ANTHROPOGENIC IMPACT ON RHESUS MACAQUE (*Macaca mulatta* Zimmermann, 1780) BEHAVIOR IN PASHUPATINATH TEMPLE AREA, NEPAL

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Submitted to

Central Department of Zoology

Institute of Science and Technology

Tribhuvan University

Kirtipur, Kathmandu

Nepal

September, **2022**

DECLARATION

I hereby declare that the work presented in this thesis "**Anthropogenic impact on Rhesus Macaque (*Macaca mulatta* Zimmermann, 1780) behavior in Pashupatinath Temple area, Nepal**" has been done by myself, and has not been submitted elsewhere for the award of any degree. All sources of information have been specifically acknowledged by the reference to the author(s) or institution(s).

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RECOMMENDATION

This is to recommend that the thesis entitled "**Anthropogenic impact on Rhesus Macaque (*Macaca mulatta* Zimmermann, 1780) behavior in Pashupatinath Temple area, Nepal**" has been carried out by Melina Karki for the partial fulfillment of Master's Degree of Science in Zoology with special paper Ecology and Environment. This is her original work and has been carried out under my supervision. To the best of my knowledge, this thesis work has not been submitted for any other degree in any institutions.

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LETTER OF APPROVAL

On the recommendation of supervisor "Laxman Khanal, PhD" this thesis submitted by Melina Karki entitled "**Anthropogenic impact on Rhesus Macaque (*Macaca mulatta* Zimmermann, 1780) behavior in Pashupatinath Temple area, Nepal**" is approved for the examination and submitted to the Tribhuvan University in partial fulfillment of the requirements for Master's Degree of Science in Zoology with special paper Ecology and Environment.

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CERTIFICATE OF ACCEPTANCE

This thesis work submitted by Melina Karki entitled "**Anthropogenic impact on Rhesus Macaque (*Macaca mulatta* Zimmermann, 1780) behavior in Pashupatinath temple area, Nepal**" has been accepted as a partial fulfillment for the requirements of Master's Degree of Science in Zoology with special paper Ecology and Environment.

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Abbreviated forms	Details of abbreviation
UNESCO	: United Nations Educational, Scientific and Cultural Organization
HDA	: High disturbance area
LDA	: Low disturbance area

ABSTRACT

Rhesus macaques are highly commensal non-human primates and they display a close relationship with humans. There is a controversy regarding the human-macaque interactions in the wild and conflict is created due to these interactions. However, the effect of human disturbance in the behavior of the rhesus macaques are understudied. This study is mainly focused on the effect of human disturbance on feeding and grooming behavior of rhesus macaques in Pashupatinath Temple area, Kathmandu. Two groups of macaques from differential disturbance area were taken. Focal animal sampling was performed to note the behavior of the macaques, whereas instantaneous scan sampling was used for the collection of number of people at that exact time. Six focal animals from each group were observed. There was no difference ($t= 0.007$, $P= 0.497$) between the time spent in overall activity by two groups regardless of the human presence. Despite the overall activities of males and females being insignificant in high ($t= -0.109$, $P= 0.457$) and low ($t= -0.038$, $P= 0.485$) disturbance area, there was a noticeable difference in the individual activities. In both the study groups, males rested more than females; whereas females groomed more than males. Assessing the human disturbance effect in grooming activities suggested negative association in overall males and females. In the low disturbance area, the effect on grooming were insignificant for both the sexes (males and females) unlike the macaques in high disturbance area showing negative association of human presence with grooming. Similarly, overall macaques from both high and low disturbance area did not show any effect of human disturbance in feeding whereas the females from both groups showed positive effect of human disturbance on feeding. However, non-significant difference was observed in the feeding of individual sexes from both high and low disturbance area. In conclusion, food provisioning of the people, teasing, scaring off macaques, and throwing stones towards them might be the cause for the reduced grooming time in macaques. However, in presence of humans they get to feed on provisioned food due to which the time spent on feeding might have increased. The reason for insignificant difference between the groups could be due to habituation of the macaques in the anthropogenic environments.

1. INTRODUCTION

1.1 Background

Natural habitats of flora and fauna have been altered by urbanization and modernization in a seemingly visible way (Lowry et al. 2013, Thatcher et al. 2019). The expanding human populations are transforming wildlife habitat in a rapid rate, therefore giving options of either survival or the removal of the wildlife from the human modified landscapes (Lowry et al. 2013, Kaburu et al. 2019). The species which shows the higher degree of behavioral flexibility tend to survive and thrive in the emerging anthropogenic environments (Kaburu et al. 2019). This environment provides wildlife with many challenges, such as loss of natural habitat and food, and significantly higher human disturbance. After facing such challenges for the survival, some species adapt to their surrounding environment. This adaptation brings behavioral modification in foraging behavior, activity patterns, and movement patterns (Lowry et al. 2013, Kaburu et al. 2019, Thatcher et al. 2019).

The behavioral flexibility is associated with the high cognitive skills and has been particularly observed on non-human primates. Non-human primates have a large brain with well-developed cortices which can regulate the complex cognitive behaviors (Dunbar & Shultz 2007, Kaburu et al. 2019). Over the last two decades, the number of studies on non-human primates' flexibility to accommodate in a human modified environment and human-non-human primates interactions have increased (Fuentes & Wolfe 2002, Fuentes 2006, McLennan et al. 2017).

Studies on behavioral adaptability are mainly focused on the misuse of the new feeding area and adjustment of social organization. This can be observed in various examples such as, in an experimental setup, bonnet macaques (*Macaca radiata*) from urban areas were more efficient in extracting food from experimental bottles in comparison to the individuals living in areas of low anthropogenic impact (Balasubramaniam et al. 2020). The observable changes in the social organization of freely living bonnet macaques (*Macaca radiata*) in Bandipur National park of southern India was the formation of social group with one male (Sinha et al. 2005). The distribution of anthropogenic food and its abundance resulted in the formation of smaller groups of female led by a single male. In another example, Barbary macaques (*Macaca sylvanus*) observes their environment and act according to the human induced changes to obtain food and avoid the risk (Waterman et al. 2019). In the study site where the dog were predicted to be the primary predators, macaques were found climbing trees and avoided open areas where

they could be seen (Waterman et al. 2019). Although the studies about the behavioral adaptation of non-human primates are increasing (Lowry et al. 2013, McLennan et al. 2017), very less is known about the effect of human presence on their affiliative behaviors such as social grooming (Balasubramaniam et al. 2020).

These kinds of affiliative social behavior provide benefit to non-human primates for their health and fitness (Tanaka & Takefushi 1993, Akinyi et al. 2013, Solanki et al. 2020), and are also important in humans or other social group forming animals to maintain the social group structure (Balasubramaniam et al. 2018, Balasubramaniam et al. 2020). Social grooming is the most common form of social affiliation in non-human primates which can be defined as visual examination, search and manipulation of skin or hair of the partner with hands (Kaburu et al. 2019).

Grooming provides many health related benefits in primates such as removal of ectoparasites (Tanaka & Takefushi 1993), provides better thermoregulation (Tanaka & Takefushi 1993, Akinyi et al. 2013) and helps in coping with stress (Jaman & Huffman 2013). In addition, grooming also plays a major role in maintaining long-term social bonds, increases mating opportunities, supports the grooming partner at the time of conflicts and supports group wide social structure (Belzung & Anderson 1986, Lehmann et al. 2007, Balasubramaniam et al. 2018). Grooming is observed as the most performed behavior in primates which included up to 20% of their time budget in a day (Jaman & Huffman 2013, Kaburu et al. 2019, Solanki et al. 2020). Even though there are several benefits of grooming it decreases vigilance for predators (Kaburu et al. 2019), provides greater exposure to parasites (Akinyi et al. 2013, Kaburu et al. 2019), and reduces resting or foraging time (Dunbar & Shultz 2007, El Alami et al. 2012).

Resting and foraging in primates is also influenced by body mass between the adults and the immature (Jaman & Huffman 2013). There are different responses by the primates of different age-sex classes such as exploiting new food resources and access to limited food resources (Belzung & Anderson 1986, Jaman & Huffman 2013). Adaptive variability can be observed on the behavior and ecology of the food enhanced primates which likely differs depending on how they use the anthropogenic food sources. (Sha & Hanya 2013). Activity budgets in primates can also be fluctuated according to the seasons such as change in temperature, rainfall, fruiting seasons, and plant growth in relation to habitat type (Dunbar 1992, Agetsuma & Nakagawa 1998).

Non-human primates' flexibility to modify their interactions in presence of human can help to understand the negative impact created on primates' social behavior (Fuentes 2006, Riley & Wade 2016). This may result in group instability and also affect individual primate health (Kaburu et al. 2019).

Similar to other macaques and baboons, rhesus macaques are known to be highly commensal and the relationship of such commensal macaques with humans is of major concern (Kamal et al. 1997, Radhakrishna et al. 2012, Air 2015, Koirala et al. 2021). The modified anthropogenic landscapes by humans have created the selection pressure on the behavior of primate which is the recent change over the long evolutionary time-scales. In the era of urbanization where the forest areas are converted to human settlement area, the interactions between the human and wildlife is increasing which is leading to the coexistence (Air 2015, Beisner et al. 2015, Koirala et al. 2021) of human with wildlife sharing the same ecology (Fuentes & Wolfe 2002, Fuentes & Hockings 2010) which also becomes the major factor for the increased study of human-primate interface (Radhakrishna & Sinha 2011, Riley & Wade 2016, Kaburu et al. 2019). Humans interactions with primates vary greatly in the form and frequency which include either to be neutral or have little or no interactions such as food provisioning, religious beliefs and mutual tolerance (Riley & Priston 2010, Radhakrishna & Sinha 2011, Sengupta et al. 2015), to having aggressive or destructive behavior such as mutual aggression, culling or habitat destruction (Southwick et al. 1976).

The time-budget of the behavioral activities of commensal macaque groups helps to understand about the importance of the adaptive ability of the macaques under anthropogenic environmental pressure (Jaman & Huffman 2013, Waterman et al. 2019). These studies will help to understand different adaptive behaviors of primates with regards to anthropogenic environmental pressure which further helps in management of primates for their conservation (Jaman & Huffman 2013).

1.2 Objectives of the study

This study was performed on the basis of the general objective to assess the effect of human presence in the behavior of rhesus macaque in the Pashupatinath Temple area.

The specific objectives of this research were:

- To understand the behavioral pattern of rhesus macaques under different extent of human disturbance.

- To observe the effect of human disturbance on the social behavior (grooming) of rhesus macaques.
- To observe the effect of human disturbance on the feeding behavior of rhesus macaque.

1.3 Significance of the study

Different studies related to the behavioral pattern of the rhesus macaques (*Macaca mulatta*) have been conducted to minimize the human macaque interaction in different areas, as well to understand the general biology of the species which will lead to the conservation and management of the species and the conflicts.

However, the anthropogenic impact on the behavior is rarely observed and analyzed. Since rhesus macaques are usually found in the close proximity to human settlement, the impact of human on modification of their behavior is still less studied. Especially in the urban areas, where there is very limited natural habitat and resources, the behavioral modification is the must for the survival of the species.

There are many studies performed on the behavior of wild macaques but there is a study gap in the behavior analysis of the urban macaques. Especially the effect of human-macaque interaction in the behavior of macaques.

1.4 Limitations of the study

- Since the study was conducted during the time of pandemic, there was a gap in the data collection time due to nationwide lockdown.
- Due to the excessive movement of the macaque group, the data couldn’t be collected at the allocated time.

2. LITERATURE REVIEW

2.1 Human-primate interactions

Primates observe their environment and act according to the human induced changes to obtain food and avoid the risk (Waterman et al. 2019). Primates are referred to as guardian of humans, good luck charm to humans, spirits of the ancestors, and epitomes of fertility, sexuality and wisdom in different regions from Tibet to Africa (Riley & Priston 2010). In the regions such as Nepal and India, Hinduism is considered to be the primary religion and macaques are considered to be the symbol of strength and energy in a form of spiritual beings (Chalise 2013, Sengupta et al. 2014). But the alterations of landscape by humans (e.g.: forest conversion, roads and highways constructions, use of specific forest, irrigation channels) creates division on primate groups (Fuentes 2006).

On the path leading to development, many primate species tend to change their behavior according to the settlement areas (Lowry et al. 2013). Among all the other primates, rhesus macaques are the widely distributed primate population which are well adjusted in the urban habitats in Nepal. Due to the rhesus macaques living in close proximity to the human settlements, many cases of human-primate conflicts in urban areas can also be observed. Even though the rhesus macaques are supposed to be nuisance, they have very crucial role in the environments such as seed dispersion (Riley & Priston 2010, Sengupta et al. 2014).

Rhesus macaques spend most of their time in the behavioral activities such as feeding, resting, grooming, moving or playing in case of juveniles and infants. They modify their behavior according to the change in ecological factors (Jaman & Huffman 2013). The macaques found in the rural habitats fed less on natural food and more on human food. They also rested and moved more in the day and got engaged in more aggressive acts than the macaques in the urban areas (Wolfe 1992). In urban areas, monkeys depends more upon the anthropogenic food due to lack of specific forest or suitable habitat. Therefore, they are usually found near temples or shrines where there is food provided by peoples due to various religious reasons (Fuentes 2006). Human- macaque interface in temples is best explained as the mutual benefit, where the macaques acquire the provisioning as well, human receive satisfaction for feeding. This type of mutual relationship is also hazardous when there is no distinct barrier between the macaque and humans such as high aggression, bites, and disease transmission (Riley & Wade 2016).

2.2 Social behavior/ grooming among macaques

Grooming is one of the major social activities observed in primates (Jaman & Huffman 2013, Solanki et al. 2020). Grooming can be divided into two types: grooming to/by other (allo-grooming) and grooming own body (self-grooming) (Tanaka & Takefushi 1993, Akinyi et al. 2013). Usually self-grooming includes grooming on the easy and visible regions of the body such as lower arms, genitals, legs, and the tail part, all places that are readily accessible for an individual grooming itself. But the areas that are not readily accessible such as, back and the head, there is the need of allo-grooming (Boccia 1983, Tanaka & Takefushi 1993, Akinyi et al. 2013).

Grooming as being the most performed social activity (Jaman & Huffman 2013, Solanki et al. 2020), most of the act performed during grooming are removal of ectoparasites, skin flakes, social function and sexuality courtship (Tanaka & Takefushi 1993, Solanki et al. 2020). Allo-grooming plays a major role in a hygiene than in self-grooming (Tanaka & Takefushi 1993, Akinyi et al. 2013, Solanki et al. 2020). It was found that Chimpanzees who performed allo-grooming had higher removal movement frequency rather than when they were self-grooming (Zamma 2011). Observing the grooming reciprocity, it was found that in the wild Japanese macaques those individuals who groom more were likely to get more grooming and the macaques that were ranked higher received comparatively more grooming (Ventura et al. 2006, Akinyi et al. 2013, Xia et al. 2021). So, we could say that positive relation was found between the grooming and the bloc which might not clarify the inclination of macaques to co-ordinate their grooming up the hierarchy (Boccia 1983, Ventura et al. 2006, Akinyi et al. 2013).

Although grooming plays the major health related benefits (Tanaka & Takefushi 1993, Akinyi et al. 2013, Solanki et al. 2020), the human interactions with primates tends to decrease their time of grooming and multiplicity of grooming partners (Kaburu et al. 2019, Kaburu et al. 2019). Different studies conducted on human-primate interactions provide the insights on primates spending more time resting and on social activities to feed more on anthropogenic food (Fuentes 2006, Fuentes & Hockings 2010, Jaman & Huffman 2013, Thatcher et al. 2019), but Balasubramaniam et al. (2020) found that anthropogenic food had no effect on macaques grooming behavior instead monitoring humans seemed to lower macaques' grooming effort. Subjects' sex did not show any effect of anthropogenic factors on macaque grooming as well other forms of affiliation (Balasubramaniam et al. 2020), but in case of bonnet macaques (*Macaca radiata*), increase in grooming frequency and grooming reciprocity were observed

due to foraging on anthropogenic food in the female macaques (Sinha et al. 2005). In conclusion, grooming while increases the health related benefits, in the meanwhile can also reduce the time for monitoring humans in the urban macaques in presence of human disturbance (Kaburu et al. 2019).

2.3 Feeding behavior of macaques under human disturbance

Rhesus macaque spent half of the sampling time feeding (Goldstein & Richard 1989). Feeding can be observed of two methods: foraging on natural foods and foraging on anthropogenic foods. Food availability emerges as the key influence on time budget of feeding (Belzung & Anderson 1986, Menon & Poirier 1996, Jaman & Huffman 2013). Macaques found in the rural area spent most time feeding on the natural food from the gardens and forests than the urban group. Whereas, the urban group get access to the provisioned food which is easily gained and is high in calorie which give them the time to rest and get engaged in social activity more (Marriott 1988, Jaman & Huffman 2013). In the natural areas which are less impacted by humans, the availability of the foods vary seasonally. Thus, the time spent in feeding also vary seasonally (Jaman & Huffman 2013, Sha & Hanya 2013, Thatcher et al. 2019). As explained in Gogoi & Das (2018), in the seasons when natural foods are present in higher percentage, the macaques fed 70% on natural food and 25% on provisioned food. But in the months of dry season, the feeding percentage of provisioned food reached 54%. Also, the behavior of feeding varies in rhesus macaques in accordance to their desire to feed and their social rank (Belzung & Anderson 1986).

Food provisioning is one of the way for the survival of urban primate species, but this might lead to the change in the behavior pattern in the wild primates species (Pragatheesh 2011, Gogoi & Das 2018). In a study performed by Pragatheesh (2011), wild rhesus macaques were usually fed by the travelers, due to this whenever the vehicles halt, macaques surrounded the travelers to offer eatables. In retaliation, some people pelt stones, this type of condition brings the major risk to the macaque groups of them being dependent upon anthropogenic food than natural food, and also due to throwing of stones, they may be wounded or can lose lives. Food provisioning on the middle of the road cause rising trends in mortality of macaque in wildlife-vehicle collision leading to the declining of population in the long term. Also, the provisioning of the food negatively effect on the role of the macaques to disperse seeds in maintaining the ecology and environment (Sengupta et al. 2015).

Provisioning food also plays a major role in the aggressive behavior in macaques (Southwick et al. 1976, Sha & Hanya 2013, Sengupta & Radhakrishna 2018). The aggression between the macaques increased six fold during the feeding period than in non-feeding periods (Southwick et al. 1976). The feeding of the urban macaques can fluctuate during different seasons because the availability of the natural food is way high in some seasons (Spring, summer) than in other (winter) (Lowry et al. 2013). In the human macaque interaction during provisioning of food, macaques are almost never aggressive towards humans (Beisner et al. 2015). Instead, begging behavior by standing on their hind limbs (Sinha et al. 2005) were observed. This type of behavior induced human to feed macaques (Sengupta & Radhakrishna 2018). In addition, feeding on anthropogenic food or provisioned food significantly reduce time spent in foraging (Wolfe 1992, Tang et al. 2016, Thatcher et al. 2019).

3. MATERIALS AND METHODS

3.1 Study Area

3.1.1 Location

This study was carried around the historical and one of the oldest Hindu temple (Pashupatinath Temple) of the Kathmandu Valley (Fig. 1). It was listed as UNESCO World Heritage Site in 1979. It lies in the bank of scared Bagmati River and covers an area of 0.64 hectares which includes 518 temples and monuments (limited 2018). The animals present in this area have a great religious and ecological importance. Animals seen in this area include spotted deer (*Axis axis*), barking deer (*Muntiacus vaginalis*), dogs, rhesus macaques' troops, cows and bulls, and many varieties of birds.

Among all the animal species, rhesus macaques are the major attraction of this area because they are widely spread. They are also one of the nuisance causing animals.

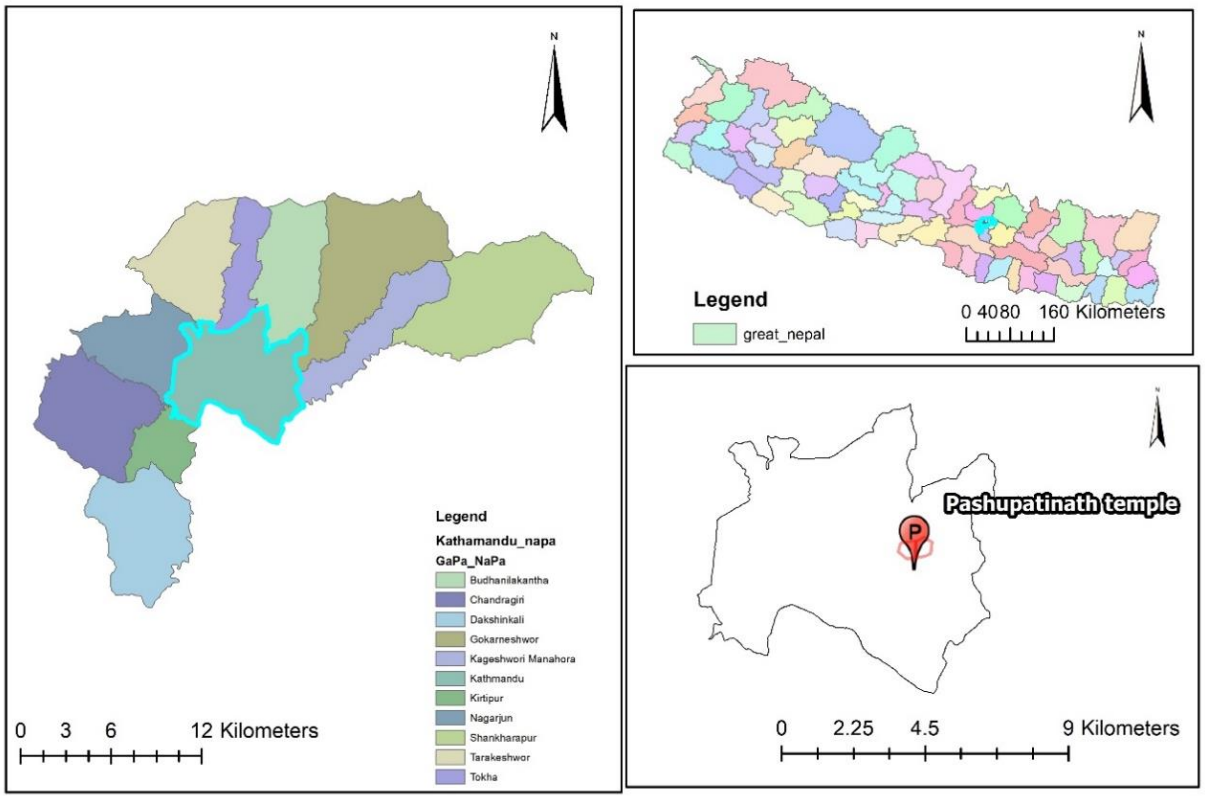

Figure 1. Map of the study area.

3.1.2 Study site

Pashupatinath Temple area is large and comprises of various places from forest areas to temple areas and residential areas. There are different groups of rhesus macaques widely spread on those areas and share the habitat between the groups. The forest area comprises of mainly three types of forest namely *Schima-Pyrus*, Moist (*Myrsine Persea*) and Mixed (*Quercus-Myrsine*) (Shrestha & Devkota 2013).

Figure 2. Map of the study area showing distribution ranges of the two study troops

For my research, I chose two groups of macaques from two different areas separated by the Bagmati River (Fig. 2). One group was from the area including Mrigasthali, Biswaroop Forest and stairs leading to the Guheswori Temple. Due to the flow of visitors throughout the day (high human-macaque interaction), the rhesus macaque group ranging in this area were regarded as higher disturbance area group (HDA). Other group was from the area of Pashupati Area Development Trust and the area including the main Pashupatinath Temple (low human-macaque interaction). There was no access for the visitors inside the fenced park and macaques spent most of their time inside the park so there was very less human-macaque interaction. Therefore, this area was considered as low disturbance area (LDA).

3.2 Materials

- Data sheet
- Stopwatch

3.3 Methods

3.3.1 Preliminary field Survey

The preliminary field survey was performed from January 1, 2021 to January 15, 2021. In those 15 days of preliminary survey, different groups of macaques were observed to find their location, group size, group categories and range. The selection of two groups of macaques for the research and the group individual's characteristics were also noted for the further study. Since the macaques were close to human proximity they were observed through naked eyes.

3.3.2 Data collection

The data for the research were collected through the following ways:

3.3.2.1 Group size

Two groups of macaques were selected for the research. Group 1 was selected from the low disturbance area (LDA) which comprised of total 40–45 individuals in a group where, 8–10 were adult males, 15–16 were adult females and remaining were juveniles and infants. Similarly, Group 2 was selected from high disturbance area (HDA) which comprised of total 50–60 individuals where, 14–15 were adult males, 18–20 were adult females and remaining were juveniles and infants. These are the approximate numbers for the group when they were together.

3.3.2.2 Focal/Study animals

The behavioral sampling was conducted for six adult individuals in each group (Figs. 3 and 4) totaling to 12 individuals for two areas (Table 1).

Table 1. Distinguishing characteristics of individual macaque for focal animal sampling

Group 1			
S.N.	**Category**	**ID**	**Characters**
1.	Adult male	G1M1	Big sized male (alpha), Right earlobe hanging by splitting
2.	Adult male	G1M2	Young adult male, have a big red mole in the upper lip
3.	Adult male	G1M3	Aged adult male, have a big scar in left hand
4.	Adult female	G1F1	Big female, have hole in nose and tons of fur
5.	Adult female	G1F2	Small female among the three specimens and have more pinkish face than others
6.	Adult female	G1F3	Female of the alpha male, have scar in nose probably from fighting

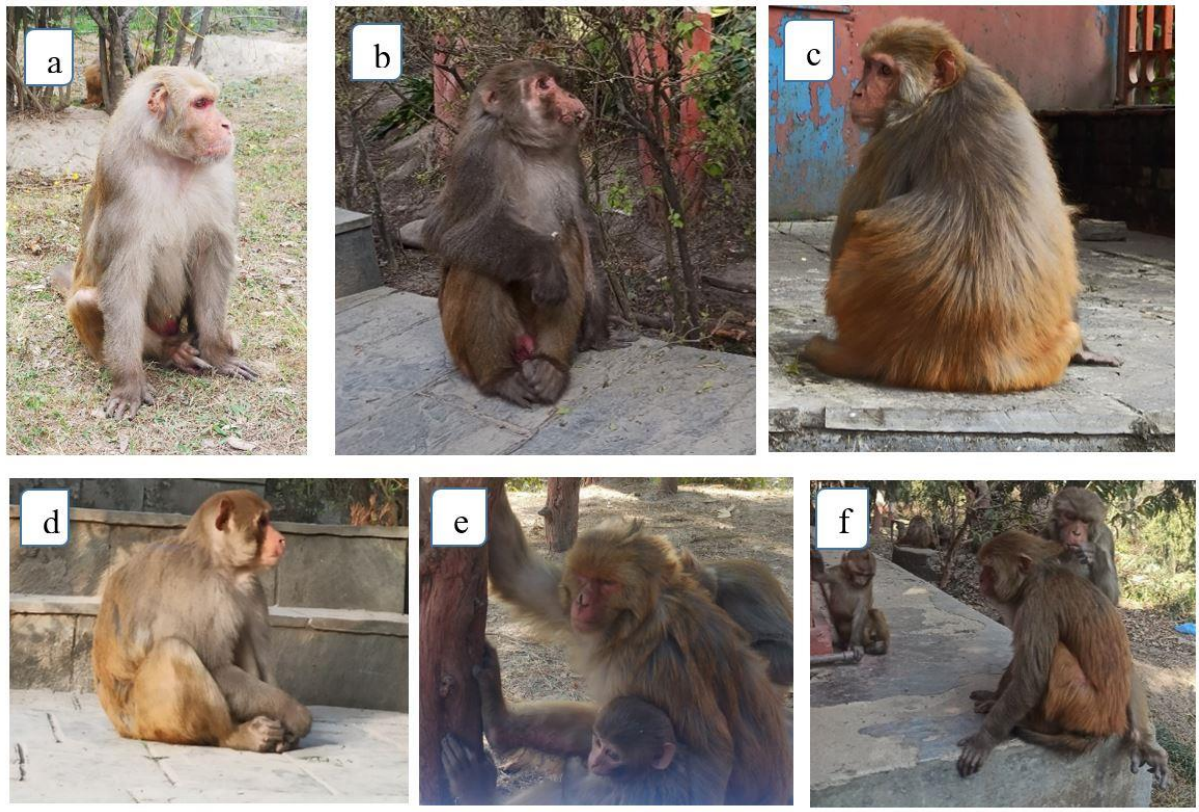

Figure 3. Focal animals from the Group 1. **a-** G1M1, **b-** G1M3, **c-** G1F3, **d-** G1M2, **e-** G1F1, and **f-** G1F2

Group 2			
S.N.	**Category**	**ID**	**Characters**
1.	Adult male	G2M1	Young and energetic male and have slightly raised back
2.	Adult male	G2M2	Wounded leg: left hind leg which was not found later and changed. **New replaced male**: Scar in the back side
3.	Adult male	G2M3	Young male, ear bitten of right side, slightly raised back
4.	Adult female	G2F1	Fur at the beginning of tail part was absent and scar above left ear. Disappeared in the middle of study. **New replaced female**: Fur at the beginning of tail part was absent, protruding nipples, left ear bitten
5.	Adult female	G2F2	Had curve tail and small hole in the nose, later disappeared/died. **New replaced female**: Curve tail and big nose
6.	Adult female	G2F3	Tail was curved to form U shape.

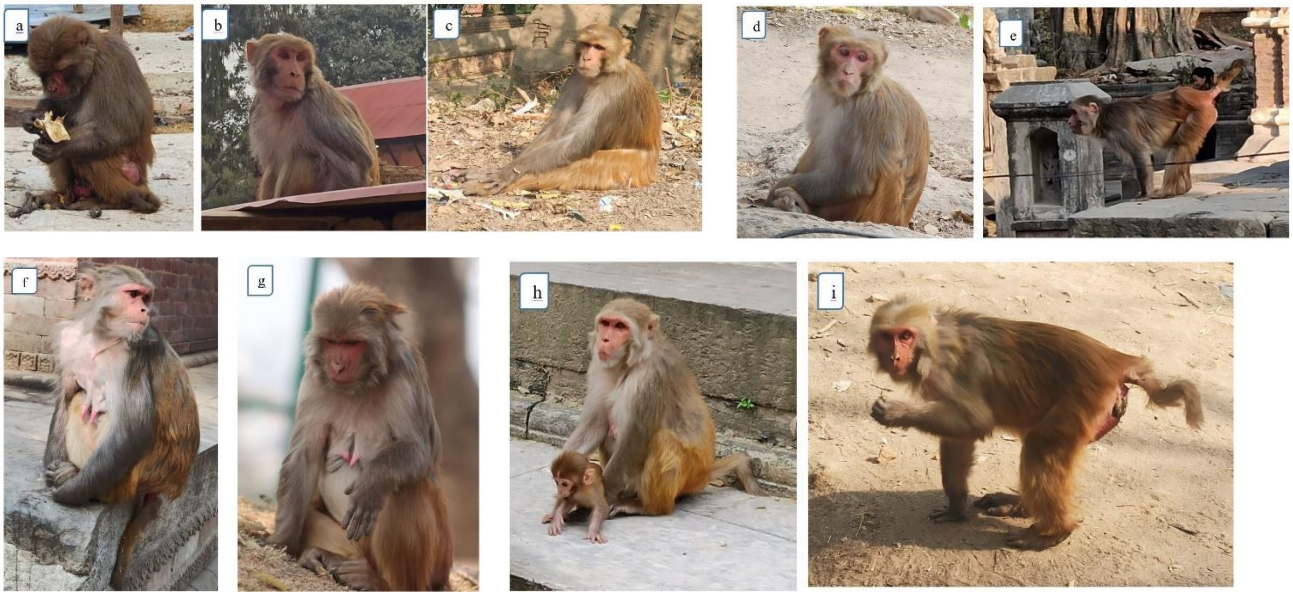

Figure 4. Focal animals from the Group 2. **a-** G2M2, **b-** G2M2 (replaced), **c-** G2M1, **d-** G2M3, **e-** G2F1, **f-** G2F1 (replaced), **g-** G2F2, **h-** G2F2 (replaced), and **i-** G2F3.

3.3.2.3 Behavioral observation

Behavioral observation was carried out through two types of sampling methods- focal animal sampling and instantaneous scan sampling (Altmann 1974).

The data was collected in two shifts as morning and afternoon. The morning time data was collected from 7:00 AM to 12:00 PM and the afternoon data was collected from 12:00 PM to 5:00 PM. The data were collected after the troops were visible at that duration of time. For the two groups, if one group's data was collected in the morning then the other group was collected in the afternoon. So, in a day I had one data for the morning and other for afternoon. Data was collected according to the ethogram (Table 2).

Table 2. Ethogram for behavioral observation

Actions	Character description
Moving	Involves movement due to any factors such as: dogs, humans, and other group of macaques
Feeding	Foraging or feeding on either natural food or anthropogenic food. Feeding either by sitting or moving
Grooming	Either being groomed by other individual or grooming other individual
Sitting/Resting	Resting by laying and looking around, sleeping, sleeping in sitting position, laying doing nothing
Aggression	Fighting with same group or different group either male or female or child

Focal animal sampling

It is a type of sampling techniques where each and every activities performed by macaques are recorded (Altmann 1974). In this research, a data sheet was prepared to collect the behavioral data for general behavior (Appendix I) from Magh 2077 (January 2021) to Bhadra 2078 (September 2021). Between this time periods, the data couldn't be collected for two months due to nationwide lockdown and one month due to monsoon. The data was collected four days a week and the days were altered each week so the data for all seven days could be obtained. For each individual 20 minute of continuous data was collected in one viewing. The data for animals that were lost for >3 minute were left and again continued after they were visible (Balasubramaniam et al. 2020). Animals who had less than 20 minute data per day, those data were discarded. The total amount of data collected during focal animal sampling is shown below (Table 3).

Table 3. Total time for data collection of two groups

Group	Data collection (time)	Total time
Group 1 Male (51 hrs)	51 hrs	101 ± 1 hrs
Group 1 Female (50 hrs)	50 hrs	
Group 2 Male (52 hrs)	52 hrs	101 ± 1 hrs
Group 2 Female (49 hrs)	49 hrs	

Instantaneous sampling (Point time sampling)

This is a type of sampling technique where the behavior is recorded at that exact time. In this research, once every 2 minute within each 20 minute focal sampling, we used Point-time Sampling (Altmann 1974) to know whether the activity performed was resting, grooming, feeding, moving or aggression. The main point of this data collection was to note the number of people present around 100 m radius during the activities performed by macaques. Number of people were recorded in each 2 minute time interval between the focal sampling times. The data sheet for instantaneous sampling is present in (Appendix II).

3.4 Data analysis

3.4.1 Time budget activity comparison

The general behavioral pattern of two macaque groups in high disturbance area (HDA) and low disturbance area (LDA) are shown in the form of graphs. Normality of the data was performed through Shapiro-Wilk Normality Test in R (R Core Team 2020). Since the data was normal for the overall behavior, significant difference between the two groups were calculated through t-test in EXCEL 2013. Also, the significant difference between the grooming and feeding behaviors among the group were calculated using Mann-Whitney U test in R.

3.4.2 Effect of human disturbance on grooming and feeding behavior

There were 10 values for the number of people in each 20 minutes time duration. From each sampling time, the maximum number of people (per 20 minutes sampling time) were selected for the analysis. The data was calculated in minutes, so data for less than one minute was discarded during the analysis. The data normality was checked through Shapiro-Wilk Normality Test in R, since the data were not normally distributed, they were log transformed to make normal. All the zeros were removed after the log transformation. Also, the outliers for the number of people were discarded. The log transformed data were analyzed by simple linear regression in R.

4. RESULTS

4.1 Diurnal activity budget of rhesus macaques in Pashupatinath Area

Both LDA group (40.06%) and HDA group (39.84%) macaques spent most of their time on resting. Group 1 spent more time on grooming than the group 2 whereas the later spent more time on feeding than the former. However, there was no significant difference between the activity patterns of both group 1 and group 2 macaques of high and low disturbance area (t= 0.007, P= 0.497). Aggression was the least performed activity in both the groups (Fig. 5).

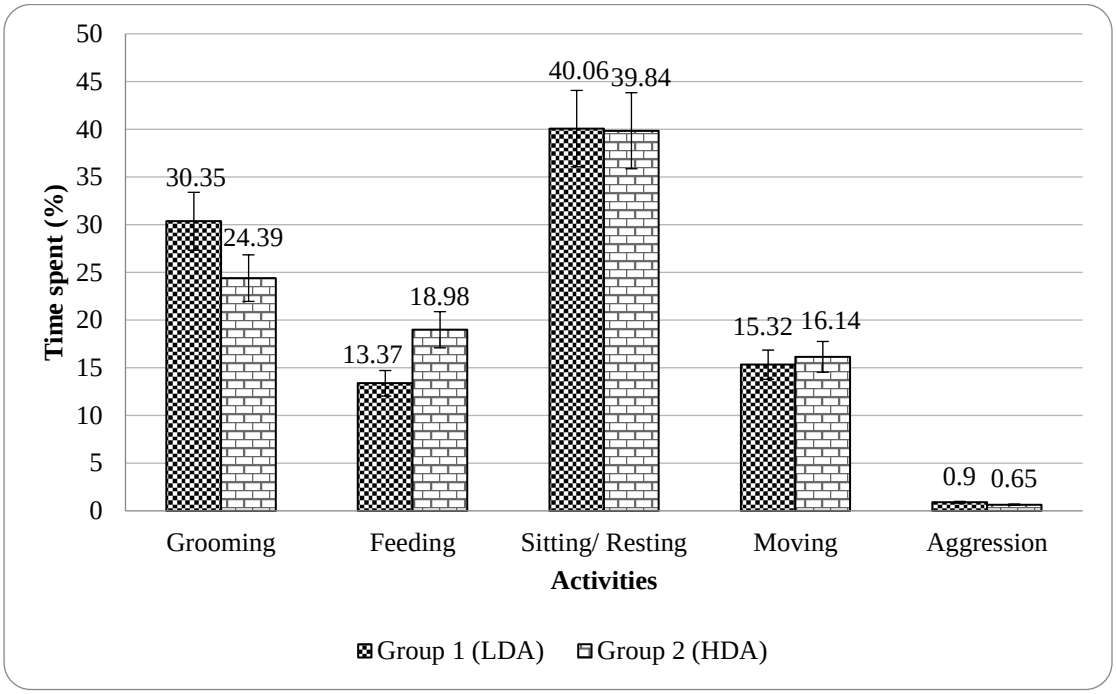

Figure 5. Rhesus macaque activities in high and low disturbance area

4.1.1 Activity pattern difference by sex under differential disturbance

There was a noticeable difference in the behavior between the males and females of the group-1. Grooming (42.52 %) was the highest performed activity by female, whereas the male spent most of the time resting (47.75%). Also, the movement (18.59%) and aggression (1.36%) were observed more in male (Fig. 6). However, there was no significant difference between the activity patterns of male and female in low disturbance area (t= -0.038, P= 0.485).

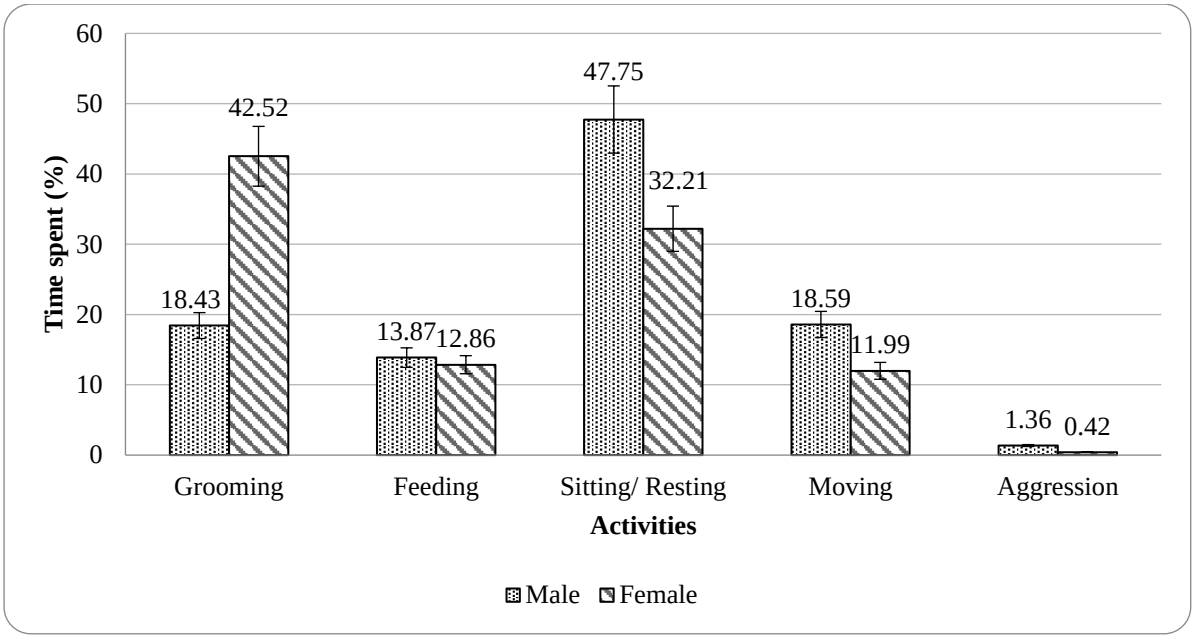

Figure 6. Macaque activities in low disturbance area

In HDA group males spent most of the time resting (48.88%) whereas females spent most of their time grooming (32.93%). Females also spent most of their time feeding (21.11%) and resting (30.32%). Whereas, male spent comparatively more moving (16.78%) and in aggression (1.09%) (Fig. 7). There was no significant difference between the activity patterns of male and female in high disturbance area (t= -0.109, P= 0.457).

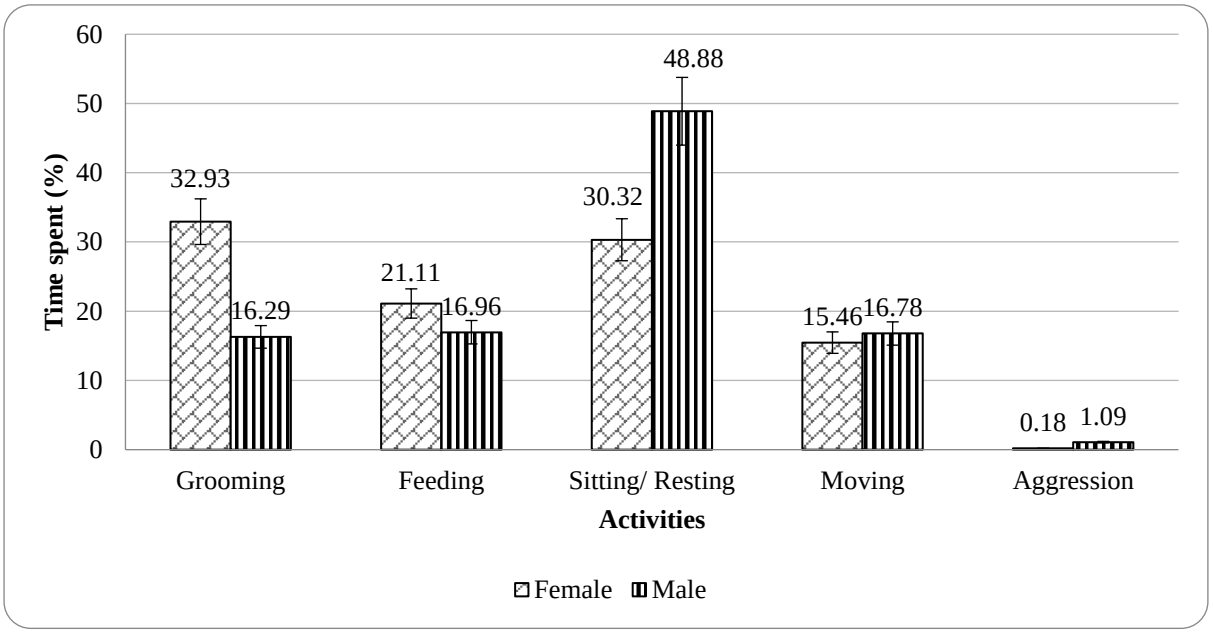

Figure 7. Macaque activities in high disturbance area

4.2 Effect of human disturbance on grooming behavior

Females from high disturbance area groomed less than the females of low disturbance area. Similarly, females groomed comparatively more than males in both high and low disturbance area (Fig. 8). There was a significant difference [(v=1861, P<0.001), (v=2433, P<0.001) and (v=4170.5, P=0.03644)] between the grooming behaviors of male and females as well as females of both high and low disturbance area respectively (Annex I).

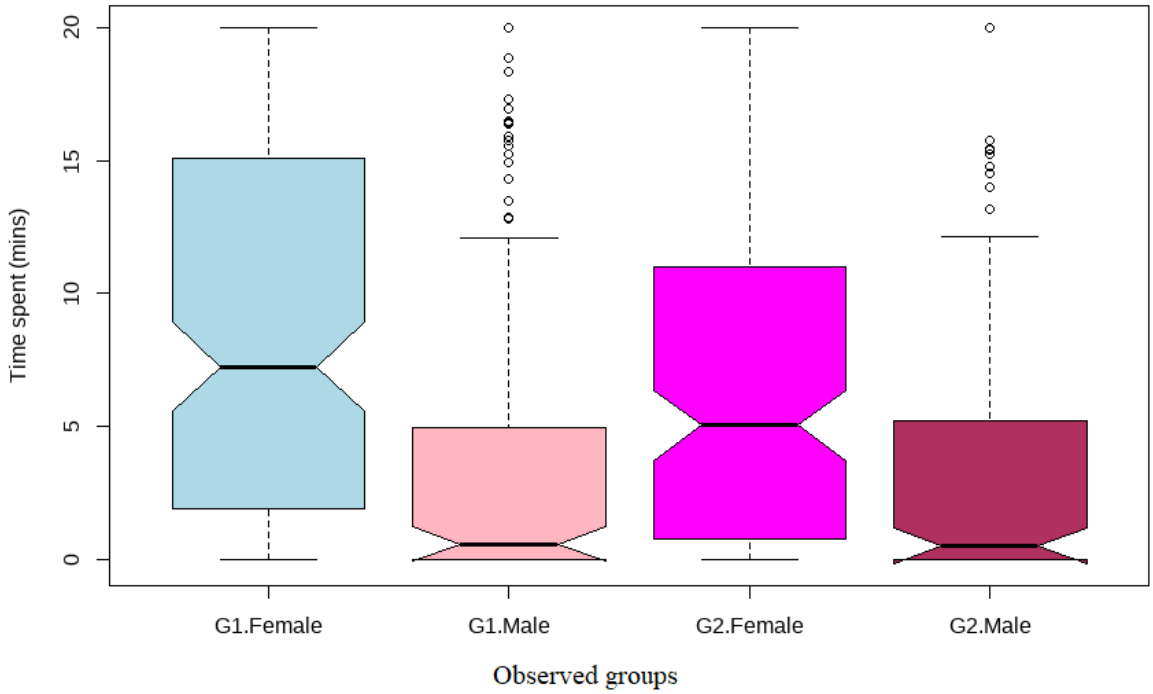

Figure 8. Grooming activities in males and females of high and low disturbance area

Both males (R^2 = 0.08451, F-statistic= 12.18, P< 0.001) and females (R^2 = 0.06097, F-statistic= 14.54, P< 0.001) of the study troops showed negative association of grooming with human disturbance (Fig. 9).

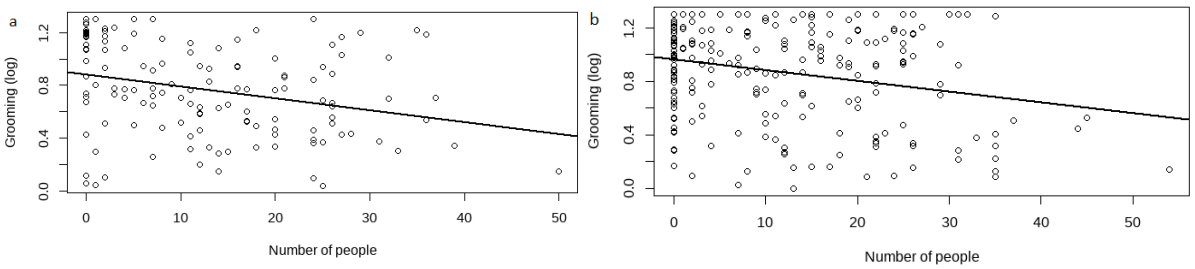

Figure 9. Grooming activity. **a**-all males (high and low disturbance area), **b**-all females (high and low disturbance area)

4.2.1 Effect of human disturbance in low disturbance area (Group-1)

There was a significant negative effect of human disturbance in grooming of macaques in low disturbance area R^2 = 0.03433, F-statistic= 6.719, P= 0.01028 (Fig. 10c). However, the effects were not significant for individual sexes (males: R^2 = 0.02747, F-statistic= 1.978, P= 0.1641(Fig. 10a); and females: R^2 = 0.0297, F-statistic= 3.581, P= 0.06091 (Fig. 10b)).

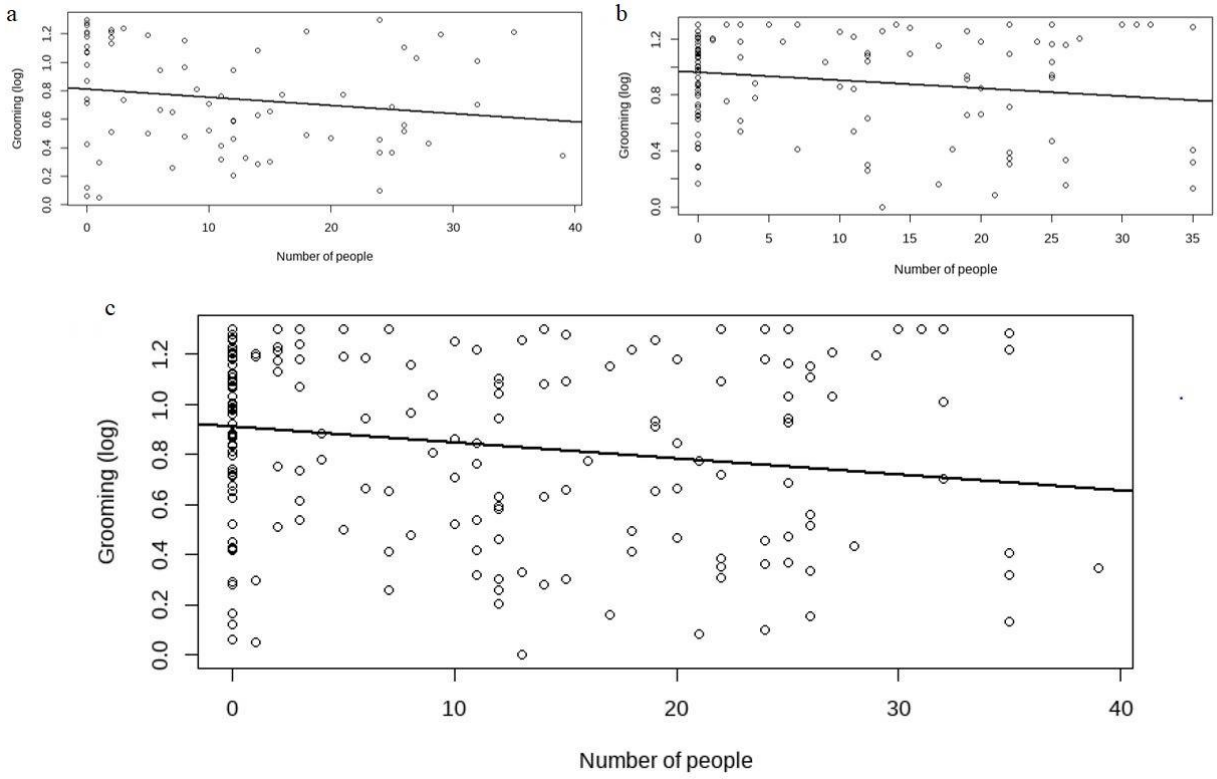

Figure 10. Grooming activity of low disturbance area. **a**-male macaque activity, **b**-female macaque activity, **c**-overall male and female activity

4.2.2 Effect of human disturbance in high disturbance area (Group-2)

There was significant negative effect of human disturbance in grooming of macaques in high disturbance area R^2 = 0.1242, F-statistic= 23.69, P<0.001 (Fig. 11c). Similar results were found for the individual sexes (males: R^2 = 0.08499, F-statistic= 9.753, P= 0.002314 (Fig. 11a); and females: R^2 = 0.2221, F-statistic= 17.13, P<0.001 (Fig. 11b)).

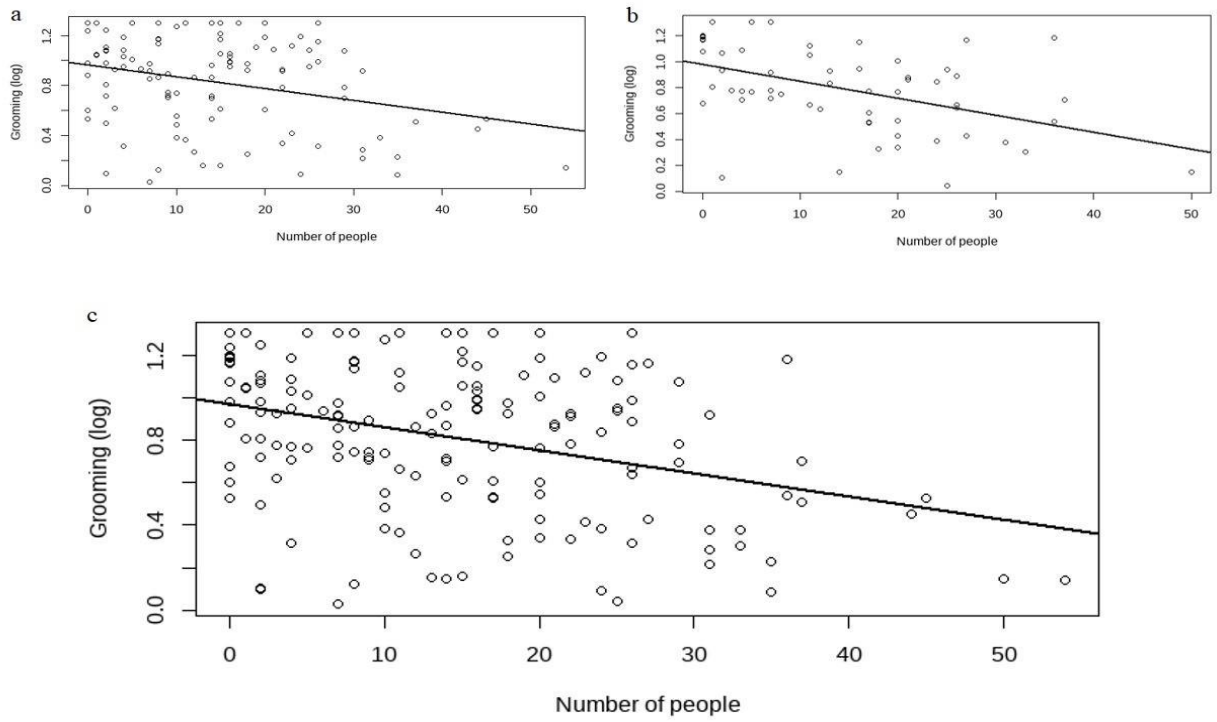

Figure 11. Grooming activity of high disturbance area. **a**-male macaque activity, **b**-female macaque activity, **c**-overall male and female activity

4.3 Effect of human disturbance on feeding behavior

There was a significant difference between the time spent in feeding between the two groups (v=37341, P<0.001) (Annex II). Macaques from high disturbance area fed more than the low disturbance area. Also the females from high disturbance area fed more than the females of low disturbance area (Fig. 12).

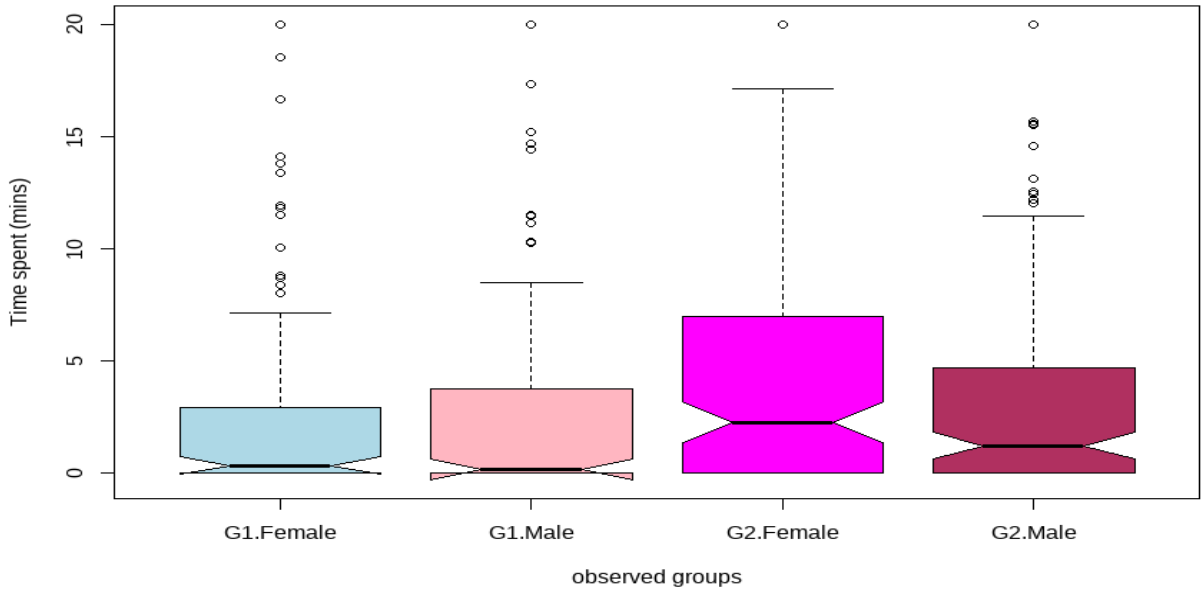

Figure 12. Feeding activities of males and females in high and low distribution area

Males from the study troops showed no effect in the feeding behavior (R^2 = 4.192e-06, F-statistic= 0.0005827, P= 0.9808) in association with human disturbance. Whereas, females from the study troops showed positive association of feeding (R^2 = 0.03371, F-statistic= 4.989, P= 0.02707) in presence of humans (Fig. 13).

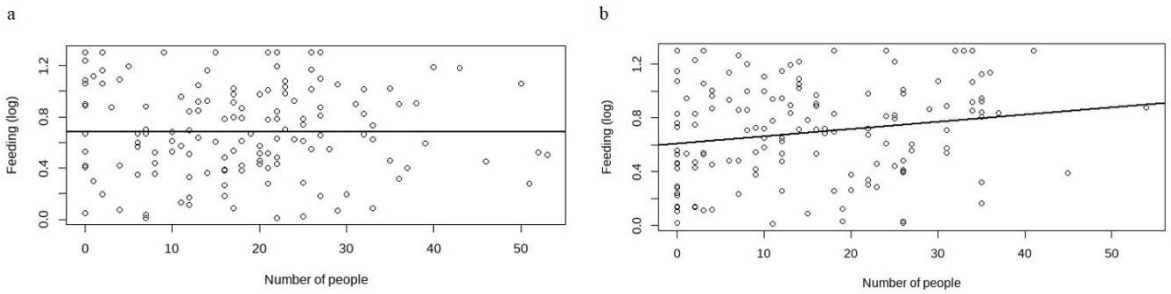

Figure 13. Feeding activity. **a**-all males (high and low disturbance area), **b**-all females (high and low disturbance area)

4.3.1 Effect of human disturbance in low disturbance area (Group 1)

No effect of human disturbance was seen in feeding of macaques in low disturbance area (R^2 = 0.005179, F-statistic= 0.6196, P= 0.4328) (Fig. 14c). Similarly, the effects were not significant for the individual sexes (males: R^2 = 6.25e-05, F-statistic= 0.003563, P= 0.9526 (Fig. 14b); and females: R^2 = 0.01538, F-statistic= 0.9527, P= 0.3329 (Fig. 14a)).

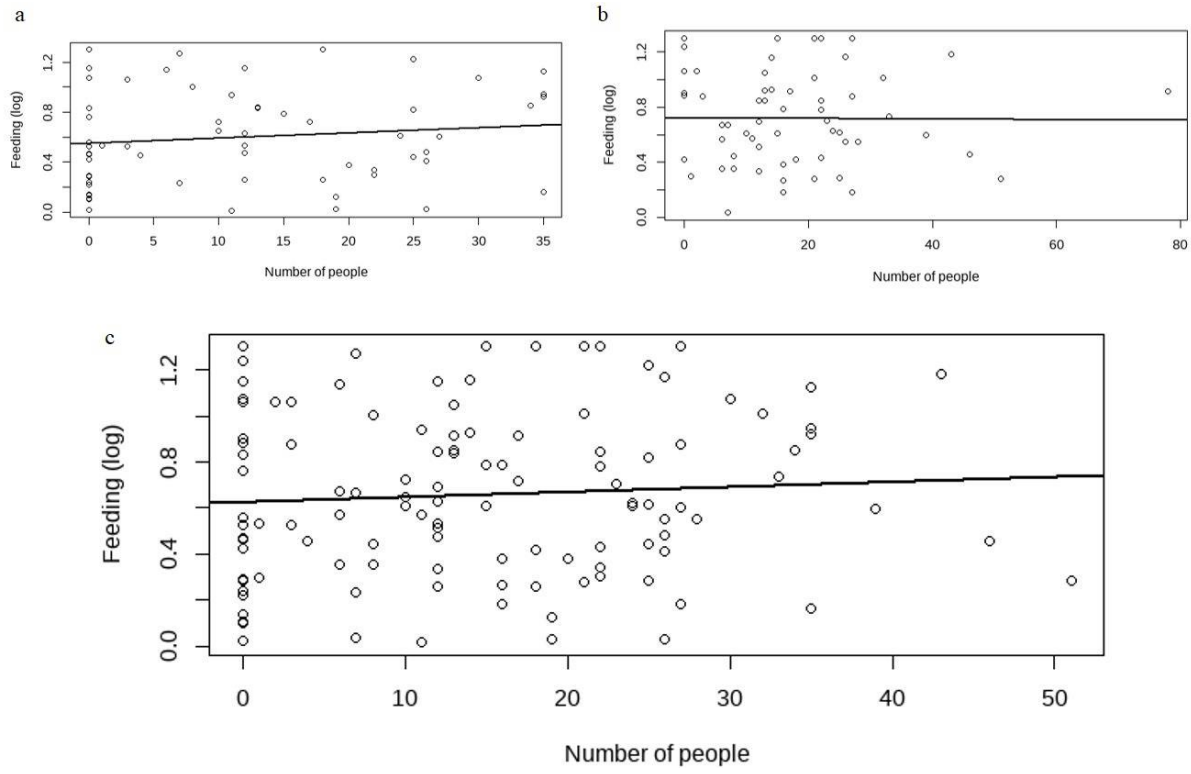

Figure 14. Feeding activity of low disturbance macaques. **a**-females, **b**-males, **c**-males and females

4.3.2 Effect of human disturbance in high disturbance area (Group-2)

No effect of human disturbance was seen in feeding of macaques in high disturbance area (R^2 = 0.008069, F-statistic= 1.326, P= 0.2512) (Fig.15c). Similarly, the effects were not significant for the individual sexes (males: R^2 = 0.003227, F-statistic= 0.2622, P= 0.61 (Fig. 15b); and females: R^2 = 0.02359, F-statistic= 1.933, P= 0.1683 (Fig. 15a)).

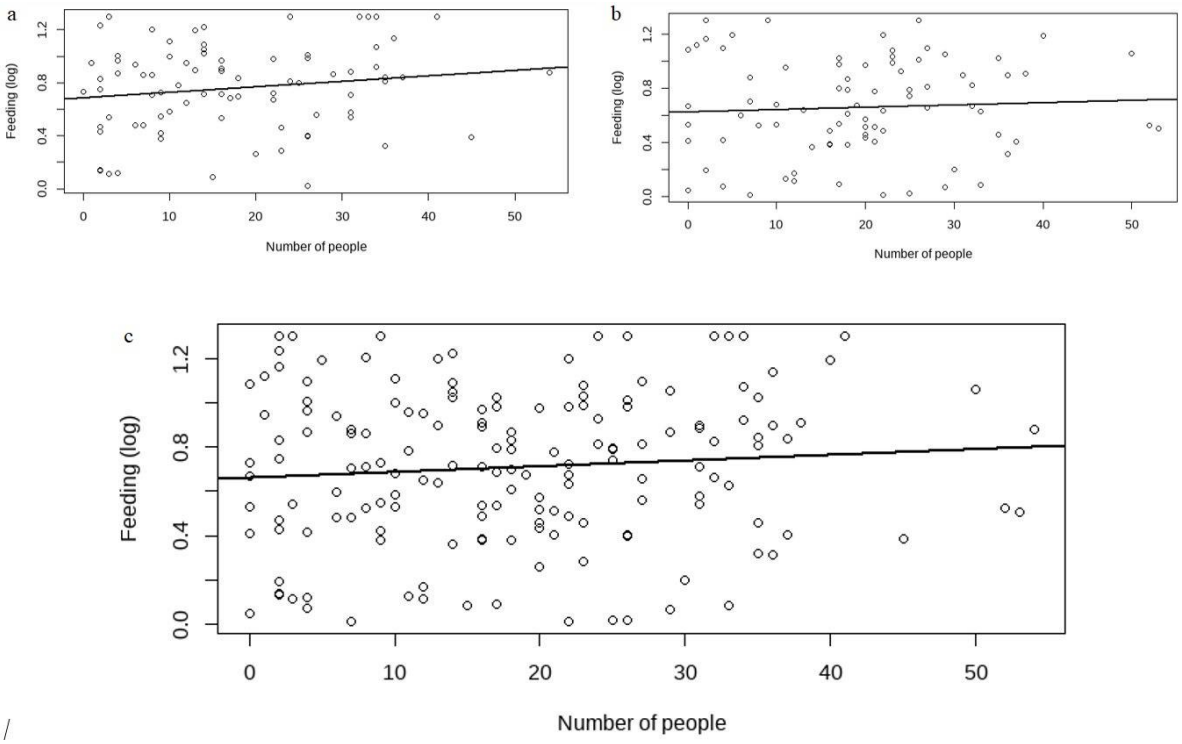

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Figure 15. Feeding activity of high disturbance macaques. **a**-females, **b**-males, **c**-males and females

5. DISCUSSION

5.1 Diurnal activity pattern of macaques in Pashupati Area

It was found that macaques from both high and low disturbance area spent most of their time resting and grooming followed by other activities such as moving, feeding and aggression. Similarly, male macaques spent more time in resting while the female macaques spent most of their time grooming in both the groups. This might be because the female should be able to groom themselves, their males as well their child because social function is the most important act that is performed for the better hygiene (Solanki et al. 2020). However, male macaques tend to groom usually females to increase the chance of mating (Cooper & Bernstein 2008) than other male and juveniles. In rare cases, it was noticed that male macaques groom their child but not for a very long time. The time duration when female macaque spend grooming her child, males tend to rest, which verifies the result of male spending more time resting in both the groups. Slight variation in the time spent grooming was observed between the females of the two groups. The LDA females tend to groom more than the HDA females. This might be because of the difference in the home range between the two groups. In the low disturbance area, there was a park which the visitors couldn't access, and the most of the grooming and resting activities were performed inside that park without any disturbance. In my research, the dominant individuals and the females were observed to have less skin infection compared to the less dominant males and females similar to the findings in Akinyi et al. (2013) higher performance of grooming indicates less chances of parasitic infestation and better maintenance of hygiene between the groups. In the LDA area, macaques used to go outside only to feed and then return for other social activities. Whereas, in the high disturbance group also there was a park near the Mrigasthali, but the visitors were allowed there to see the deer in the park. In that context, the visitors also provisioned food and teased the monkeys which might be the reason for the less grooming time in HDA females.

The time spent foraging seemed to be less in low disturbance group than in the high disturbance group. This might be because of the less provisioning of the food to the low disturbance group and also the prohibition of entry of the visitors inside the park which led to low encounter and provisioning than in HDA group. One of the most exciting thing noticed in both the groups were, even though they were provided food by humans, they also tend to feed on natural food like insects, plant leaves and seeds (Gogoi & Das 2018). Despite that less time was spent in

foraging than social behavior in all the groups unlike the result drawn in (Koirala et al. 2017) where the wild groups of macaques spent more time feeding than in social behavior. Also the available human food might have played a major role in grooming behavior of the macaques in semi provisioned macaque group (Koirala et al. 2017) similar to our findings in HDA group macaque populations. Moving and aggression behavior were also observed similar in both groups. The main reason for the movement of macaques in the groups was due to the predators such as dogs, eagles and majorly the other macaque group. Each troops in rhesus macaques uses a home range which they share with other troops and avoid close proximity to the neighboring troops. Those encounters can vary from no agonism to very aggressive encounters such as chases and fights (Saito et al. 1998). During the time of aggression, male macaques show the higher aggression than the female macaques (Saito et al. 1998). This might be due to the dominancy in male macaques (Cooper & Bernstein 2008) to protect their home range. Also smaller home range tend to make Japanese macaques more defensive thus leading to aggression (Saito et al. 1998).

5.2 Effects of human disturbance in grooming behavior of macaques

The results showed that there was no significant difference between the number of people and the time spent grooming when individual analysis was performed for LDA group male and female with number of people. This might be due to the area (habitat) the low disturbance group occupy/use. Since human had no access to the area where the macaques spent their time performing the social behavior, human presence didn't affect their behavior. Other analyses for the high disturbance group, where there were more human macaque interactions and overall male and female grooming activity in relation to human presence showed the negative effect of human disturbance on grooming behavior. Frequent interactions with humans lead to monitoring of the human activity by macaques which in turn leads to reduction in grooming behavior (Balasubramaniam et al. 2020). Increase in human macaque interaction leads to the shorter grooming bouts. In addition, in the area with higher human macaque interactions the grooming bouts were tend to be short due to more human vigilance (Kaburu et al. 2019, Balasubramaniam et al. 2020).

Primates tend to modify their activity in accordance to their anthropogenic environment (McLennan et al. 2017) but the research showed that primates modify their behavior also in relation to human presence (Kaburu et al. 2019, Balasubramaniam et al. 2020). Kaburu et al. (2019) explained that macaques' activities are not only directly affected by human presence,

they also have an indirect effect. In opposition to the fact that human presence affect the grooming activity of the macaque can potentially reduce the opportunity of the groomer to monitor humans or be vigilant towards the predators or conspecifics (Cords 1995, Kaburu et al. 2019). Bonnet macaques (*Macaca radiata*) showed reduction in grooming activity and partner diversity with regards to the time-constraints imposed by anthropogenic factors (Balasubramaniam et al. 2020).

Grooming is a social behavior which is not only influenced by the human presence but also can be strongly influenced by many socio-ecological or environmental factors such as group size, social stability (Balasubramaniam et al. 2018), dominance rank (Cooper & Bernstein 2008, Carne et al. 2011) and kinship (Ventura et al. 2006). These factors showed some variation in the grooming behavior of the macaques (Kaburu et al. 2019). Human macaque interactions can shape the grooming behavior of macaques even though the dominance rank is very clear (Kaburu et al. 2019). Grooming is one of the important social activities that is performed in primates (Jaman & Huffman 2013, Solanki et al. 2020). It plays a major role in the health and fitness of the primates (Akinyi et al. 2013). The study performed in the baboon population showed the skin wounds that was caused by the clustering of the ticks in various body parts which was formed due to inaccessibility of grooming (Akinyi et al. 2013). Even though grooming has a hygienic function, it is not the primary function of social grooming, physical characteristics also tend to influence the characteristic of grooming (Boccia 1983). The wild Japanese macaques groomed most those individuals from whom they receive more grooming and are from the higher rank (Ventura et al. 2006).

Despite the benefits of grooming, the human presence tend to negatively affect the grooming bout and grooming time of the macaques. Since no impact of human disturbance was observed in grooming behavior of the males and female macaques of LDA group, there might be other factors as well which affect the grooming time. Also, the further analysis to show why the human population did not affect the grooming time needs to be performed. It might be due to the provisioning of food for the macaques which might be the cause for increase in grooming time in low disturbance area or might be the less human macaque encounter. Detailed study must be conducted to know the proper reason behind it.

5.3 Effects of human disturbance in feeding behavior of macaques

From our research we found that there was no significant difference between the number of people and feeding activity of the macaques. Human disturbance didn't show any effect to the feeding behavior of macaques in both high disturbance area and low disturbance area and also the overall male macaques. This might be because of the adaptation of the macaques with the human interactions. In some cases it was also observed that there was food all over the ground but the macaques were not interested in feeding. After being full, they didn't seem to be interested in foods like rice grains, wheat and peas but in case of someone providing fruits such as bananas and apples, and juice, they immediately went to grab that and fed on it.

One of the reasons for not getting significant result might be due the sampling time of the research. There was the provisioning of food in the temple areas two times a day where macaques were provided with the boiled flour dough by the concerned authorities. Also, the individual people and organizations provide fruits and high calorie foods like grams, bananas and maize in the morning or the afternoon time. Due to intake of high calorie food, the macaques spent most of the time resting and performing social activities (Jaman & Huffman 2013). Those type of provisioning when done, if it exceeds the sampling time they were not noted. Also the rhesus macaques become more active and search for food in the morning and evening time which was also not covered in the data. Another reason might be the macaques were observed to feed on natural foods such as seeds, leaves and flowers. Even in human presence and they were being provisioned with the foods such as biscuits, they preferred to feed on natural food in the forested areas (Tang et al. 2016). Despite the scenario of feeding on natural food, macaques living in isolated habitats forage less and eat more human food (Wolfe 1992, Sengupta et al. 2014, Sengupta & Radhakrishna 2018). During feeding, natural food was consumed more in the morning (70%) and provisioned food were likely to be fed on afternoon (25%)(Gogoi & Das 2018). Thus, data sampled in the afternoon did not provide much of the evidence for the human disturbance effect in feeding behavior.

The feeding behavior of rhesus macaques also varies with the spatial distribution of the food, macaques' social rank and their desirability (Belzung & Anderson 1986). Access to human food is also influenced by the behavior of the macaques either by begging (Sengupta & Radhakrishna 2018) or by stealing the food or other valuable items (scarfs or glasses) which is carried by the visitors to the temple and trading them for food (Kaburu et al. 2019). As seen from the results, feeding on anthropogenic foods increase the time for resting and social

behavior in urban macaques (Jaman & Huffman 2013). In less human-modified environment, there is seasonal fluctuation on food availability. Therefore, time allocation for the resting, feeding and social interactions also change seasonally (Jaman & Huffman 2013) in addition, the macaques from the rural or wild macaques groups were observed to spent half of the sampling time feeding (Goldstein & Richard 1989). This implies that the urban macaques' group spent less time feeding which also might be the reason for the insignificant results from human disturbance.

However, the overall females from low disturbance area and high disturbance area did have slightly positive effect on the feeding behavior in presence of humans. They fed more when there was the presence of humans (Riley & Wade 2016, Sengupta & Radhakrishna 2018). The reason for female macaques showing the effect of human disturbance on feeding might be due to the fact that female macaques fed more than the male macaques in high disturbance area (Figure 15a). Female macaques being a lactating mother have high demand of nutritious food in comparison to male. So, they should feed as much as they can to fulfill this energy demand. So, provisioning of food by humans provide high nutritional value and more energy in a short period of time (Thatcher et al. 2019).

In a study, 60% of the people fed the macaques due to their begging/aggressive behavior (Sengupta & Radhakrishna 2018). Maximum aggressive encounters were also faced during the time of feeding (Southwick et al. 1976, Hill 1999), also especially in males because the male are dominant in the group (Kaburu et al. 2019) and the chance of feeding is also based on hierarchy (Jaman & Huffman 2013). To minimize the aggressive behavior during the feeding time various methods were deployed but the fact that availability of food sources peaks at a certain time of day led to the increased frequencies of agnostic interactions (Southwick et al. 1976, Hill 1999). However, provisioning of foods by humans provide the macaques with the benefits of minimizing foraging time (Kaburu et al. 2019), increased social behavior (Balasubramaniam et al. 2020) supports the dependency of macaques' in anthropogenic food (Sengupta & Radhakrishna 2018, Kaburu et al. 2019), risk of disease transmission and hinder the macaques' ecological role (Sengupta et al. 2014).

6. CONCLUSION AND RECOMMENDATION

6.1 Conclusions

In this research, the study was conducted among the two groups of Rhesus macaques in Pashupatinath Temple area that were exposed to differential level of human disturbance due to the accessibility of the visitors to the macaque habitat. Despite the group belonged from two different level of human disturbance, significant differences between the overall activities of the two groups were not found. However, there were differences between the activities such as grooming, feeding and resting of the males and females within and between the low and high disturbance group.

The result for the human disturbance on feeding behavior of low disturbance area was found to be insignificant, whereas there was negative effect of human disturbance on the grooming behavior of the high disturbance area. The reason might be the frequency of the human-macaque interactions in high and low disturbance group. Overall test for the male and females of both high and low disturbance group showed negative effect of human disturbance on grooming behavior.

The research did not show any difference in the feeding behavior of macaques in presence of humans in both high and low disturbance area. Whereas, increased feeding in the presence of humans was found in overall results for female from both areas. This might be due to more energy demands of female than male.

6.2 Recommendation

This research was conducted to see the effect of human disturbance on macaque behavior pattern. However, seasonal differences, day-wise differences were not included as factor for the change in behavior. To properly investigate the effect of human on macaques and effect of macaques on humans for the coexistence of both species following things can be done:

- Determine the effect of food provisioning and the nutritional value of food affect the social behavior
- Disease transfer due to human-macaque interactions

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APPENDICES

Appendix I: Data collection sheet for focal animal sampling

Observer's Name: …… Date: …….. Start time: ……. Group: ……..…

Specimen ID: ……..... Location: ……. Weather: ……

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APPENDIX II: Data collection sheet for instantaneous sampling

Time	No. of people	Grooming	Feeding	Moving	Sitting	Resting	Playing	Others
2								
4								
6								
8								
10								
12								
14								
16								
18								
20								

ANNEXURES

Annex I:

Table 4. Table showing the V value and P value for the Mann-Whitney U test for grooming at α=0.05.

Categories	V	P-value
G1 male vs G1 female	1861	<0.001
G2 male vs G2 female	2433	<0.001
G1 male vs G2 male	3823	0.5628
G1 female vs G2 female	4170.5	0.03644
Male (G1+G2) vs Female (G1+G2) (Unpaired)	27161	<0.001
Group 1 vs Group 2 (Unpaired)	41159	0.07789

Annex II:

Table 5. Table showing the V value and P value for the Mann-Whitney U test for feeding at α=0.05.

Categories	V	P-value
G1 male vs G1 female	2971	0.8091
G2 male vs G2 female	3524	0.3828
G1 male vs G2 male	3411	0.1167
G1 female vs G2 female	2583	0.004191
Male (G1+G2) vs Female (G1+G2) (Unpaired)	44196	0.6472
Group 1 vs Group 2 (Unpaired)	37341	<0.001

PHOTO GALLERY

Photo plate 1. Feeding on garbage

Photo plate 2. Feeding on roadside grass

Photo plate 3. Expecting food

Photo plate 4. Provisioned food

Photo plate 5. Dead infant

Photo plate 6. Social behavior