented the forest and is responsible for negative responses in primates. Harcourt and Parks, (2003), reported that the species that are present in Madagascar is the extant species that has now become resistance to the fragmented forest and their movement is restricted to a very small range. According to Brum *et al.* (2014), Lehman & Fleagle, (2006) and Zhang & Quan, (1981), a strong association was observed between the village cover with phylogenetic structure in Asian primates. Asian landscape has a long history of agricultural activities, leading several primate species to extinction. Harcourt & Parks (2003) and Ellis & Ramankutty (2008) reported that tropical Asia presents higher human population density and, consequently, higher cover of villages than any other tropical continent. Chapman & Peres (2001) and Mittermeier *et al.* (2012) have reported that the increase interface with the human densities exposes the primates not only to habitat degradation, but also to hunting pressure for meat and medicine. Zhang & Quan, (1981) and Srivastava (2006) reported that in China and India respectively, that Macaca species are forced to live at elevation over 3000 m to escape from deforestation and species living near to farms are reputed to raid crops and end up hunted.

There are many studies conducted that report the behavioral adaptation in monkeys with the change in temporal and spatial environmental conditions. An interesting example of behavioral adaptation in macaques was observed in the case of the Japanese Snow Monkeys (*Macaca fuscata*) of the Jigokudani valley. These snow macaques are known to take hot water bath in hot springs. It is believed and as researchers and animal experts say, these macaques have learned such behavior from the local Japanese people. Almost every household in Japan, have backyard pools with hot water and people are known to take hot water bath. Experts say years ago a single female, out of curiosity jumped in one such water pool and was followed by the other members of her troop. This was perhaps the reason behind this particular behavior. An internet article relates high population density with increased aggression, which contradicts the fact that primates have behavioral mechanisms to regulate and control the social tension and negative aspects of crowding within the troop. In the experimental setup using 7 Rhesus macaques were observed over a wide range of population density, with the maximum population density was 200 times more than the minimum population density. It was seen that as the population density increased, males and females showed different types of responses. Male monkeys show increase rate of aggression and female monkeys explicit change in all type of behaviors namely to males they showed only grooming, huddling and appeasement displays while to kin females they become more aggressive, and to non-kin adult females they showed an increase many negative behavior.

Social behavior has undergone a revolution for years, as a result of attitude change among the evolutionary biologist and with the retrieval of the comparative methods, especially as applied to behavior and life histories (Alexander, 1974).

In recent years animal tracking is essentially became very important in understanding and identifying the local movements and migrations across oceans and landmass of an individual or a group of individual animal species. The question regarding the amount and ease of data collection, size and price needs to be addressed before the tracking method is selected. Tobler (2008), have used new technologies like Camera traps and GPS collars to study the ecology of low land Tapirs and other large rainforest mammals. Move bank, an online database of animal tracking data, provides a gist of data collection methods used for animals; which includes (i) Band or ring: code based physical method, light-weight, mostly used for birds. (ii) Global positioning system: GPS incorporated tags for large animals, which calculates location with respect to the time, using a satellite system. (iii) Very high frequency (VHF) radio transmitter: is an electric tag emitting high frequency radio signals. Ideal for populations restricted to small geographic area and (iv) Light level geo locators: Light sensitive in nature, detects sunrise and sunsets to identify the movement of the animals. The fact that primates act as significant crop best can be conferred from their crop raiding behavior which are known to cause ever increasing conflict between humans and primates. This behavior is a result of their opportunism, adaptableness, cleverness and calculating capacity. The work by Nijman & Nekaris (2010) in Sri Lanka based on "testing a model for predicting primate crop-raiding using crop- and farm-specific risk values" suggests that it is difficult for farmers to accurately predict the susceptibility to crop-raiding as its level depend on time of the year, size & type of crop, farm location and primarily on the primate species involved. The method of crop susceptibility is used to determine the frequency of crop damage for individual farms. It calculates the risk value (RV) by summing the rates of crop-raiding incidence for individual crops using pooled data from all farms used in the sample.

Various studies were also conducted on the behavior and social life of primates in India. Agoramoorthy (1987), Sugiyama & Parthasarathy (1968) worked on the social life of Hanuman Langurs (*Trachypitheus Entellus*. Sugiyama & Parthasarathy (1968) studied the known facts about the Japanese Macaque with the social behavior and compared it with the other species of monkeys found in other parts of the world. It mainly talks about the social life of Hanuman Langur of Dharwal area of Mysore state. The social ranking of the Langur troops are not strict nor do they have differentiation of social organization into central and peripheral parts. When two adjacent troops come face to face, both the alpha males fight, but such fights are mainly demonstrative and a mark of territorial-ship. New born Langur babies and adult females share a unique kind of relationship as observed by Jay (1962), where the mother langurs give away their new born babies to the female members of the own troop or a member of another troop who do not have their own babies and tries to snatch away the young ones. Such behavior contradicts that of the Japanese macaques where the mother rarely parts the infant from herself.

The major threats to the wildlife in India includes the loss of habitat and forest fragmentation, poaching and killing, human intrusion, monoculture cultivated area, timbering, illegal intrusion into forest areas, and human–wildlife conflicts as reported in many studies by Choudhury (1988), Choudhury (1991), Choudhury (2001), Choudhury (2013) and Molur *et al.* (2005). Habitat loss and fragmentation are the biggest threats to the wildlife of northeast India, including southern Assam as reported by Mazumdar (2014) and Srivastava (2006). It is reported in many studies conducted by Choudhury (1988), Choudhury (1995) and Choudhury (1996) that due to the break in the continuation of canopy the life span and behavior of primates gets affected. Such threats have affected the behavior and range of Hoolock Gibbons (Endangered 2008,The IUCN red list, Brockelman, Molur & Geissmann) as they stay on land and move between small forest patches and food trees in villages and sleep at very low altitudes according to Choudhury (1991), Kakati (1997, 1999 & 2004). Mazumder (2014) documented in a study that due to the deforestation these animals have constrained themselves to the small gardens, urban areas and secondary forests which have led to their increased population in such areas. Jhum cultivation or slash and burn cultivation is primarily practiced by the Khasi tribal communities for planting several trees, fruits, vegetables, which fetches good market value. Unfortunately, jhum cultivation is usually done in areas that fall within the habitat range of the *N. bengalensis*, *H. hoolock*, and *T. phayrei*, thus disturbing the territories of the most threatened species as documented by Choudhury (1995 & 2000). Slow lorises are often seriously harmed and even burned by fires resulting from this practice as these animals freeze rather than flee when facing danger mentioned by Mazumder (2014) in a study. Deforestation of dense forest cover is most detrimental to the slow lorises, hoolock gibbons, and Phayre's langurs as reported by Choudhury (1988, 1995 and 1996), Islam *et al.* (2013) and Srivastava (1999) because the habitats of these animals are easily fragmented as these are purely arboreal species. Thus concentrating the efforts on conserving the forest patches to at least retain connectivity for genetic flow is very essential for avoiding extinction (Wyman *et al.* 2011).

A series of documentary on the life of Rhesus Macaques of Jaipur, by the National Geographic Channel, depicts the social relationship of the monkeys, their opportunistic behavior, and their interdependent relationship with the humans and other animal species. Various cases of inter-specific interactions between Rhesus Macaques and Hanuman Langurs have been known. Parthasarathy (1972), Roonwa & Mohnot (1977), Pirta (1984) Manohar & Mathur (1990), have reported instances of interaction between the two species which describes in details the play behavior between infants and juveniles of Rhesus Macaques and Hanuman Langurs, but a specific instance of interaction between the two species was reported by Nerlekar (2012). As reported by him, the interaction ranges from play initiation to chase and touch. Another case study conducted by Pragatheesh (WII), in 2011 near the Pench National Park, MP, tried to establish the relation between human feeding and the various parameter of a population like group size, movement and road kills. The study clearly indicates the following: movement of the macaques species studied was restricted by the availability of food from passerby. The roadside habitats during summer and winter were relatively high compared to the interior of the forest. Human feeding behavior influenced road kills: Road kills showed a proportional trend with vehicular density, maximum during summers and minimum during monsoon. It also revealed that the maximum road kills were found in areas with high frequency of artificial feeding (feeding by passerby). Summers had the maximum number of visitors and thus maximum road kills were also observed during summers. It was made clear from the points that irregular feeding being a primary reason behind the aggressive behavior of the macaques. Besides high natality and low mortality, religious attachment of local people with rhesus is one of other reasons for their high population (Imam & Ahmad 2013).

Sharma *et al.* (2011) reported that there were two basic types of troop exist: the bisexual troops and the all male band. The bisexual troops are matrilineal groups of adult females and off springs and are further of two types depending upon the number of males in the troop: A) - uni-male bisexual troops and B) - multi-male troops: more than one adult male. In majority of the interactions it was found that langurs and visitors were standing within a distance of few meters. This indicates that the Hanuman langurs do not fear the proximity of the humans and intent to exploit all the opportunities and advantages they can, while being in proximity of humans.

MATERIALS AND METHOD

The objective behind the project was mainly to identify the factors that are causing the rhesus macaques (*Macaca mulatta*) to migrate into the urban area. The framework designed for project involves defining and answering the following points: 1) Identifying the species- its peculiarity, 2) defining the area for study- why that particular area was selected. 3) Identifying the parameters for the study and 4) determining and relating the factors with interactions or migration to the selected sites. Species selected: *Macaca mulatta* or Rhesus Macaques. With Delhi's increased monkey nuisance, the species responsible behind this menace was identifies and further was selected as the study species.

Selection of site: three sites were selected for the study, which were representative of:

1) Residential area: Chittaranjan Park, in South Delhi,

2) Sub urban area: area near Tuklakabad fort, (South Delhi Ridge) in south Delhi (Sinha, 2014).

3) Forested Area: Kamla Nehru Ridge, in North Delhi. (Sinha, 2014).

Parameters selected for the study are green cover, availability of food, dustbins and dumps, water resources, predators, interactions with humans and aggression

The method use in the study is Line transects method:

It is a distance sampling method; use to determine the abundance of animals present in an area. This method involves setting up of parallel lines which are equally spaced across the site selected for the study. The track has to be of a specified length, and has to be divided into equal distances at equal intervals, these are the sample points. The observer needs to walk straight through the track, at a constant speed and stop at these sample points for equal interval of time and take down the observations. This procedure is repeated twice or thrice daily for a specified period of time. The Fig. 1, explains the line transect method. Population density is then defined using certain calculations.

In the following study a tack length of 1km was taken and was divided into 5 equal sampling points, each at a distance of 200mts from the previous point. The sampling was conducted during the afternoon hours using a car. A constant speed of 5km/hr was maintained throughout the survey. Each sample point was given 6 minutes of halting time. Counting was accompanied by clicking pictures.

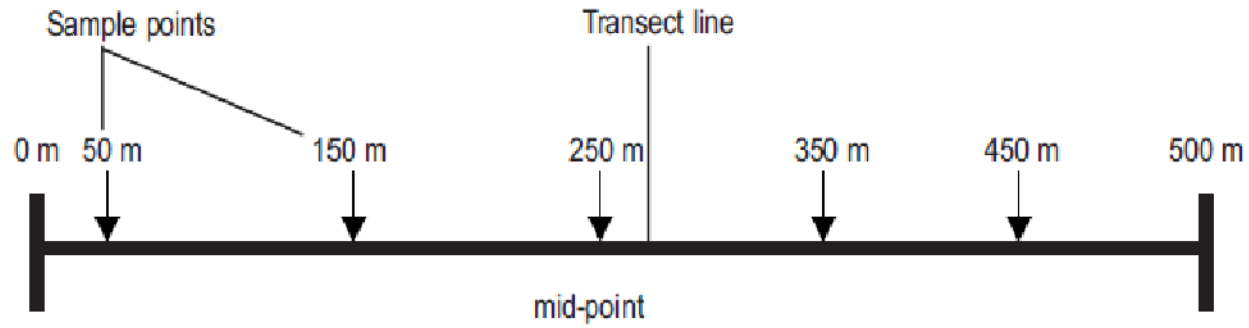


Fig. 1. Defining the track for the line transect method. (Source: Bird Survey Methods by Claire Carlton, National Parks Association)

The survey was conducted talking with the locals inhabiting of the site selected for the study. It was based on identifying and understanding the interaction type between the locals & the monkeys and linking them to the parameters chosen in order to develop a hypothesis that explains their movement in area and their interaction with the humans. The same methodology was applied to all the sampling sites.

OBSERVATIONS AND CALCULATIONS

A. Residential area (Chittaranjan Park):

Fig. 2. Showing the area under green cover in Chittaranjan Park (residential area).

Case 1:
Description of the interaction:
(i) **Spotted near:** Overhead water tank of a building (F Block)
(ii) **Date of spotting:** 4th June 2014
(iii) **Temperature:** 43° Lo 26°
(iv) **Spotting timings:** 6:50pm
(v) **Group description:**
(vi) **Group size:** individual
(vii) **Adults:** one and probably aged **Infants:** 0
(viii) **Physical ailment if any:** number of facial spots present

Table 1: The parameters & availability in CR Park Case 1.

Availability	**Parameters selected**	**Sl. No.**
Ornamental park present nearby	**Green cover:**	**1**
	Food available :	**2**
Present	Natural (flowers, leaves)	
Present at a distance of 250 mts approx	Dustbins and dump	
	Water sources:	**3.**
Absent	Natural (lakes & pond)	
Overhead water tank present	Man made (tanks & water baths)	
Absent	**Predators:**	**4**
	Human interaction:	**5**
1	No. of humans :	
Normal	Interaction type	
	Aggression:	**6**
No expression	Facial expression & chase	
Nil	Bites & scratches	

Case 2:
Description of the interaction:
(i) **Spotted near:** E-block Ornamental Park
(ii) **Date of spotting:** 6th June 2014
(iii) **Temperature:** 45° Lo 29°
(iv) **Spotting timings:** 8:04pm
(v) **Group description:**
(vi) **Group size:** individual
(vii) **Adults:** same individual as spotted in case1 **Infants:** 0
(viii) **Physical ailment if any:** number of facial spots present

Table 2: The parameters & availability in CR Park Case 2.

Availability	**Parameters selected**	**Sl. No.**
Ornamental park present	**Green cover:**	**1**
	Food available :	**2**
Present	Natural (flowers, leaves)	
Present at a distance of 170 mts approx	Dustbins and dump	
	Water sources:	**3.**
Absent	Natural (lakes & pond)	
Water sprinklers & a small water fountain	Man made (tanks & water baths)	
Absent	**Predators:**	**4**
	Human interaction:	**5**
8-10	No. of humans :	
Normal, calm, usual	Interaction type	
	Aggression:	**6**
No expression	Facial expression & chase	
Nil	Bites & scratches	

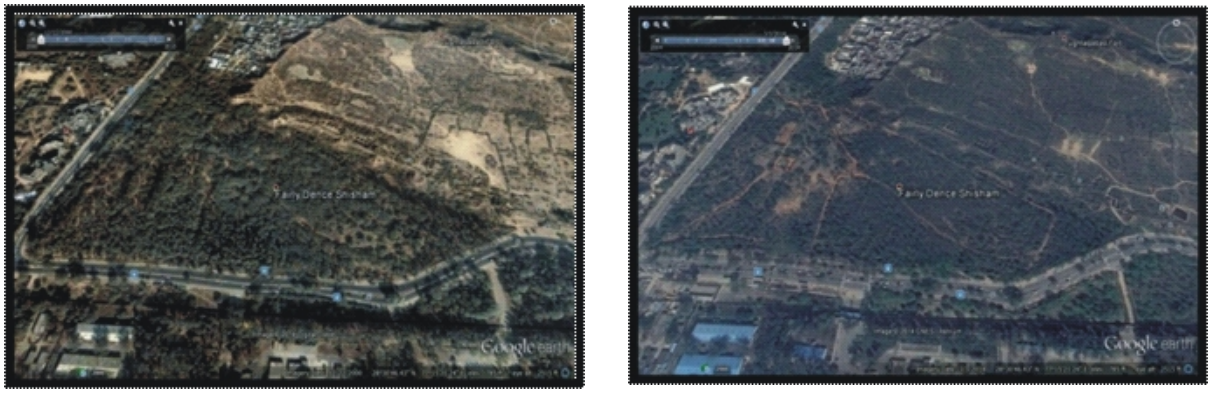
Case 3:
Description of the interaction:
(i) **Spotted near:** Residential lane
(ii) **Date of spotting:** 7th june 2014
(iii) **Temperature: 45°** L0 **31°**
(iv) **Spotting timings:** 8:45am
(v) **Group description:**
(vi) **Group size:** 6-7 individuals
(vii) **Adults:** 6-7 **Infants:** present but number not defined
(viii) **Physical ailment if any:** number of facial spots present

Table 3: The parameters & availability in CR Park Case 3.

Availability	**Parameters selected**	**Sl. No.**
3 trees, and few residential gardens	**Green cover:**	**1**
	Food available :	**2**
Present	Natural (flowers, leaves)	
Present at a distance of 120 mts approx	Dustbins and dump	
	Water sources:	**3.**
Absent	Natural (lakes & pond)	
Absent	Man made (tanks & water baths)	
Absent	**Predators:**	**4**
	Human interaction:	**5**
0	No. of humans :	
Not defined	Interaction type	
	Aggression:	**6**
Nil	Facial expression & chase	
Nil	Bites & scratches	

Case 4: An interesting observation was made during the survey in the residential area, a case of interaction was observed wherein an individual monkey, somehow managed to sneak inside a kitchen of a flat, and tried to eat a piece of frozen meat. Since the meat was completely frozen, the monkey left it, and rather chooses to eat the fruits available in the refrigerator. This behavior could either be attributed to the curious opportunistic nature of the rhesus macaques or can be considered as a demonstration of carnivorous feeding habits, which are not well known in the case of Rhesus Macaques. Such carnivorous feeding habits have been observed in other members of the primate family.

Sub Urban Area (Tuklakabad Fort Area):



2000 **2014**

Fig. 3. Showing the area under green cover in Tuklakabad fort area.

Table 4: The parameters & availability in Sub Urban Area.

Availability	**Parameters selected**	**Sl. No.**
Semi aired patch of land. Dense Sheesam growth present, huge fig trees.	**Green cover:**	**1**
	Food available :	**2**
Present	Natural (flowers, leaves)	
Small domestic dump present, developed by the nomads living there	Dustbins and dump	
	Water sources:	**3**
Present and 3 in number	Natural (lakes & pond)	
Present 3-4	Man made (tanks & water baths)	
Absent	**Predators:**	**4**
	Human interaction:	**5**
Not defined	No. of humans :	
Normal to aggressive	Interaction type	
	Aggression:	**6**
Some cases	Facial expression & chase	
1	Bites & scratches	

On having a talk with the nomads staying in that area, the following observations were recorded:

1.The Rhesus Macaque troop lives inside the forested area (South Delhi Ridge).

2. The monkeys are most active in the morning hours.

3. The fruits of the "Pakhriya Trees"- a species of white fig trees, attract these macaques.

4. The macaques have been snatching especially flour rich items from their tents.

5. A few cases of bites and scratches by these macaques were observed:

6. A girl named Priyanka, 8 year old, was a recent victim of monkey bite. She was bitten on her right arm. Despite the injury she suffered, she was not provided with proper medication by the local MCD hospitals.

7. They have not encountered any cases of road accidents of the macaques.

Line Transect Method:

Area: Tuklakabad Fort Area
Time: 5:15pm – 5.45 pm
Date: 22nd June 2014
Sky: Mild cloudy
Temperature: 36C
Track length: 1km
No. of observation points: 5

Table 5: Details of line transect method in Suburban area.

Sample points	**1st (0mts)**	**2nd (200mts)**	**3rd (400mts)**	**4th (600mts)**	**5th (800mts)**	**6th (1000mts)**
No of individuals	Nil	26	12	12	Nil	Nil
Human presence	Nil	2 (Fruit Vendor)	1(Fruit Vendor)	2(Fruit Vendor)	Nil	Nomad settlement
Interaction type	NA	Casual and normal	Casual and normal	Casual and normal	NA	NA

Calculations:

Sample size = 50 Mean group size(x) = 8.33
Standard deviation = 9.6 Confidence level= 95%
Confidence interval= +2.66 Estimated sample size= 49 Mean population range = 5.6 to 10.99.

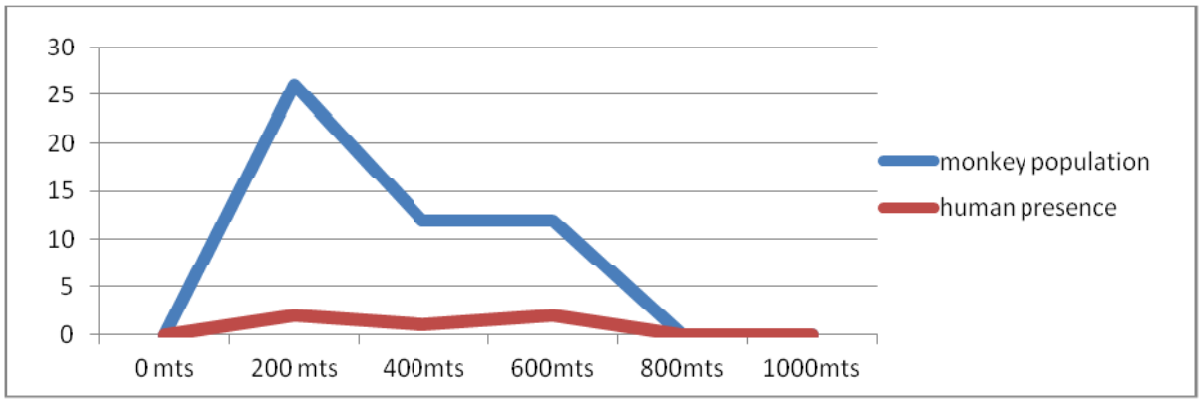


Fig. 4. Distance travelled vs individuals observed in the sub urban area.

Forested Area (Kamla Nehru Ridge):

Table 6: Depicting the parameters & availability in forested area.

Availability	**Parameters selected**	**Sl. No.**
Forested area.	**Green cover:**	**1**
	Food available :	**2**
Present	Natural (flowers, leaves)	
Nil	Dustbins and dump	
	Water sources:	**3.**
Present and 3 in number	Natural (lakes & pond)	
Water bowls available	Man made (tanks & water baths)	
Absent	**Predators:**	**4**
	Human interaction:	**5**
Not defined	No. of humans :	
Normal to aggressive	Interaction type	
	Aggression:	**6**
Many cases	Facial expression & chase	
No bites and scratches but cases of snatching are highly common.	Bites & scratches	

The following points were outlined while the survey was conducted:

1. The monkey problems are more during the morning hours.
2. The monkeys are spotted more towards the boundary of the ridge rather within the forest area.
3. Instances of snatching are quite high, cases of aggression is also very common.
4. A lot number of people come to ridge for morning walks and Ridge also serves as a spot of tourist attraction.
5. These monkeys are fed regularly by the visitors coming for their morning walk.

Table 7: Details of line transect method in Forested area (track 1).

Sample points	**1st (0mts)**	**2nd (200mts)**	**3rd (400mts)**	**4th (600mts)**	**5th (800mts)**	**6th (1000mts)**
No of individuals	Nil	Nil	Nil	3	6	Nil
Human presence	Nil	Present (2)	Nil	Nil	Present (4 pedestrians)	Residential area begins (0)
Interaction type	NA	NA	NA	Casual and normal	Casual and normal	NA

Line Transect Method:
Area: Kamla Nehru Ridge
Time: 1:05pm - 1:35pm
Date: 2nd June 2014 Sky: Cloudy
Temperature: 35C Track length: 1km
No. of observation points: 5

Table 8: Details of line transect method in Forested area (track 2).

Sample points	**1st (0mts)**	**2nd (200mts)**	**3rd (400mts)**	**4th (600mts)**	**5th (800mts)**	**6th (1000mts)**
No of individuals	5	10	Nil	3	Nil	Nil
Human presence	Present (fruit juice stall =8)	Present (bus stand = 4)	2(fruit vendors)	Nil	Present pedestrians (2)	Nil
Interaction type	Casual and normal	Casual and normal	NA	NA	NA	NA

Calculations:
Sample size = 27
Standard deviation = 9.8
Confidence interval= +3.7
Mean population range = -1.45to 5.95
Mean group size(x) =2.25
Confidence level= 95%
Estimated sample size= 27

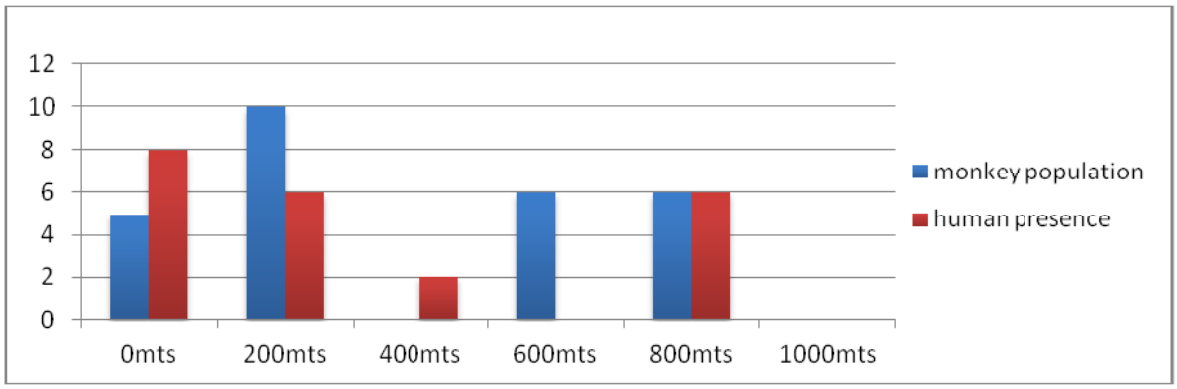


Fig. 5. Distance travelled vs individuals observed in forested area.
(Average of observations from track1 and track2)

DISCUSSION

A. Residential area (Chittaranjan Park)

Taking the four cases of interactions observed during the survey in Chittaranjan Park, the following observations can be made:

The single male monkey spotted in case 1 and case 2 were the same individual, as identified by similar facial marks or spots noticed by the Witness (in this case myself). This particular individual was an aged male and it is certain that it lives alone as witnessed by many locals a lot of time.

It is highly likely that the individual might have been abandoned from his group by a new alpha male. And thus he prefers to stay in areas or shades near the residential areas (near to his original home which is presumed to be Jahapanah city forest) where he has proper access to food and water due to the presence of well maintained ornamental parks and gardens. This could be related to his aggression level: it was observed that this particular male completely unaffected by the proximity human presence around him.

Another possibility is that, this male could be suffering from a disease, as suggestive of the black and brown spots on his face, and he has moved out of the troop. In the 3rd case mentioned in the last report, a group of 6-7 individuals with infants were spotted in a residential lane. This particular lane has a well maintained ornamental park and a ground present at both of its end. This is indicative of the fact that they were tracing their path back to their original home after having fed themselves completely. Interestingly the 4th case is of high importance. In this an individual macaque tries to eat pieces of frozen meat. This could either be attributed to the curious opportunistic behavior of the rhesus monkeys or might be a case of carnivorous behavior, which is not well known in case of rhesus macaques, although some members of the primate family (baboons & gorillas) are known to be carnivores. And if this actually turns out to be a case of carnivorous behavior then, it might suggest a change in the feeding habits of rhesus macaques. One such example of behavioral change is the Snow Macaques of Jigokudani valley in Japan.

In all these cases, it is clear that the individual prefers to stay in the areas adjoining the ornamental parks, so it can feed on readily available food (natural in most cases) from these parks. Another interesting fact is that, these monkeys do not attack the fruit vendors or the fruit stall, although, such places top the list for easy available food. Such behavior is challenging the intellect level of these monkeys, in a way they are acting smart by avoiding conflict with the fruit vendors but at the same time feeding on fresh food vegetation which is easily available to them.

B. Sub Urban Area (Tuklakabad Fort Area)

It was observed that these monkeys spend their entire day in the outskirts or the edge of the vegetative patch, and move inside the vegetative patch during the night hours. Inside the fort area, two-three water bodies (lakes) are present viz are the only water source inside the fort area. Although there are some manmade cemented ditches present along the edge of the vegetative patch. The water bodies inside the fort are declared contaminated by the Municipal Corporation of Delhi. Thus it is absolutely clear that the monkeys are travelling to the outskirts of the vegetative patch, because of the freshly available fruits and the food (flour) from the fruit vendors and the nomads living there. Another fact that supports this assumption is the vegetation type found in that area. The vegetation there, mainly composed of semi aired and aired, thus might lacks water content, which further is making the monkeys travel more towards the edge of the fort. Also sampling method conducted provided a very predictable result: the maximum density of macaques was found in sampling points, which also had either a fruit stall nearby.

C. Forested Area (Kamla Nehru Ridge)

Kamla Nehru Ridge attracts a number of tourists, especially is famous amongst the morning walkers. It happens to be the major cause for the monkey trouble in that area. People coming for morning walks, are often seen feeding the monkeys. Secondly, during the morning hours, a number of fruit vendors are also present. Such opportunities attract these macaques towards the boundary of the forested area, despite having abundant supplies of natural products within the forested area. It was observed that these macaques spent their entire day inside the forest, but are encountered toward the outskirts especially during the morning hours. Such irregular feeding habits are the main cause for the increased aggressive behavior of these macaques.

CONCLUSION

The effect of urbanization on Rhesus Macaques, have mainly two aspects to it. The negative aspect talks about the effects of the increased level of conflict between human and monkeys. There is an interdependent relationship between the urbanization and the loss of green cover. With more and more areas getting urbanized, there is a loss of habitat, food and water resources for the monkeys. Such loss corresponds to the increased migration of the monkeys into the urban areas. Understanding the basic ethology of monkeys, it becomes quite clear that such problems will keep on accelerating until and unless some measures are taken, that benefits both the species. Capturing the monkeys, sterilizing and relocation is helpful but is a one sided method of conflict management. According to John Hicks (2013), such procedure causes a terrible mental suffering for the monkeys, moreover relocating them to another monkey's territory, almost for certain lead to their death from attacks of the resident monkeys.

Another way to resolve conflict is by employing the strategy of interspecies interaction, wherein Hanuman Langurs are employed to scare off the Rhesus Macaques. Although it being a more natural concept, but it just is making the two species to move towards coexistence: A concept by India's leading primatologist, Iqbal Malik. Now the second approach, we get a glimpse of natural conflict management strategies employed by the Monkeys themselves. With the surveys discussed in this report, a slight inclination towards this concept can be observed. The Rhesus Macaques are migrating into the residential area, for food resources and yet at the same time, being the top opportunist, they avoid snatching the food resourced available to them, causing no disturbance to the fruit vendors. This basically contradicts with the general behavior observed in the case study of the Galta Ji Temple, although they are been fed regularly by the devotees, still they do not hesitate to launch attacks on the nearby fruit vendors, when opportunity prevails.

REFERENCE

Agoramoorthy, G., (1987). Reproductive behaviour in Hanuman Langur, *Presbytis entellus*. PhD Thesis. University of Jodhpur, Jodhpur.

Ahsan M.F. & Khan M. A. R., (2006). Eco-ethology of the common langur *Semnopithecus entellus* (Dufresne) in Bangladesh, *Univ. J. Zool. Rajshahi Univ*. Vol. **25,** (2006).

Alexander R.D., (1974). The evolution of social behavior. *Annual Review of Ecology and Systematics*, **5** (1974), pp. 325–383.

Aureli F., (1997). Post-conflict anxiety in nonhuman primates: the mediating role of emotion in conflict resolution, *Aggressive Behavior*, **23**, pp. 315–328.

Bagchi S and Mishra C. (2006). Living with large carnivores: predation on livestock by the snow leopard (*Uncia uncia*), *J. Zool.*, 268, pp. 217–224.

Bleisch B, Brockelman W, Timmins R.J, *et al.* (2008). *Trachypithecus phayrei*, *The IUCN Red List of Threatened Species*. Version 2014.1 (2008).

Brum, Fernanda T. *et al.*, (2014). Clade-specific impacts of human land use on primates. *Natureza & Conservação*, Volume **12**, Issue 2, July–December 2014, Pages 144-149.

Chapman C.A & Peres C.A., (2001). Primate Conservation in the new millennium: the role of scientists, *Evol. Anthropol. Issues News Rev.*, **10** (2001), pp. 16–33.

Chauhan A. and Pirta R. S, (2010). Public Opinion Regarding Human-Monkey Conflict in Shimla, Himachal Pradesh, *J Hum Ecol*, **30**(2): 105-109.

Choudhury A., (1986). Wildlife in North-East India, *North-Eastern Geographer*, **18** (1986), pp. 92–101.

Choudhury A., (1988). A primate survey in southern Assam, India. *Primate Conserv*, **9** (1988), pp. 123–125.

Choudhury A., (1988). Phayre's leaf monkey (*Trachypithecus phayrei*) in Cachar, *J. Bombay Nat Hist Soc*, **85**(1988), pp. 485–492.

Choudhury A., (1991). Ecology of the hoolock gibbon, a lesser ape in the tropical forest of NE India *J Trop Ecol*, **7** (1991), pp. 147–153.

Choudhury A., (1995). *Mammals of Southern districts of Assam Cheetal*, **34** (1995), pp. 10–17.

Choudhury A., (1995). *Conservation of non-human primates in Assam Bonbani* (1995), pp.6–9.

Choudhury A., (1996). Primates in Assam – status and conservation, *Tigerpaper*, **23** (1996), pp. 14–17.

Choudhury A., (1996), A survey of Hoolock Gibbons *(Hylobates hoolock)* in southern Assam, India, *Primate Rep*, **44** (1996), pp. 77–85.

Choudhury A., (1997). Checklist of Mammals of Assam, (second ed.) Gibbon Books and ASTEC, Guwahati, India (1997)

Choudhury A., (2000). Primates in North-eastern India, *My Green Earth*, **1** (2000), pp. 17–19.

Choudhury A., (2000). A survey of hoolock gibbon *(Hylobates hoolock)* in Dibru-Saikhowa National Park, Assam, India *Primate Rep*, **56** (2000), pp. 61–66.

Choudhury A., (2001). A Systematic Review of the Mammals of North-east India with Special Reference to Non-human Primates D.Sc. thesis Gauhati University (2001) 209 pp + 3 maps.

Choudhury A., (2001). Primates of NE India: an overview of their distribution and conservation status. *ENVIS Bull Wildl Protected Areas*, **1** (2001), pp. 92–101.

Choudhury A., (2013). The Mammals of North-East India (first ed.) Gibbon Books and the Rhino Foundation for nature in NE India, Guwahati, India (2013).

Dutta H., (2012). *Man versus monkey, current science*, Vol. **103**, NO. 7, 10 October 2012.

Ellis E.C., Goldewijk K. Klein, Siebert S., Lightman D., Ramankutty N., (2010). Anthropogenic transformation of the biomes, 1700 to 2000 *Glob. Ecol. Biogeogr.*, **19** (2010), pp. 1010–1035.

Ellis E.C. & Ramankutty N., (2008). Putting people in the map: anthropogenic biomes of the world. *Frontiers in Ecology and the Environment*, **6**(8): 439–44, - Eco Soc America.

Felsenstein J. (1985). Phylogenies and the comparative method. *Am. Nat.*, **125** (1985), pp. 1–15.

Felsenstein J. (2014). Phylogenies and the comparative method, *Am. Nat.*, **125** (1985), pp. 1–15.

Sinha G.N., (2014). An introduction to the delhi Ridge, Department of forest and wildlife, government of national capital territory of Delhi, New Delhi 2014.

Hasan M.K., M. Abdul Aziz, S. M. Rabiul Alam, Yoshi Kawamoto, Lisa Jones- Engel, Randall C. Kyes, Sharmin Akhtar, Sajeda Begum and M. Mostafa Feeroz (2013). Distribution of Rhesus Macaques (*Macaca mulatta*) in Bangladesh: Interpopulation Variation in Group Size and Composition, *Primate Conservation*, **26**(1): 125-132.

Harcourt A.H. & Parks S.A. (2003). Threatened primates experience high human densities: adding an index of threat to the IUCN Red List criteria.

Imam E. & Ahmad A., (2013). Population status of Rhesus monkey (*Macaca mulatta*) and their menace: A threat for future conservation. *International Journal of Environmental Sciences*, Vol. **3**, No 4, (2013).

IUCN 2013.

John H., (2013). Primate overpopulation solution and management. The primate trust of India. year: 2013.

Jay P.C (1962). aspects of maternal behaviour among langurs *Ann. N. Y. Acad. Sci.*,**102**,468-476.

Kumar A. and Chopra G., (2012). Study on Home Range of Rhesus Monkey, *Macaca Mulatta* (Zimmermann, 1758) in Saraswati Plantation Wildlife Sanctuary (SPWS) Kurukshetra, Haryana (India), *New York Science Journal*, 2012; **5**(1).

Lehman J. Fleagle, (2006). Biogeography and primates: a review S. Lehman, J. Fleagle (Eds.), Primate Biogeography, Springer, New York, USA (2006), pp. 1–58.

Mittermeier R.A. & Schwitzer C., Rylands A.B., (2012). Primates in Peril: The World's Top 25 Most Endangered Primates 2012–2014. Bristol, UK.

Melnick Don J., Pearl Mary C, & Richard A.F. (1984). Male Migration and Inbreeding Avoidance in Wild Rhesus Monkey, *American Journal of Primatology* **7**: 229-243 (1984).

Molur S, Walker S, Islam A, Miller P, Srinivasulu C, Nameer PO, Daniel BA, Ravikumar L, editors. (2005). Conservation of Western Hoolock Gibbon *(Hoolock Hoolock Hoolock)* in India and Bangladesh Population and Habitat Viability Assessment (PHVA) workshop report Zoo Outreach Organisation/CBSG-South Asia, Coimbatore, India (2005) 132pp.

Mazumdar M. K., (2014). Diversity, habitat preferences, and conservation of the primates of Southern Assam, India: The story of a primate paradise Department of Life Science and Bioinformatics, Assam University, Silchar, Assam, India (2014).

Nathan R. (2008). An emerging movement ecology paradigm. *Proc Natl Acad Sci U S A.* Dec 9, 2008; **105**(49): 19050–19051.

Nerlekar A., (2012). An instance of inter species interaction between Hanuman Langur (*Semnopithecus entellus*) and Rhesus Macaque (*Macaca mulatta*), academia.edu

Nijman V. & Nekaris K. A. (2010). Testing a model for predicting primate crop raiding using crop and farm specific risk values.

Pragatheesh A., (2011). Effect of human feeding on the road mortality of Rhesus Macaques on National Highway - 7 routed along Pench Tiger Reserve, Madhya Pradesh, India, *JoTT Communication* **3**(4): 1656–1662.

Pirta, R. S (1984). Cooperative behavior of rhesus monkeys (*Macaca mulatta*) living in urban and forested areas in current primate researches. ed M.L Roonwal, S.M Mohnot & N.S Rathmore.pp.271-83, Jodhpur: University of Jodhpur.

Polina Perelman, Warren E. Johnson, Christian Roos, Hector N. Seuánez, Julie E. Horvath, Miguel A. M. Moreira, Bailey Kessing, Joan Pontius, Melody Roelke, Yves Rumpler, Maria Paula C. Schneider, Artur Silva, Stephen J. O'Brien, Jill Pecon-Slattery (2011). A Molecular Phylogeny of Living Primates 10.1371/journal.pgen.1001342.

Kanskey R. & Knigh A.T., (2014). Key factors driving attitudes towards large mammals in conflict with human, *Biological Conservation*, Volume **179**, November 2014, Pages 93-105.

Sharma G., Chena Ram, Devilal & Rajpurohit L. S. (2011). Study of man-monkey conflict and its management in Jodhpur, Rajasthan (India), *Journal of Evolutionary Biology Research* Vol. **3**(1), pp. 1-3, January 2011.

Singh & Thakur (2012). Rhesus macaque and associated problems in Himachal Pradesh – India, TAPROBANICA, ISSN 1800-427X, Vol. **04**, No. 02: pp. 112-116.

Srivastava A, (2006). Conservation of threatened primates of Northeast India Primate *Conserv*, **20** (2006), pp. 107–113.

Tobler Mathias W., (2008). The ecology of the lowland tapir in Madre De Dios, Peru: using new technologies to study large rainforest mammals (page, volume etc) : *Tobler, Mathias Werner* The ecology of the lowland tapir in Madre de Dios, Peru: Using new technologies to study large rainforest mammals, Texas A&M University, 2008, **146** pages; 3321971.

Wyman Miriam S., Stein Taylor V., Southworth J. & Horwich Robert H., (2011). Does Population Increase Equate to Conservation Success? Fragmentation and Conservation of the Black Howler Monkey, *Conservation and Society*, **9**(3): 216-228, 2011.

Y.-Z. Zhang, S.W.G.-Q. Quan, (1981). On the geographical distribution of primates in China**.** *J. Hum. Evol.*, **10** (1981), pp. 215–218.

Camperio-Ciani, A., (1986). *Aggressive Behav.* Volume **12**, Issue 6, 433–439.

Sharma, G., (2006). *Int. J. Primatol.*, **27**,117–120.