Beyond the forest: Intraspecific and interspecific aggression in Rhesus macaques (Macaca mulatta)

by

Charushree Santosh
Enrolment no: 50BB22A73008

Dissertation Thesis

Submitted to Academy of Scientific and Innovative Research

For the partial fulfilment for the degree

Master of Science
in
Wildlife Science

Under the supervision of

Dr. H. N. Kumara
&
Sh. Prashant Mahajan

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

AcSIR

July 2024

DECLARATION

I hereby declare that the work conducted under the thesis entitled **"Beyond the forest: Intraspecific and interspecific aggression in Rhesus macaques (Macaca mulatta)",** is a record of original and independent research work done by me and subsequently submitted for the award of the degree of **Master's in Wildlife Science** at the **Academy of Scientific and Innovative Research**. This research work has been carried out under the guidance and supervision of **H. N. Kumara**, **Principle Scientist**, and co-supervision of **Prashant Mahajan**, **Scientist-C** of Wildlife Institute of India, Dehradun. The work has not formed the basis for the award of any other degree, diploma, or any other qualification. I also declare that the thesis embodies my own work, analysis, observation, understanding and the particulars given in it are true to the best of my knowledge.

Charushree Santosh
Enrolment No: 50BB22A73008
Place: Dehradun
Date: 30 June 2024

H. N. Kumara
Supervisor

डॉ. एच एन कुमारा / Dr. H.N. Kumara
प्रधान वैज्ञानिक / Principal Scientist
सालीम अली पक्षीविज्ञान एवं प्रकृति विज्ञान केन्द्र
Salim Ali Centre for Ornithology and Natural
कोयम्बटूर - 641 108
Coimbatore (Post), Coimbatore - 641 108

Prashant Mahajan
Co-supervisor

CERTIFICATE

This is to certify that the thesis by **Charushree Santosh** entitled "**Beyond the forest: Intraspecific and interspecific aggression in Rhesus macaques (Macaca mulatta)"** is an original and independent research work submitted to the **Academy of Scientific and Innovative Research**, for the award of the degree of **Master's in Wildlife Science**.

Charushree Santosh has put one semester of research work embodied in this thesis under my guidance and supervision. The work presented in this thesis has not been submitted to any other University or Institute for the award of any degree, diploma or distinction.

(Dr. Ruchi Badola)
Dean
Faculty of Wildlife Science

H. N. Kumara
Supervisor
Dr. H.N. Kumara
Principal Scientist
Ali Centre for Ornithology and Natural
(Post), Coimbatore – 641 108

CERTIFICATE OF PLAGIARISM CHECK

It is certified that the Master's dissertation thesis titled **"Beyond the forest: Intraspecific and interspecific aggression in Rhesus macaques (Macaca mulatta)"** submitted by **Charushree Santosh** has been examined by us for plagiarism check as per UGC (Promotion of Academic Integrity and Prevention of Plagiarism in Higher Educational Institutions) Regulations. The following inferences are drawn from this check:

a) Thesis has significant new work/knowledge as compared to already published work or work under consideration for publication elsewhere.
b) No sentence, equation, diagram, table, paragraph or section is found to have been copied verbatim from previous work unless it was placed under quotation marks and the source was duly cited.
c) The work presented is original work of the author (i.e. there is no plagiarism) and there is no fabrication of data or result by manipulating research materials, equipment or processes, or by changing or by omitting data or results such that the research is not accurately represented.

The similarity indices for the individual chapters as reported by the software iThenticate are as follows:

S. No	Chapter	iThenticate® similarity index
1.	Chapter 1: Introduction	3 %
2.	Chapter 2: Study area	0%
3.	Chapter 3: Methods	1%
4.	Chapter 4: Results	3%
5.	Chapter 5: Discussion	4%
6.	Chapter 6: Conclusion	0%
Overall		**2%**

Dr. Manohar Pathak

Librarian

Dr H N Kumara

Supervisor

Dr. H.N. Kumara
Principal Scientist
Ali Centre for Ornithology and Natural
641 108
(Post), Coimbatore - 641 108

Contents

List of tables

Acknowledgment

This journey towards my Master's dissertation has been a rollercoaster of challenges and triumphs, and I wouldn't have made it without the support of so many amazing people.

First and foremost, my deepest gratitude goes to my supervisor, Dr. H. N. Kumara. Your guidance, expertise, and unwavering support have been the pillars of this project. I especially appreciate your patience while I wrestled with the proposal, your insightful feedback on countless ideas, and your encouraging words that lifted me up during setbacks. I'm equally indebted to my co-supervisor, Sh. Prashant Mahajan. Your willingness to share your knowledge and provide constructive criticism has been instrumental in shaping this dissertation into its final form.

A heartfelt thank you to my incredible batchmates, especially Tiew, Krishnapriya, Mukul, Aslam, Shashank, Nandita, Abhimanyu, Prakriti, Arnab, Niyaz, and Rishi. You guys are the reason I survived the "WII experience." Your unwavering support, understanding, and moments of laughter kept me going. Whether it was lending a listening ear during moments of frustration, celebrating milestones together, or simply providing a much-needed distraction, your friendship has been a constant source of strength. A one liner dedicated to Sneha from the junior batch for the support she provided on a short notice.

To my wider circle of friends (special mention to Swathi Arul) and family, my deepest gratitude for believing in me. Your willingness to support me in any way possible has meant the world. Thank you for understanding the demands of this project and for making sacrifices so I could focus on my work.

My deepest appreciation goes to the Wildlife Institute of India (WII) for providing the opportunity to pursue this Master's degree. The supportive environment and access to excellent resources have been invaluable to my academic growth.

Finally, I would like to thank Dr. Qamar Qureshi and Dr. Vishnupriya Kollipakam for their invaluable assistance with the statistical analysis of my research. Their expertise and guidance were crucial in ensuring the accuracy and robustness of my findings.

This dissertation would not have been possible without the contributions of each and every one of you. Thank you again for your unwavering support and encouragement.

Summary

Rhesus macaques and human have been coexisting from a long time. Living in such close proximity to each other have bought various challenges to both species. Some challenges could be solved by behavioural modifications. This study looks at how various factors affect the aggression in both macaques and humans towards each other and their conspecifics. This study helps in understanding the frequency of aggression in macaques towards each other and humans in different settings. Direction of major aggressive interactions and the factors behind these events were also noted. Human aggression towards macaques were also seen. Most common reason for human initiated aggression was property damage while, for macaques it was threat. This kind of behavioural studies help us manage conflict with this communal species and also lets us see how human presence and behaviour might influence macaque behaviour.

Chapter 1: Introduction

1.1 Introduction and Literature review

As the recurrence of human-induced environmental changes continues to rise, many species have adapted or are adjusting multiple aspects of their lives accordingly. Humans bear the cost of dealing with crop raiding, property damage, and personal attacks, while animals risk disruptions to their daily activities. Urban-dwelling animals often alter their daily activity patterns and natural movement patterns in order to avoid disturbances caused by humans (Gaynor et al., 2018; Brody & Pelton, 1989). This shows how human presence can alter the conditions under which animals make behavioural decisions (Wilson, 2020). Human activities can have a bottom-up effect on animal behaviour, as altering natural habitats and intentional or unintentional food provisioning aids a change in natural animal behaviour (Wilson, 2020). They can also create a top-down effect by changing animal threat perception behaviours. Population-dependent behaviours also alter significantly due to human interference in the form of excessive hunting, habitat destruction and others (Wilson, 2020). Behavioural changes due to noise pollution are well known. Numerous studies have shown that birds and amphibians call at higher frequencies than usual to overcome noisy areas (Caro, 2007). Due to the unrestricted expansion of industries, linear infrastructure construction, and agriculture, humans are shifting their boundaries beyond their land and ranging to animal territories (Estrada et al., 2017).

This increased overlap between human and animal ranges leads to more frequent interactions. Primates are one such taxa which shows an increased number of interactions with humans as land use changes have increased. Their behavioural modifications due to anthropogenic presence largely compromise primate survival and human safety (McLennan et al., 2017; Sih et al., 2011; Tuomainen & Candolin, 2011; Wong & Candolin, 2015). According to Estrada (2017), around 60% of the global primate population is threatened with extinction,

and nearly 75% have a declining population. They are distributed in the Neotropics, Asia, Africa and Madagascar. Southeast Asian countries account for 22% of these populations with rich primate diversity (Dwivedi, 2021; Estrada et al., 2017; Boonratana, 2014). India has 5% of the total primate population of the world, with 23 species across the country. These species can be divided into three families: Lorises (Lorisidae), Macaques & Langurs (Cercopithecidae) and Gibbons (Hylobatidae). (Menon, 2023; Divya, 2021; Boonratana, 2014; IUCN Red List). Humans live with these non-human primates, sharing spaces like forest edges and cities. As per IUCN, significant threats faced by primates are habitat loss due to agriculture, construction of linear infrastructure logging, livestock farming, hunting and illegal wildlife trading. Climate change also adds to these issues (Estrada et al., 2017).

Primates and humans share a close evolutionary history and contribute to the biological and cultural richness of the countries they inhabit. Many societies have tolerated primates as they are essential to their cultural and mythological narratives (Estrada et al., 2017). Studies on primates allow us to understand human evolution concerning behaviour, cognition, group living, tool use, language development, etc. Although with an ethical dilemma, they are used as a model organism for medical research (Estrada et al., 2017). They also help us study emerging and re-emerging diseases that can affect other primates and humans (Calvignac, 2012; Estrada et al., 2017). Primates play multiple roles within the food webs of ecosystems as prey, predator, pollinator, seed disperser, etc., and hence have a significant role in affecting the structure, function and resilience (Estrada et al., 2017). Hence, studying human-primate interactions becomes essential to understanding the positive and negative consequences of their behavioural adaptability. Such studies will also aid in understanding human perception and their primary responses regarding interactions with primates (McLennan et al., 2017; Hockings et al., 2015; Nowak & Lee, 2013).

Major places where human-primate interfaces exist are mosaic landscapes with multiple habitats like forests, rural and urban settlements, agriculture, etc. People are an inseparable part of most such primate habitats(McLennan et al., 2017). In high anthropogenic habitats, primates exhibit flexibility in their day-to-day behaviour. This shift is usually seen concerning changes in dietary preferences, daily activity, ranging patterns, habitat use, social organisation, risk-related behaviours, etc. (McLennan et al., 2017). Exposure to anthropogenic activities may also affect interactions of these animals, both intraspecific and interspecific, which can modify population and community dynamics in species (Bolnick et al., 2011), which may ultimately affect their survival and fitness (Kaburu, 2019; Lott & McCoy,1995; Lehmann et al., 2010). Kaburu (2019) mentions how the duration spent by Rhesus macaques resting and grooming significantly decreased with increased human interactions. As they are social animals, such restrictions in their daily behaviour might cost their fitness (Dunbar, 1992; Dunbar et al., 2009). Similarly, Menon & Poirier (1996) report that species like Lion-tailed macaques may avoid areas destroyed by human activities and spend more time travelling for food or avoiding humans while compromising their resting and social activity time. Cryptic behaviour to avoid detection by humans and domestic animals or aggression towards them (Kavanagh, 1980; McLennan & Hill, 2010; Beisner et al., 2015); changes in group dynamics (Cibot et al., 2015; Hockings et al., 2012); choices for sleeping or resting sites (Duarte & Young, 2011), are some other behavioural changes seen in primates. In the case of Rhesus macaques, studies indicate that they thrive while living alongside humans, as food provisioning is sufficient to allow them to spend time resting and grooming (Jaman & Huffman, 2013).

The Rhesus macaque (*Macaca mulatta*), which belongs to the fascicularis lineage (Thierry, 2007), is the most widely distributed macaque species. It can be found extensively across mainland Asia, from Afghanistan to India and Thailand to southern China (Thierry, 2007; Rowe, 1996; Smith & McDonough, 2005). The IUCN Red List of Threatened Species

lists them as least concerned. In India, they are present throughout the northern states and are now known to extend their ranges to south-eastern sectors of Bonnet macaques(Menon, 2023). These macaques' dwell in environments such as tropical, temperate, and subalpine forests, arid areas, coastal regions, rural areas, and even urban cities and towns, particularly near temples and roadsides (Thierry, 2007). Their body colour typically ranges from dusty brown to various shades depending on their geographical location, with all individuals exhibiting an orangish tint on their hindquarters (Menon, 2014). Adults are sexually dimorphic. They possess a moderately sized tail with a slight bend towards the tip. Due to their high adaptability, Rhesus macaques coexist harmoniously with humans and are primarily found in high population densities near human-inhabited areas. Their omnivorous feeding habits have facilitated the exploitation of available resources, with approximately 93% of their diet comprising human-derived sources (Southwick & Siddiqi, 1994). Natural components of their diet may include fruits, leaves, insects, seeds, and more. They also occasionally engage in raiding crops, garbage dumps, and even houses. The extent of their home range varies across different habitats depending on the availability of resources.

Macaques are more ecologically resilient to human-made environmental changes (Estrada et al., 2017). They are social animals and form multi-male/multi-female troops consisting of 20-250 individuals. Group living offers advantages and disadvantages due to conspecifics sharing similar ecological and reproductive needs (Honess, 2017; Krebs & Davies, 1993; Slater, 1999). The benefits of group living include increased foraging efficiency, reduced predation risk attributed to a higher number of vigilant individuals, enhanced access to potential mates, and potential assistance from other group members. Conversely, the costs associated with group living include competition for food, heightened predator attraction, increased susceptibility to disease transmission, and reduced individual reproductive success (Krebs, 2014). Individuals within the species may exhibit various agonistic or affiliative

behaviours to compete for survival and reproductive success. Aggression is often a primary mechanism for gaining access to vital resources such as food and mates (de Waal, 2000). Therefore, aggression plays a pivotal role in the natural behaviour of animals, particularly in species that exhibit group living. Aggressive behaviours in primates can occur in multiple contexts, including anti-predatory strategies and intertroop resource defence (Honess, 2006). Hence, aggression was always recognised as a critical element of primate social behaviour (Bernstein & Gordon, 1974; Deag, 1977; Hall, 1964). Aggression within a troop is integral to maintaining a social hierarchy and securing access to high-quality food, mates, and resting sites, thus ensuring overall fitness (Bernstein, 1976). Various factors such as age, sex, hierarchy, troop size, and composition influence agonistic interactions within the group. However, the effects of human presence and behaviour on these interactions remain poorly understood (Theil, 2017). Interactions with its conspecifics and other species and its environment have ecological implications like seed dispersal, parasite transfer, nutrient cycling, and many others, which can be altered due to human presence (Sih et al., 2010; Start & Gilbert, 2017).

Intratroop aggression is seen to increase in areas where food provisioning was common, e.g., *Macaca sylvanus* (El Alami et al., 2012; McLennan et al., 2017). Food provisioning significantly increases the frequency and duration of such agonistic interactions (Hsu, 2009). Along with food, intimidatory displays by humans like sustained eye contact, pointing, touching or attempting to touch young ones, taunting with food, etc., increase aggression towards humans (Beisner et al., 2015; Fuentes & Gamerl, 2005; McCarthy et al., 2009). This type of human behaviour is more common in tourist spots than in other places (Maréchal, 2016). Aggression initiated by humans is primarily in cases of property damage by macaques

or when an attack is directed towards them (Beisner et al., 2015). On the contrary, Hsu et al. (2009) found that in a nature park in Taiwan, 85% of aggressive incidents towards Formosan macaques were initiated by humans, appearing unprovoked, while the remaining 15% involved humans defending their possessions. Different species are seen responding differently to threats undertaken by humans. The Formosan macaques usually display submissive behaviour in reply to an agonistic interaction initiated by a man (Hsu, 2009).

Most work on anthropogenic effect on behaviour consists of comparing habitats with two extreme levels of exposure to humans (Jaman & Huffman, 2013; Saj et al., 1999), but there are very few studies which try to capture this topic across a variety of interfaces as there might be behavioural differences within such landscapes (Fuentes, 2012; Kaburu, 2019; McCarthy et al., 2009). This study looks into four such habitats and also adds to the study by Beisner(2015) to see a decadal change in the behaviour of Rhesus macaques and humans.

It has become increasingly important to understand how various species adapt to human-induced changes and to what extent their behavioural flexibility can aid in their survival amid ongoing environmental changes (Estrada et al., 2017) as more and more primate populations come into contact with anthropogenic environments (Kaburu, 2019). These interactions typically indicate broader conservation issues that must be addressed (McLennan et al., 2017). Therefore, a more comprehensive approach needs to be adapted for primate conservation. An interdisciplinary approach has to be adapted to understand the connectedness, both social and ecological, of humans as well as primates. This particular approach is now termed ethnoprimatology, a growing field of study (Fuentes, 2012; Fuentes & Hockings, 2010; McLennan et al., 2017). Such studies help us recognise mechanisms that will enable us to achieve sustainable human-primate coexistence (McLennan et al., 2017).

1.2 Objectives

This study investigates the aggressive behaviour seen in Rhesus macaques towards their conspecifics and also towards humans and aggression of humans towards the macaques in different habitats with varying levels of exposure to humans.

1.2.1 Objectives

1. To study the intraspecific aggression in Rhesus macaques across different habitats.

a. To study the frequency, direction and nature (level of aggression) of aggression across different age-sex classes of rhesus macaques.

b. To study the proximate factors influencing aggressive behaviour during such interactions. (Broad categories : food, dominance, threat).

2. To study the interspecific aggression in Rhesus macaques across different habitats.

a. To study the frequency, direction and nature (level of aggression) of aggression across different age-sex individuals of rhesus macaques.

b. To study the proximate factors influencing aggressive behaviour during such interactions. (Broad categories : food, approach, taunt, threat)

1.2.2 Hypothesis

- Intraspecific and interspecific aggression will be higher in human dominated areas, owing to concentration of resources and possible threat perception.
- More aggression will be shown by adult macaques than other age classes.
- More aggression would happen in the context of food.

- Adult human males are more likely to get involved in showing aggressive behaviour towards the macaques.

1.2.3 Research questions

1. What is the frequency of intraspecific aggression between troops of different sites?
2. Which age and sex class of macaques exhibit intraspecific aggression more in different sites?
3. What is the frequency of interspecific aggression interactions in different sites?
4. Which age and sex class of macaques show interspecific aggression more in different sites?
5. Which age and sex class of humans are more likely to get in an aggressive interaction with macaques?

Chapter 2: Study area

The study was conducted in four different locations of Dehradun district in Uttarakhand (Figure 1). Broadly the forest type of this place is tropical moist deciduous. These sites were chosen on the basis of level of human presence in them which translates to the factor of exposure of Rhesus macaques to humans. The locations were:

- Dat Kali Temple - A temple dedicated to the Hindu Goddess Kali. This place is a famous as hundreds and hundreds of devotees visit this place daily. The macaque troop in this site had the highest percentage of exposure to humans. The landscape is mosaic type with slightly open forests, roads, garbage dumps, few homes and shops near the temple. The temple holds 'langar' which is communal meal shared by devotees daily. Hence huge amount of kitchen waste is generated here. Along with it, temple waste like flowers, sweets, decorations, clothes offered to gods, etc are also generated in high amount daily. These are thrown not very far from the temple and macaques can be seen foraging through the waste. Due to religious sentiments, direct provisioning (distributing food) to macaques is a very common sighting here. Incidences of Macaques stealing and snatching food item (prasad) from the devotees are also high here.

- Buddha Temple – This is a site with tourist influx. It is a park like spot with Buddhist stupas. It is present in Clement town and has a mosaic type of landscape with forest, roads, garbage dumps, and residence place surrounding the park. The number of residences here is higher compared to Dat kali but the exposure of macaques to humans is comparatively less. A road separates the forest edge and residence area. Household kitchen waste and scraps are thrown to the forest edge making macaques sustain on these wastes. Along with this direct provisioning

also takes places but are mostly done by non-residents. Devotees and tourist offer food to them for their religious believes and amusement. Occasional stealing from houses is also noted. The forest offers a refuge for resting during day time for the macaques. The troop selected for the study spent lesser time inside the park. They mostly stayed near the forest edge and road going back and forth inside the residences and forest.

- WII Campus – This place is similar to the landscape of Buddha temple. The area is scattered with forest patches, roads and resident houses. Exposure to humans is on similar range with Buddha temple. As the campus forest offers refuge plus food resources, consuming provisioned food is comparatively less here. Inside the campus, macaques are seen to feast on different plant species like *Mangifera indica*, *Syzygium cumini*, *Ficus hispida*, *Morus alba*, etc. As the refuge spots are scattered along with houses, they spent a major amount of time resting on roofs of these houses.

- Lachhiwala Range – This range is divided into two parts by the Haridwar-Dehradun road. The landscape shares similarities with the rest with additions of few factories and a small orchard. Though exposure is least in this site, direct and indirect provisioning happens very often here. Travellers often stop to feed the macaques or sometimes to throw garbage. Although there are garbage bins, they are open and hence are raided by macaques at least thrice a day for food. Offering food for devotional reasons and amusement are also seen. People residing near by also throw kitchen waste towards the forest. At times, medical waste like syringes, medicines, protective clothing are also discarded here.

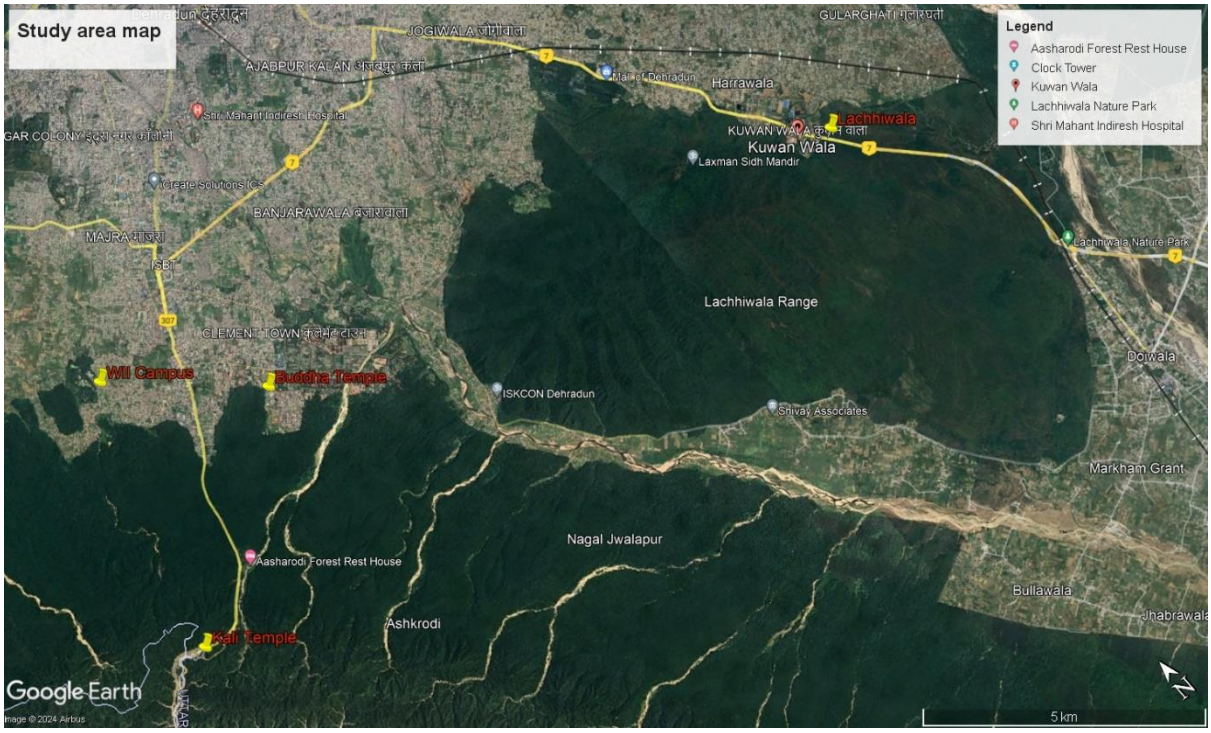

Figure 1. Map showing all four sites : Kali temple, Buddha temple, WII Campus & Lachhiwala.

Chapter 3: Methods

The field study was conducted from January 2024 to May 2024. Four sites in Dehradun were selected. Within these four sites, four troops were selected from each site having similar troop size and composition. Site and troop selection was done from late December till early January before systematic data collection started.

3.1 Site and troop selection

3.1.1 Site selection

The sites were selected on the basis of percentage of exposure of macaques to humans. (Figure 2). Scan sampling was conducted every hour during the sample collection period for the same. The number of people were segregated into five categories: 0 (no humans seen), <50, <100, <150, <200 and >200. The macaques near the Kali temple had the most frequent human contact, with very few instances of zero exposure. In contrast, the Buddha temple troop primarily encountered small groups of less than 50 people. The campus macaques experienced the most variation, with roughly half the time having no human presence and rarely seeing more than a small crowd (under 100 people). Finally, the Lachhiwala troop consistently had the least human interaction, never encountering more than 50 individuals at once.

3.1.2 Troop selection

Multiple troops in these four sites were observed and troops with similar troop size and composition were chosen. The troop size and composition of the target troop in every site is

given below (Table 1,2,3,4). All the individuals of the troop have been identified according to their age and sex classes. Infants are divided into older ones and young ones as March and April is the birthing season of these macaques. The feasibility to follow each troop was also taken into consideration before selecting them. The tables (1,2,3,4) show the troop size and composition over the period of study.

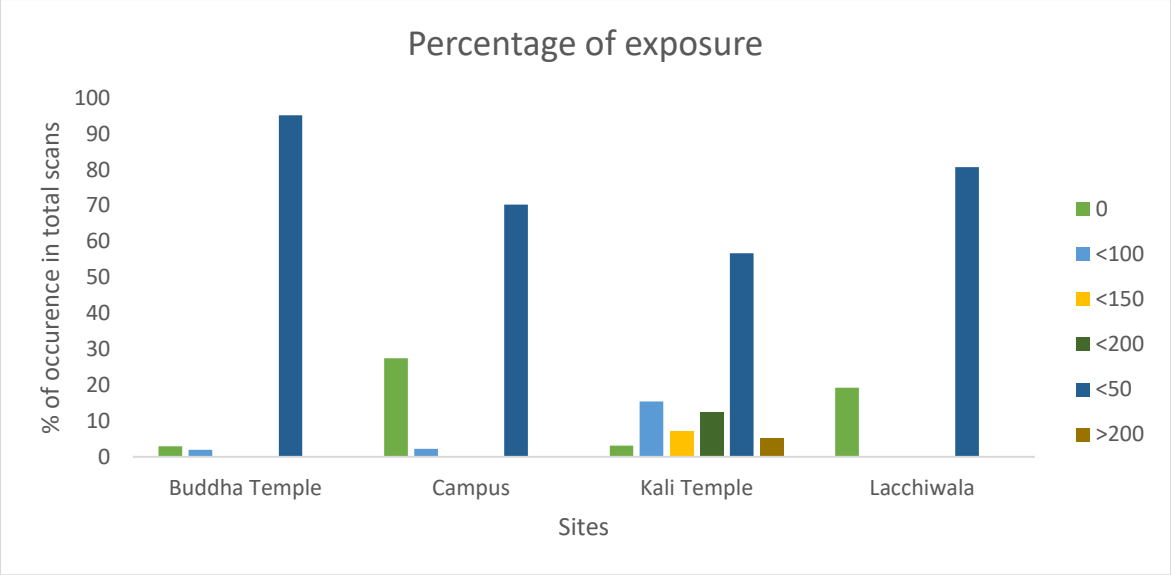

Figure 2. Percentage of exposure of Rhesus macaques to humans

Table 1: Age-sex structure of the troop in Kali Temple.

Site	Month	Individuals							Total
Kali Temple		AM	AF	SAM	SAF	I (older)	I (younger)	J	
	January	3	13	4	4	10	0	8	42
	February	4	13	4	4	10	0	8	43
	March	4	14	4	3	10	1	8	44
	April	4	14	4	3	10	3	8	46
	May	4	14	4	3	10	5	8	48

Table 2: Age-sex structure of troop in Buddha Temple.

Site	Month	Individuals							Total
Buddha Temple		AM	AF	SAM	SAF	I (older)	I (younger)	J	
	January	3	12	5	3	9	0	12	44
	February	3	12	5	3	9	0	12	44
	March	3	12	5	3	9	1	12	45
	April	3	12	5	3	9	3	12	47
	May	3	12	5	3	9	3	12	47

Table 3: Age-sex structure of troop in Campus.

Site	Month	Individuals							Total
Campus		AM	AF	SAM	SAF	I (older)	I (younger)	J	
	January	4	14	5	4	12	0	9	48
	February	4	14	5	4	12	0	9	48
	March	4	14	5	4	12	1	9	48
	April	4	14	5	4	12	3	9	50
	May	4	14	5	4	12	4	9	51

Table 4: Age-sex structure of troop in Lachhiwala

Site	Month	Individuals							Total
Lachhiwala		AM	AF	SAM	SAF	I (older)	I (younger)	J	
	January	4	15	7	3	7	0	16	52
	February	4	15	7	3	7	0	16	52
	March	4	15	7	3	7	0	16	52
	April	4	15	7	3	7	1	16	53
	May	4	15	7	3	7	4	16	56

Table 5. Number of scans per site

Sites	Kali Temple	Buddha Temple	Campus	Lachhiwala
Number of scans	106	98	78	100

3.2 Habituation and sampling time

For habituation, every troop was followed for the whole day, for 3-5 days per troop prior data collection started. The troops were followed for 6 to 9 hours a day at any time between 0700 hours to 1800 hours during data collection. One troop was followed for 3 consecutive days which is considered as 1 session. After every session the troops were switched. Every troop has been sampled for 95 - 100 hours.

3.3 Data collection

Instantaneous scan and all occurrence sampling methods were used for data collection (Altmann 1974). Nikon aculon A211 binoculars were used. Every hour two scans (one for macaque activity and one for number of humans and other animals) were taken. Whenever an aggressive interaction was noticed, the incident was recorded.

3.3.1 Activity budget

Instantaneous scan sampling was done for data collection (Altmann 1974). Scan was taken for five minutes every hour from 0700 hours to 1800 hours. During scan, the time, age and sex category of the individuals seen (adult male, adult female, subadult male, subadult female, infant and juvenile), the activity they are performing were noted down.
For simplicity, 30 behaviours are grouped into 5 categories for activity budget graphs. The 5 major groups and included behaviours are as follows:

- **Feeding:** when an individual is ingesting food (leaves, fruits, twigs, insects or provisioned food material) or is actively searching for food.

- **Moving:** when an individual is moving from one place to another. Includes walking, running, jumping from one substrate to another.
- **Socialising:** when an individual is directing a behaviour towards another individual in the troop. It includes allogrooming, playing and mating. Nursing by mothers and suckling by infants is also included in this group.
- **Resting:** when the individual is inactive. Includes sitting, sleeping and laying down.
- **Others:** this group includes behaviours like huddling, standing, scanning, masturbating and auto-grooming.

A total of 382 scans were taken during the study period. A summary of the number of scans in all four locations is given in Table 5.

3.3.2 For objective 1: Intraspecific aggression

As mentioned previously, all occurrence sampling was done to collect data for understanding intraspecific aggression. Data was collected whenever an aggressive interaction occurred between the individuals of the troop. Time, age and sex class of the actor and receiver, behaviour exhibited by the actor, causal factor(food, dominance, threat, intertroop aggression & aggression spillover), level of the aggressive behaviour exhibited (classified into high, mid and low categories) and duration of the incident was noted down. Aggressive behaviours were grouped into high, mid and low level of aggression depending on the extent of contact during the event. Behaviours like brow raising and open mouth threats were classified under low level while, mid-level of aggression consisted of behaviours like lunging, charging and chasing. Contact aggression like slapping, biting, pulling and pushing were categorised in high levels. A total of 1140 incidents of intraspecific aggression was observed and is used for analysis.

3.3.3 For objective 2: Interspecific aggression

Instances of interspecific aggressive interaction by Rhesus macaque especially with human will be noted. Humans like macaques will be classified according to age and sex classes as: children, adult males and adult females. And the data collection on their interaction with macaque will be collected as mentioned above under all occurrence or event sampling. 1333 incidents of interspecific aggressive incidents were observed and noted. This includes aggression initiated from macaques towards other animals, especially humans and also cattle, dogs and birds and vice versa. For humans, level of aggression is classified as low (shout), mid (raise hand/ stick, charge) and high level (touch, throw stone/ stick). Causal factors for intraspecific aggression were: for macaques (food, dominance, threat) and for humans (attacks, fear, property damage, food, taunt).

3.4 : Analysis

3.4.1 Activity budget

Activity budget was calculated with scan data. Data points were taken in percentage to make activity budget graphs. Multiple activity budgets were created: one showing activity budget across all the sites and others specific for each site. Age and sex classes of individuals were also considered while making the latter. G-test of Independence was used to understand the differences among the sites and also different age and sex class of individuals.

3.4.2 For objective 1 & 2: Intraspecific aggression and Interspecific aggression

G test of independence was used to understand the significant difference in frequency, level of aggression and proximate factors while Pearson's Chi squared test was used to test for significance in frequency, level of aggression and proximate factors across age and sex classes. For direction of aggression, UCINET 6 software was used. It gives a visual representation of aggressive interaction between different age and sex class. It also gives weights for each interaction which helps us understand the intensity of the interactions. The network has nodes which represent each age and sex class in a troop. Line of different width are present which ends in an arrow head pointing towards the receiver. The weights of each interaction are given along the line representing the same interaction. The red nodes are actors and the blue ones are receivers of aggression.

For interspecific aggression, humans were only categorised as adult male, adult female and immature (children) for simplicity. Nodes indicating human individuals as denoted with '_H' and '_M' for macaques as suffix.

Chapter 4: Results

4.1 Activity budget

4.1.1 Activity budget across sites

The graphical representation (Figure 3) below describes the general activity budget of activities (feeding, moving, resting, socialising and other) across all four sites. Major activity shown by the troop near Kali temple is resting (32.95%) followed by moving (24.16%), socialising (22.87%) and feeding (17.19%). The troop near Buddha temple also spent more time resting (40.45%). This was followed by moving (22.90%), socialising (23.28%) and feeding (9.43%). In Campus, the troop spent more time resting (36.84%), then socialising (31 .80%), moving (22.48%) and finally feeding (6.06%). Activity budget of Lachhiwala is similar to that of Kali temple. The troop there spend most of their time resting (35.59%), followed by socialising (25.08%), moving (22.30%) and finally feeding (16.08%). Other behaviours like scanning, standing, and auto-grooming were highest in Buddha temple (3.90%) and least in Lachhiwala (0.92%). There was a significant difference in time spent in different activities by the troops in different sites ($G = 166.01$, X-squared df = 12, p-value < 2.2e-16).

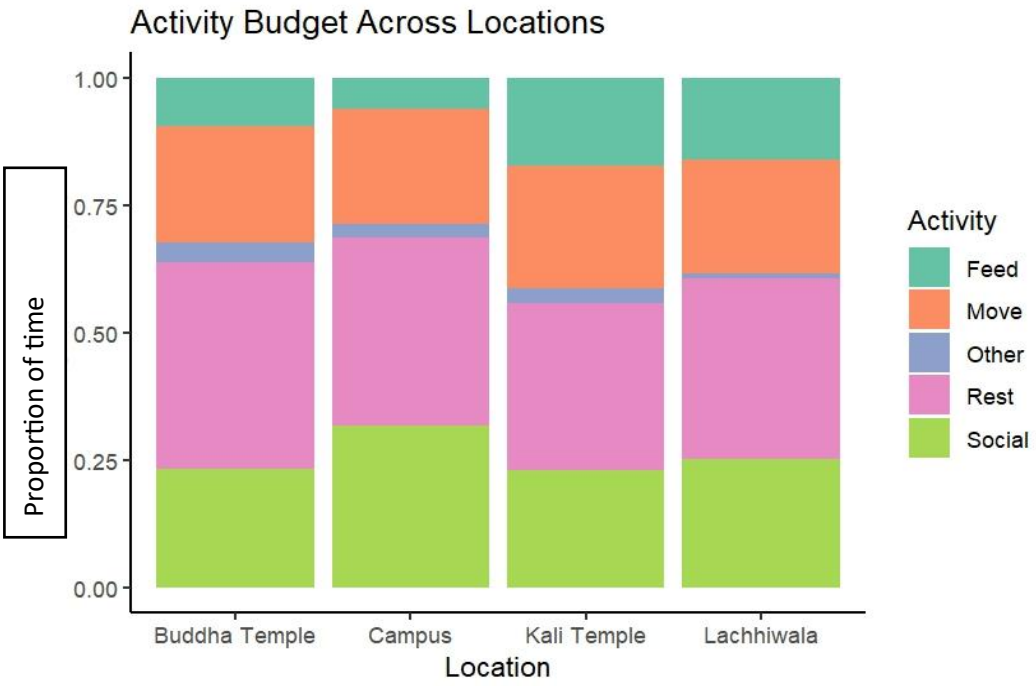

Figure 3. Stacked column bar graph representing activity budget of macaques

4.1.2 Activity budget across age-sex classes

In the troop near Kali temple (Figure 4), the adult females and subadult females are seen spe nding more time resting (38% and 37%) respectively. Similar amounts of time (22% and 21%) are spent by adult males and females feeding respectively. With respect to socialising, infants a nd juveniles spend more time (37% and 33%) respectively. Movement was shown mostly by subadult males (39%) while they showed least interest in socialising (3%). (X-squared = 158.0 8, df = 20, p-value < 2.2e-16).

Resting behaviour is more prominent in the graph (Figure 5) representing the activity budget of troop in Buddha temple. Individuals which spent maximum time in resting (54.94%) are subadult females while, infants showed least time spent (30.63%). Social behaviours were sh own most by infant (35.54%) while subadult males showed least (8.96%). Time spend in fee ding was more or less similar in this troop. Subadult males moved more (37.68%) while least was by juveniles (19.92%). (X-squared = 86.82, df = 20, p-value = 2.653e-10)

In the campus troop, resting behaviour is shown more by adults and subadults of both genders. Infants and juveniles rested for the least time as they spend more time in socialising (45% and 43% respectively). Social behaviour was least displayed by subadult males (9%) but had maximum movement (36%). Subadult females were more stationary compared to other classes (18%). Percentage of time spent in feeding was more or less similar across all age and sex class. (X-squared = 146.66, df = 20, p-value < 2.2e-16). (Figure 6)

In Lachhiwala, resting behaviour is seen most in adult females (46%), followed by adult males and subadult males (43% and 41% respectively). As seen in previous troops, social

behaviour is seen most in infants (43%) and juveniles (36%), while subadult males show least (7%). Here, movement was shown most by adult males (34%) and least by juveniles (15%). Time spent feeding was similar but among all subadult male spent more time feeding (24%). (X-squared = 230.12, df = 20, p-value < 2.2e-16). (Figure 7)

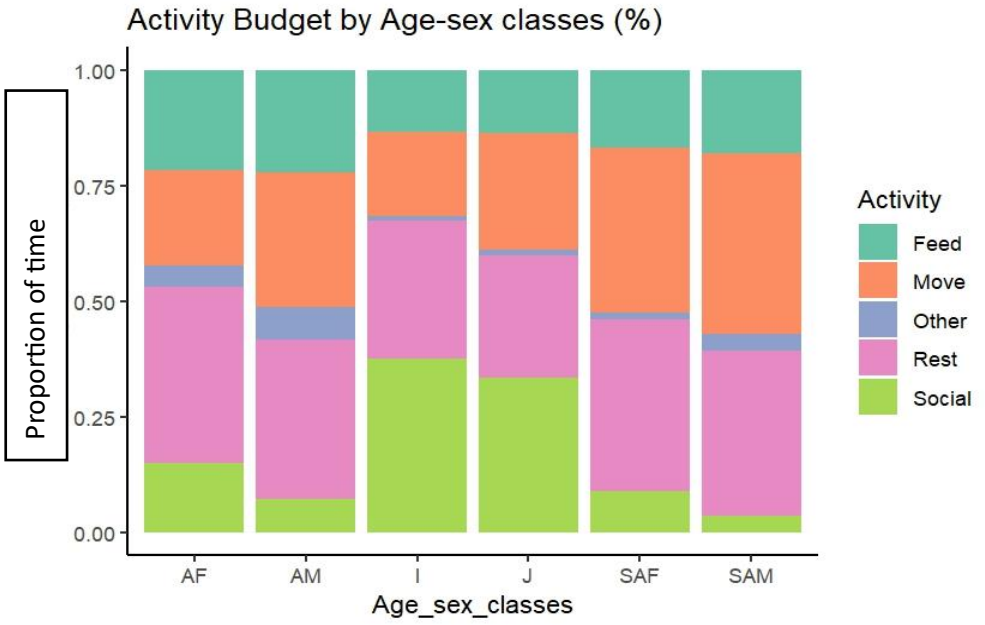

Figure 4. Stacked column bar graph representing activity budget of individuals of all age and sex class in the troop in Kali temple

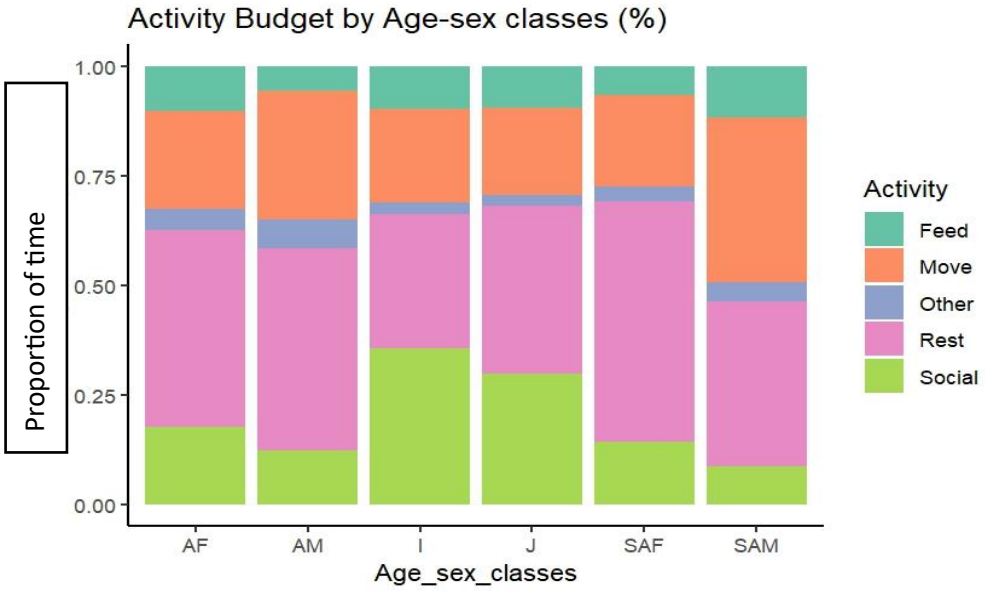

Figure 5. Stacked column bar graph representing activity budget of individuals of all age and sex class in the troop in Buddha temple.ar

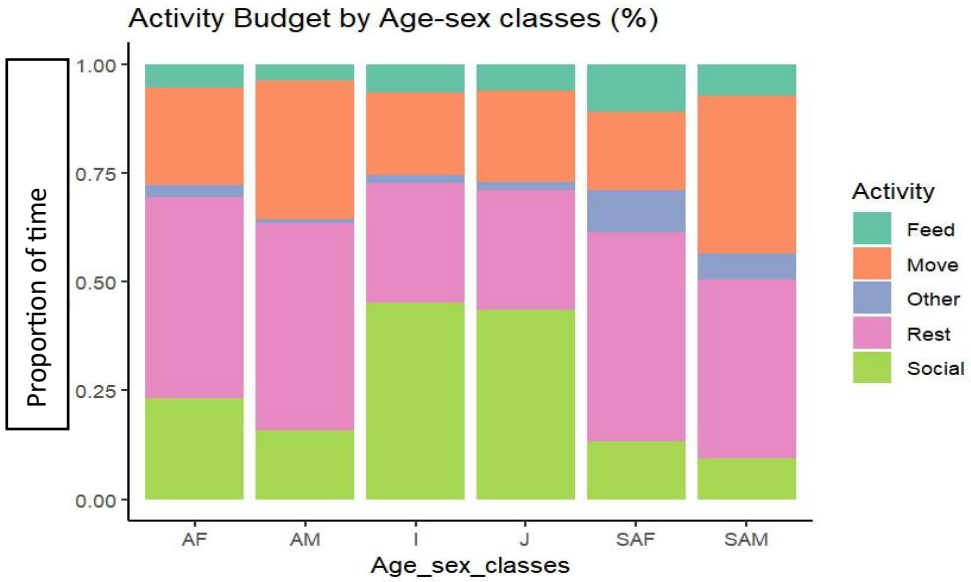

Figure 6. Stacked column bar graph representing activity budget of individuals of all age and sex class in the troop in WII Campus

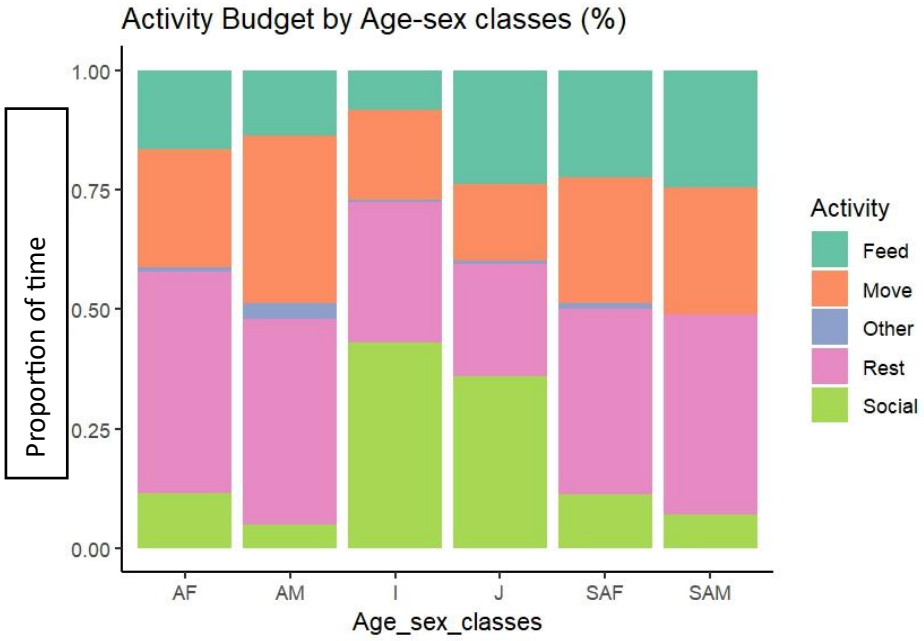

Figure 7. Stacked column bar graph representing activity budget of individuals of all age and sex class in the troop in Lachhiwala.

4.2 For objective 1: Intraspecific aggression

4.2.1 Frequency of aggression across sites

Lacchiwala is seen to have high percentage of aggressive incidents (28%), preceeded by Kali temple (27%). Both Campus and Buddha temple have same percentage of aggression (21%). There is a significant difference in aggressive incidents across these 4 habitats (G test of Inde pendence G = 19.432, X-squared df = 3, p-value = 0.0002225) (Figure 8)

4.2.2 Frequency of aggression across different age and sex classes

Adult females of Lachhiwala troop showed the most aggression (31%) while in Buddha temple the females were less aggressive (18%). In case of adult males, similar percentage of aggression was shown across all sites. Subadult males are highly aggressive in Lachhiwala (48%) while the same class showed least aggression in Buddha temple (7%). Subadult females in Kali temple showed most aggression than other sites (39%) while least was in Campus (12%). In the previous three classes, individuals in Kali temple showed aggression than the ones in Campus. (Pearson's Chi squared test X-squared = 50.519, df = 9, p-value = 8.603e-) (Figure 9)

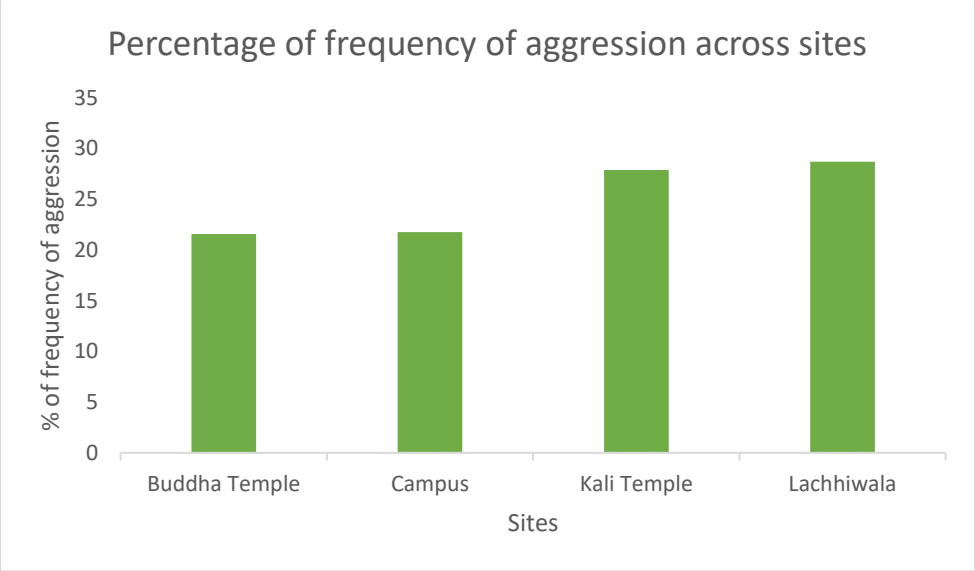

Figure 8. Bar graph showing frequency of intraspecific aggression across the sites

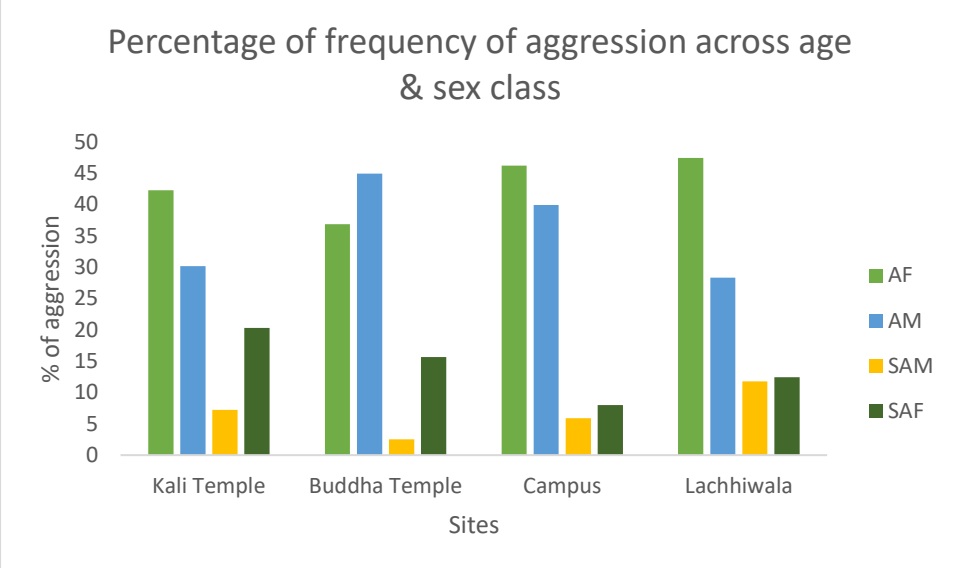

Figure 9. Bar graph showing frequency of intraspecific aggression across age and sex classes in all sites

4.2.3 Direction of aggression in each troop

In Kali temple, highly weighted interaction is between Adult male and Adult female (weight – 23.0). Subadult female was involved in such incidents very less. (Figure 10) Highly weighted interaction in Buddha temple was between adult male and adult female (weight – 35.0). aggression from and towards subadult females were very less. (Figure 11) In Campus, the highest weighted interaction (39.0) was between adult males and adult females. It is followed by interaction between adult females with each other and adult females towards infants (weights of both interaction- 35.0). aggressive interaction towards subadult females and from subadult males to adult males were the least (1.0). (Figure 12) In Lachhiwala, interactions of adult females to each other is most prominent (38.0). Adult females' aggression directed towards infants are also high (36.0). Incidents from subadult males to each other were least (1.0). (Figure 13)

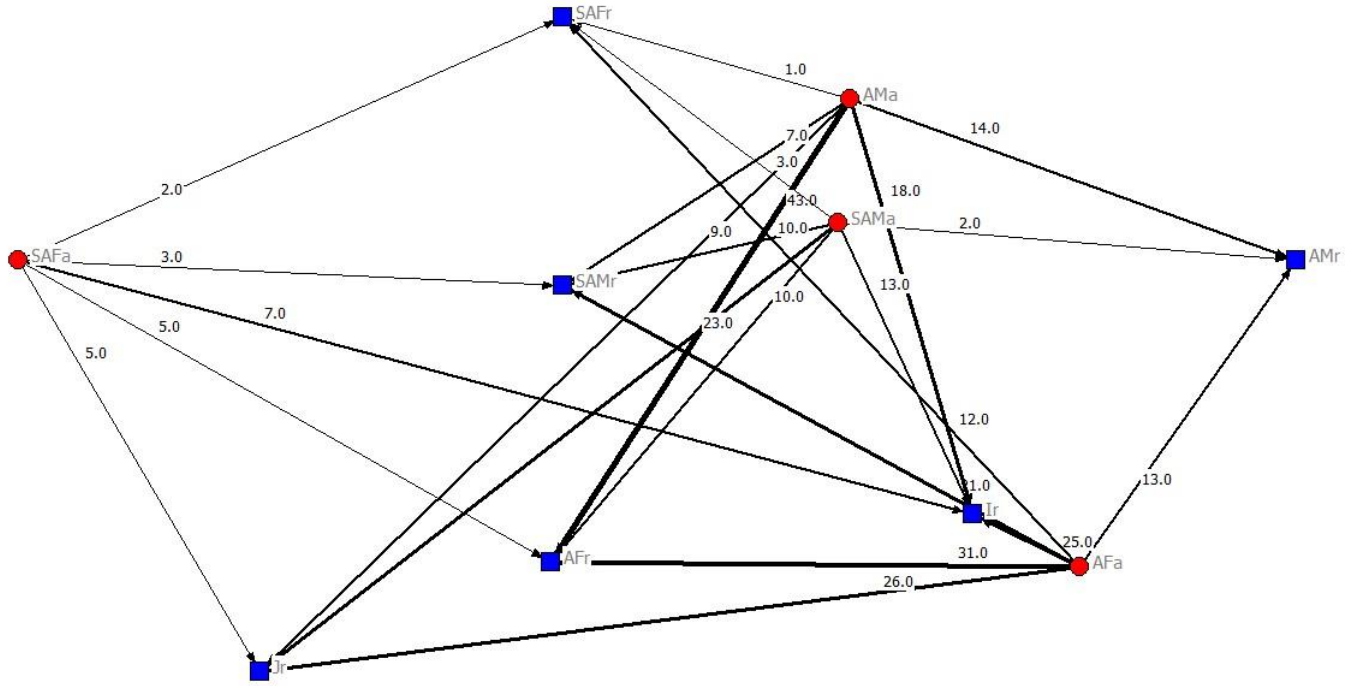

Figure 10. Social network for aggressive interaction in Kali temple

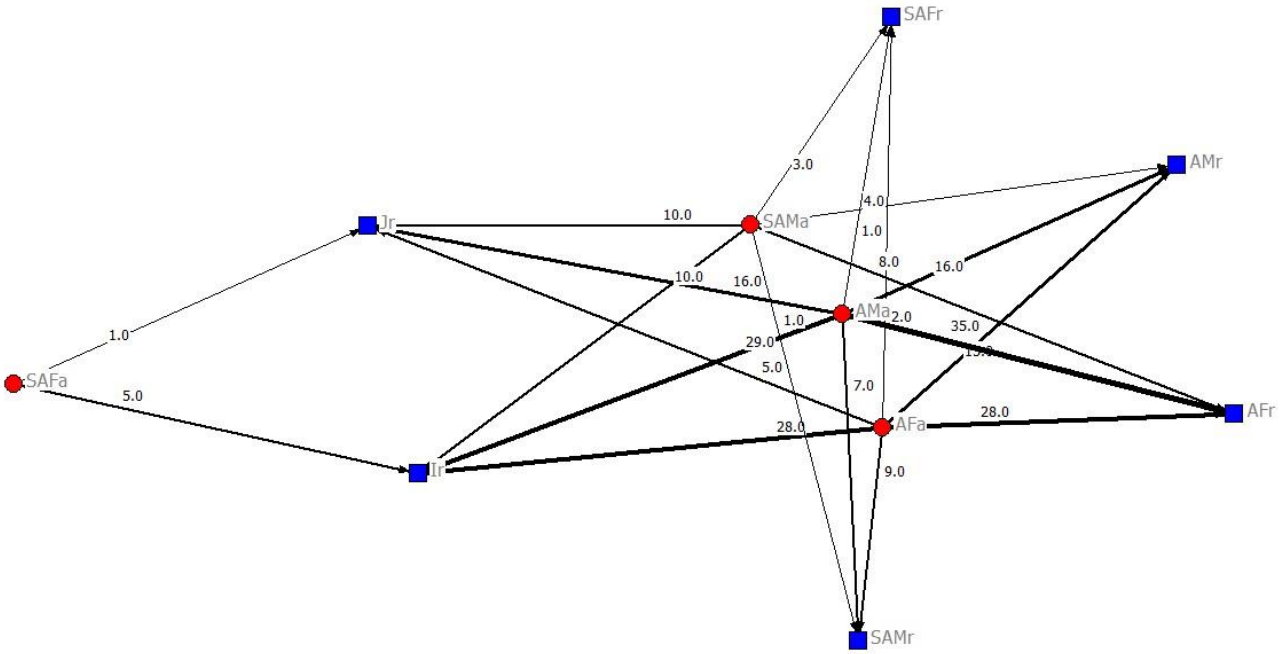

Figure 11. Social network for aggressive interaction in Buddha temple

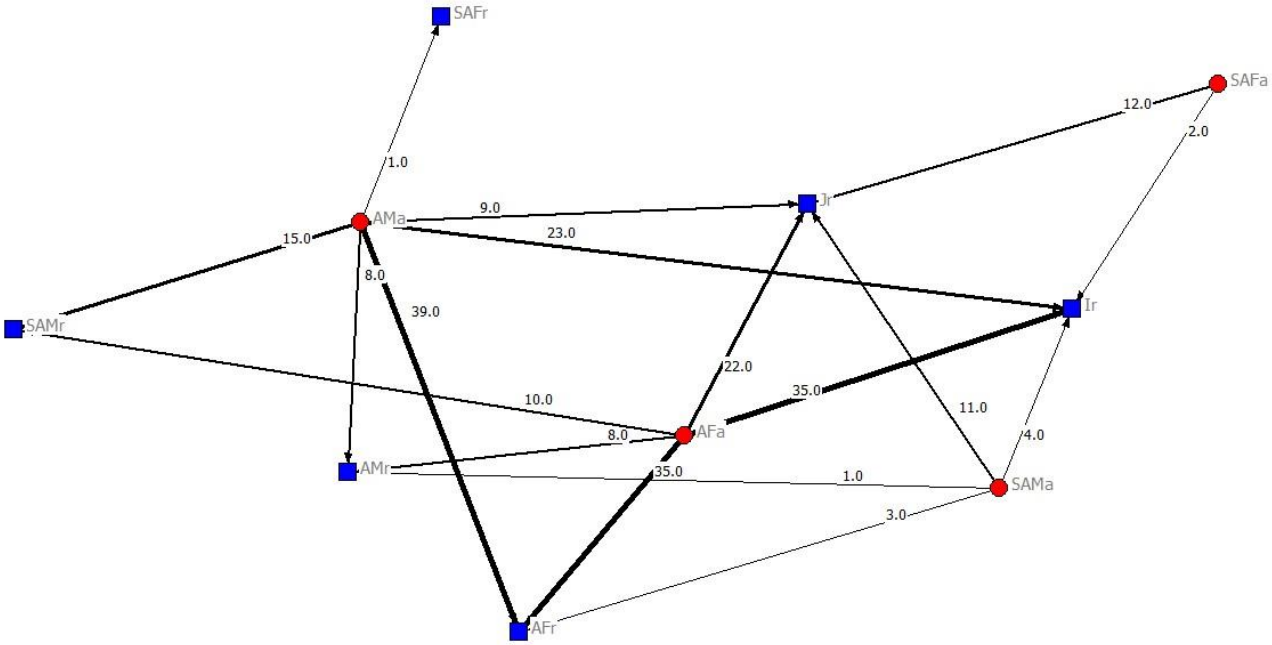

Figure 12. Social network for aggressive interaction in Campus

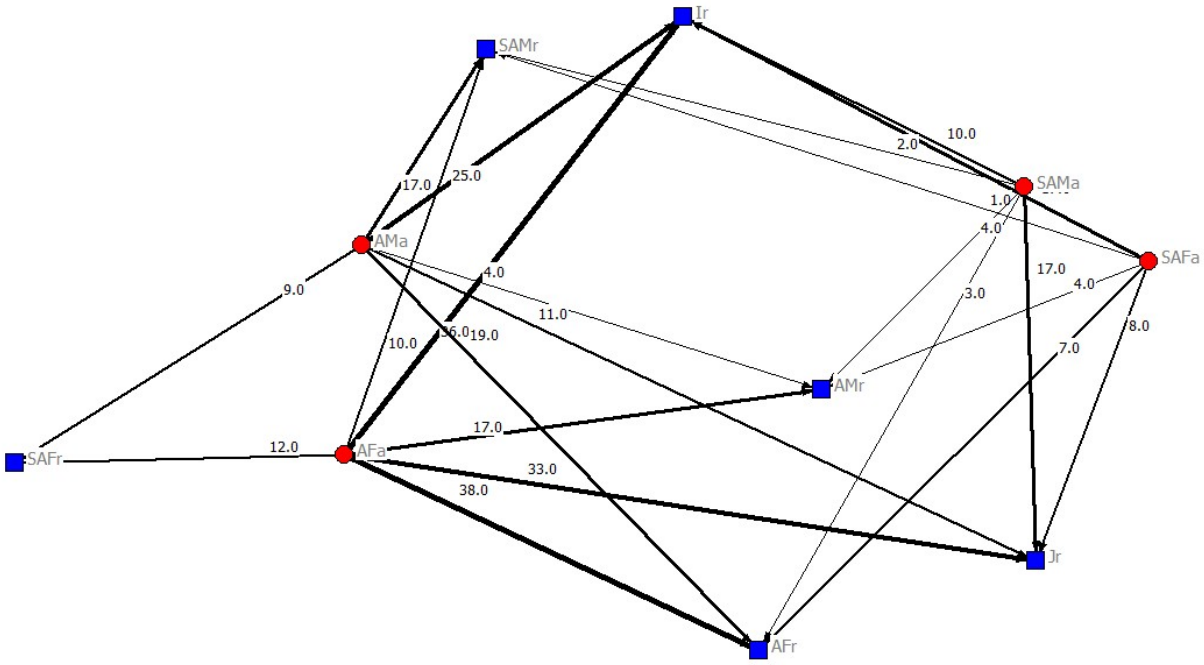

Figure 13. Social network for aggressive interaction in Lachhiwala

4.2.4 Level of aggression across sites

Mid level of aggression is seen more across all sites. It is particularly higher in Campus (61%). High level of aggression is quite low here (12%). Percentage of high level of aggression is similar in Kali and Buddha temple (17%).(G = 15.642, X-squared df = 6, p-value = 0.01581) (Figure 14)

4.2.5 Level of aggression across different age and sex classes

By performing Pearson's Chi-squared test for understanding the association between level of aggression and different age and sex classes, we have:

In Kali temple, (X-squared = 5.5894, df = 6, p-value = 0.4707) statistically, there is no association between the level of aggression and the age and sex class of the individual showing aggression. Although graphically, females are shown to initiate high level of aggression here, followed by subadult males. (Figure 15)

In Buddha temple, (X-squared = 25.915, df = 6, p-value = 0.0002309) showing association be tween level of aggression and the age-sex class of initiator. Here also, high level of aggressio n was mostly shown by adult females. Low level of aggression is mostly seen in adult males. (Figure 16)

In Campus, (X-squared = 8.3592, df = 6, p-value = 0.2129)statistically no association is seen. Graphically, adult females engage in both high and low levels of aggression. Adult males mo stly engage in behaviours categorized as mid-level of aggression. (Figure 17)

In Lachhiwala, (X-squared = 26.492, df = 6, p-value = 0.0001802)similar results for adult fe males as before.mid level of aggression is exhibited more by adults of both sexes. (Figure 18)

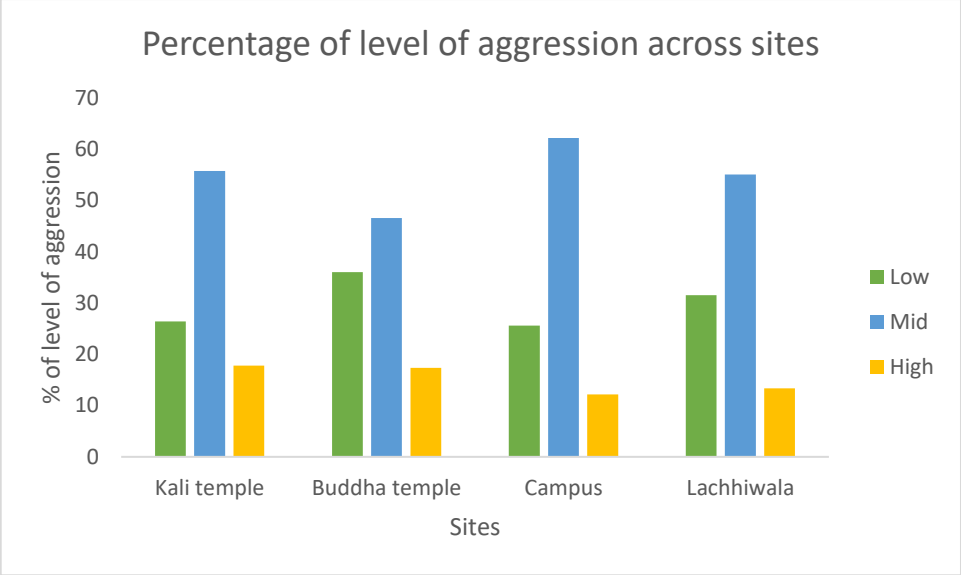

Figure 14. Bar graph of Level of aggression across different sites

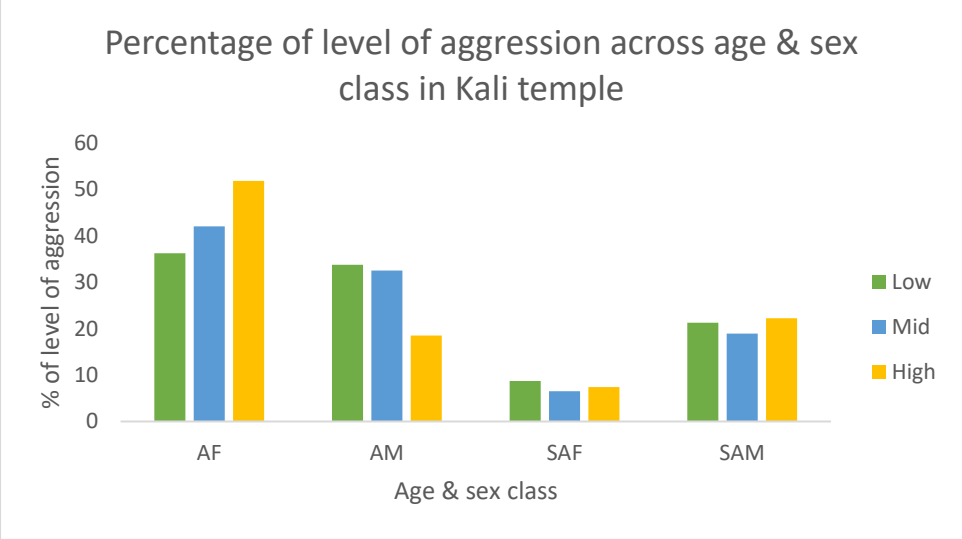

Figure 15. Bar graph showing levels of aggression across different age and sex class in Kali temple

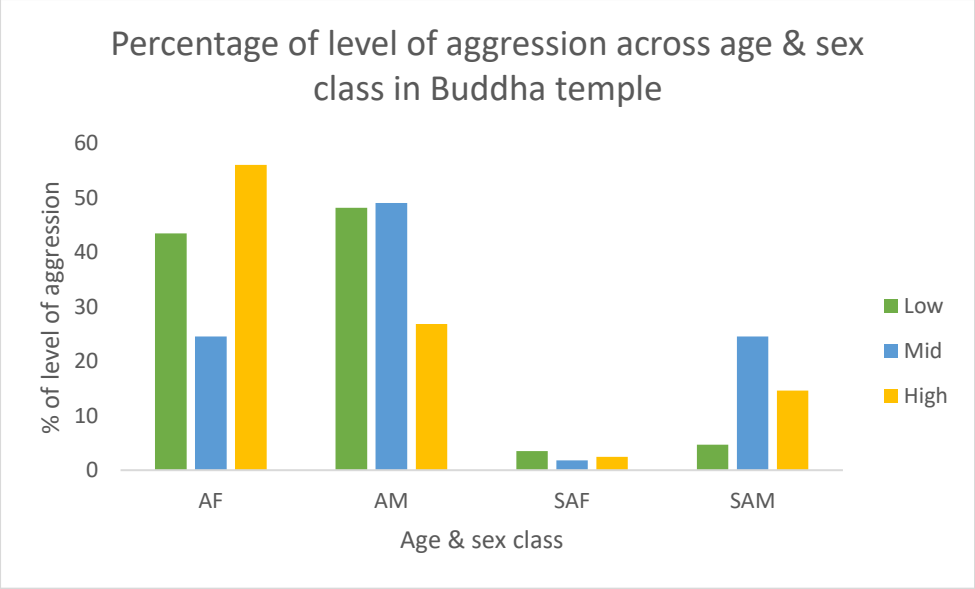

Figure 16. Bar graph showing levels of aggression across different age and sex class in Buddha temple

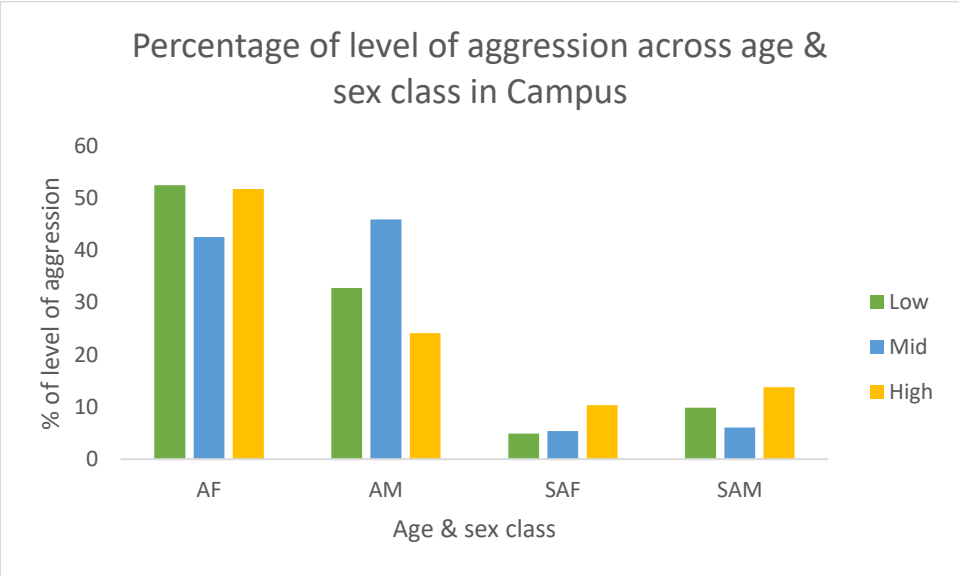

Figure 17. Bar graph showing levels of aggression across different age and sex class in Campus

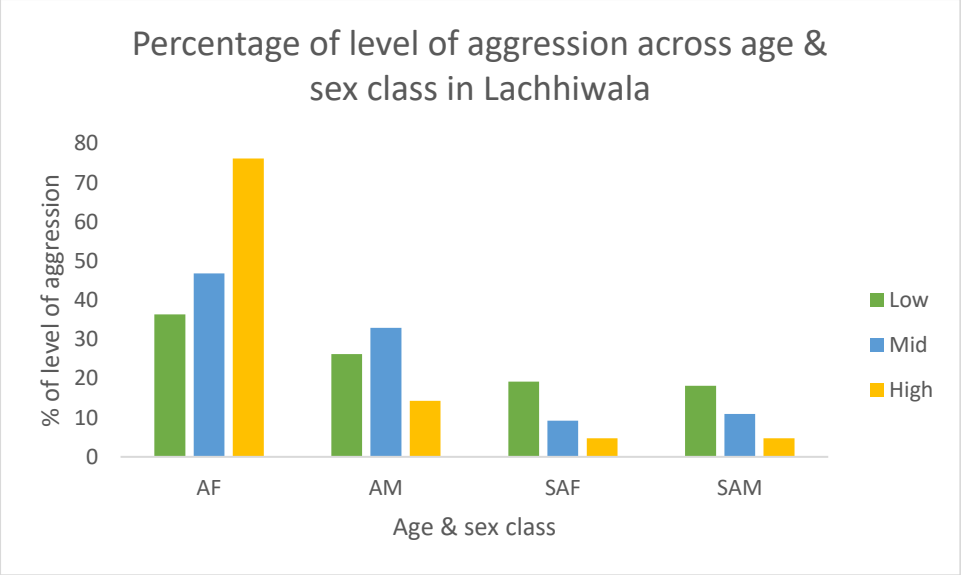

Figure 18. Bar graph showing levels of aggression across different age and sex class in Lachhiwala

4.2.6 Proximate factors of aggression across sites

There is significant association between causal factor and sites. In all four sites, aggression has occurred with respect to dominance behaviour of individuals of the troop. (G = 33.504, X-squared df = 15, p-value = 0.003996). (Figure 19)

4.2.7 Proximate factors of aggression across different age and sex classes

In Kali temple Adult males and females showed aggression spillover to subordinate individual multiple times (Figure 20). Adult females showed more aggression with respect to food whiles adult males for dominance. (Pearson's Chi-squared test: X-squared = 68.971, df = 15, p-value = 6.807e-09)

In Buddha temple Adult females reacted aggressively more towards threats (majorly threat to self, to infants or to juveniles) compared to other reasons. Subadults majorly fought for food.(Pearson's Chi-squared test: X-squared = 109.88, df = 9, p-value < 2.2e-16) (Figure 21)

Campus shows similar trends like that of Buddha temple(Pearson's Chi-squared test: X-squared = 72.837, df = 9, p-value = 4.218e-12) (Figure 22)

In Lachhiwala, subadults of both sex and adult female participated more in intertroop aggress ion. Fights with respect to food are senn more in adult female and males.(Pearson's Chi-squared test: X-squared = 95.077, df = 12, p-value = 5.098e-15) (Figure 23)

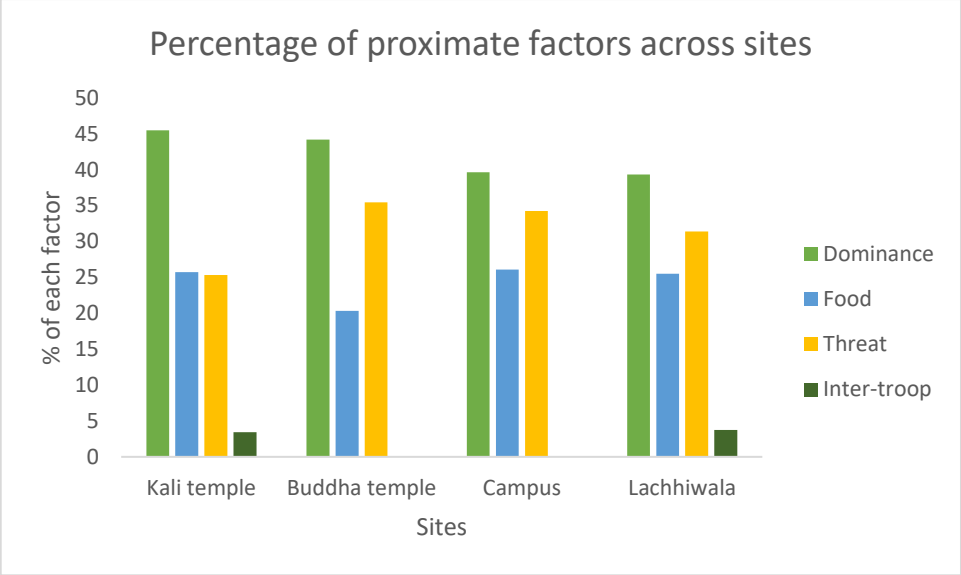

Figure 19. Bar graph showing Causal factors of intraspecific aggression across sites

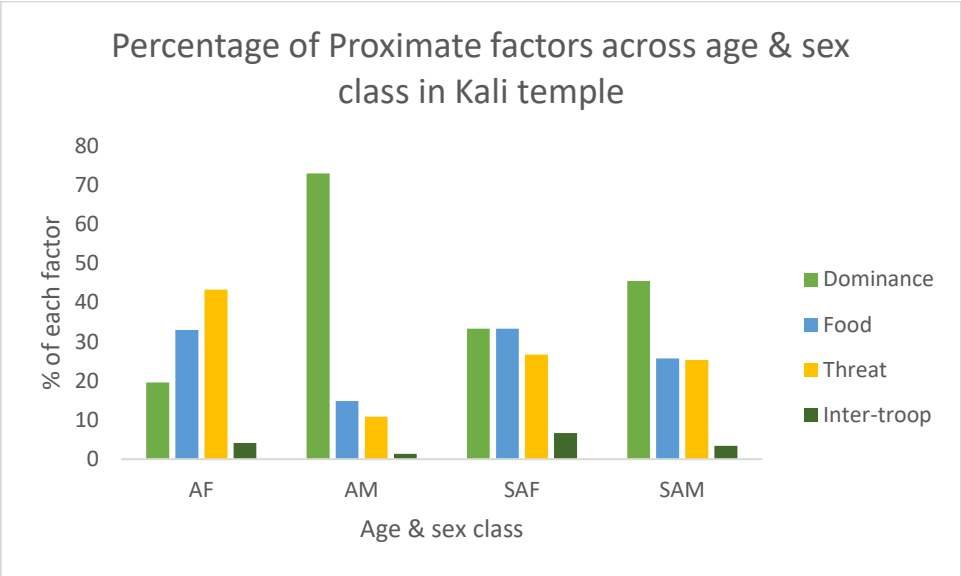

Figure 20. Bar graph showing causal factors across different age and sex class in Kali temple

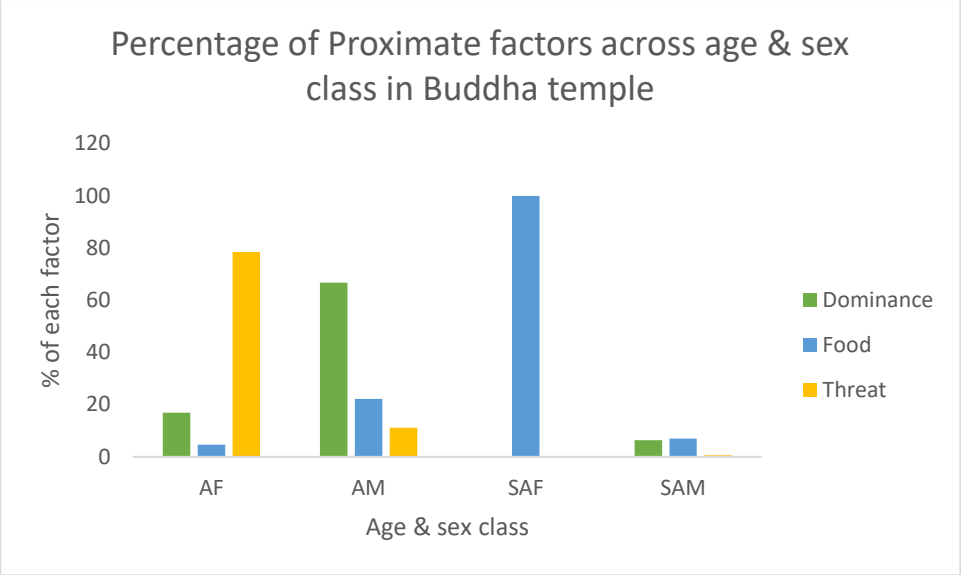

Figure 21. Bar graph showing causal factors across different age and sex class in Buddha temple

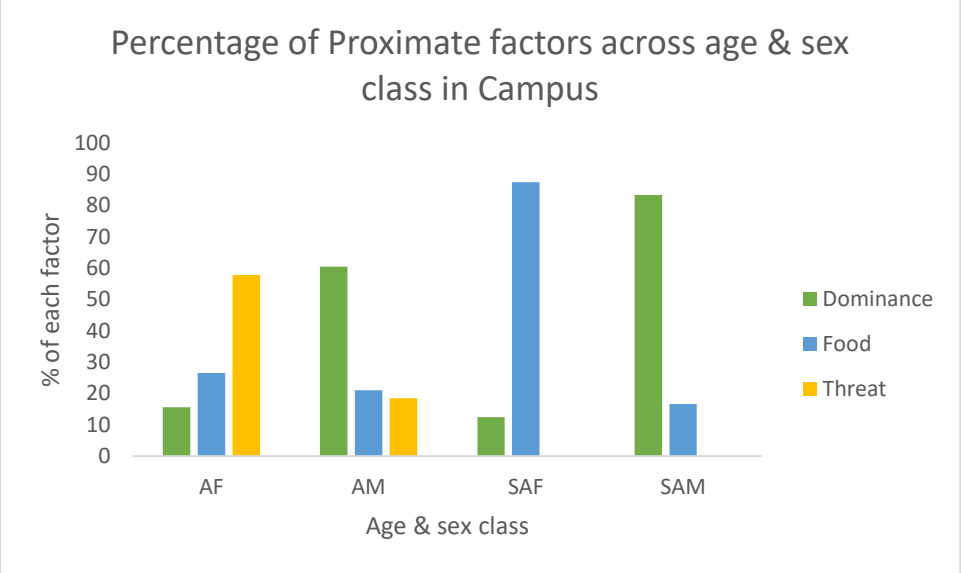

Figure 22. Bar graph showing causal factors across different age and sex class in Campus

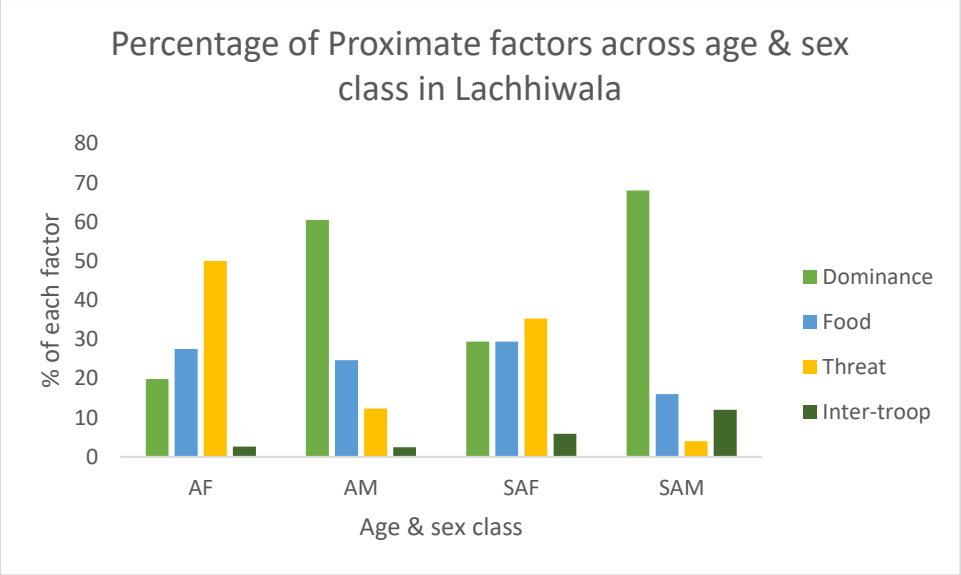

Figure 23. Bar graph showing causal factors across different age and sex class in Lachhiwala

4.3 For objective 2: Interspecific aggression

4.3.1 Frequency of aggression across sites

463 macaque-initiated and 729 human initiated aggressive encounters were observed. (Figure 24) Frequency of interspecific (human-macaque) aggression across sites shows similar results as that of Beisner, 2012 where human initiated aggression was higher compared to macaque initiated. However, Kali temple shows a different result compared to others. Here, macaque-initiated aggression is much higher than the ones initiated by humans.

(G = 250.41, X-squared df = 3, p-value < 2.2e-16)

4.3.2 Frequency of aggression across different age and sex classes

In Kali temple, adult males of both species are seen to be more aggressive adult females. As macaque aggression is more here (Figure 25.) subadult males and immatures (infants and juveniles) also contribute to this number. (X-squared = 86.673, df = 4, p-value < 2.2e-16).

In Buddha Temple, adult males and females of humans have shown more aggression towards macaques but, immature macaques have shown higher aggression than human children. (Figure 26) (X-squared = 78.349, df = 4, p-value = 3.896e-16)

In WII campus, adult female macaques had initiated more aggression than humans. Macaque infants and juveniles were more aggressive than human children. (X-squared = 50.054, df = 4, p-value = 3.518e-10) (Figure 27)

In Lachhiwala, human adult males showed more aggression than females but, adult female macaques were more aggressive than adult males. (X-squared = 53.405, df = 4, p-value = 7.01e-11) (Figure 28)

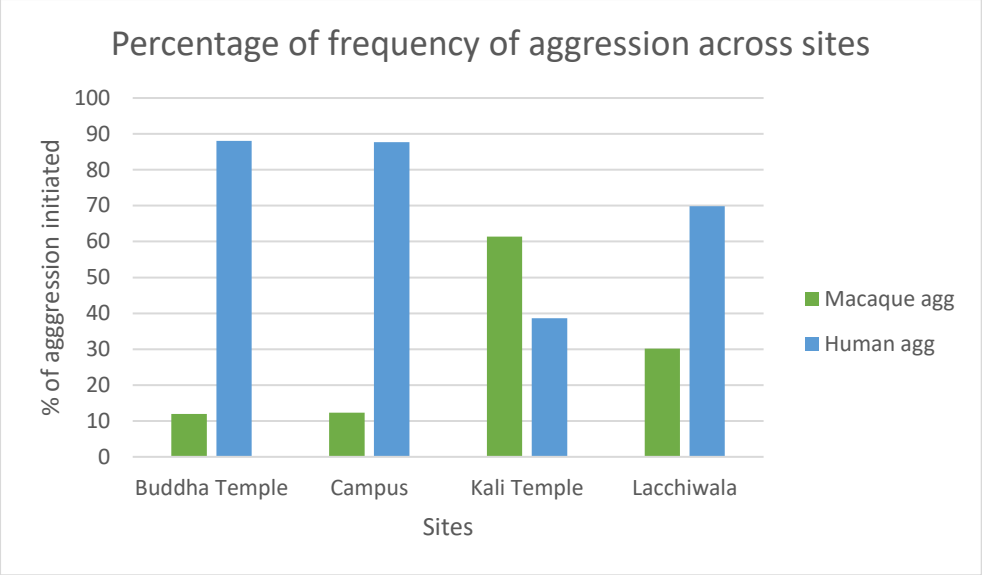

Figure 24. Bar graph showing frequency of interspecific aggression across all sites

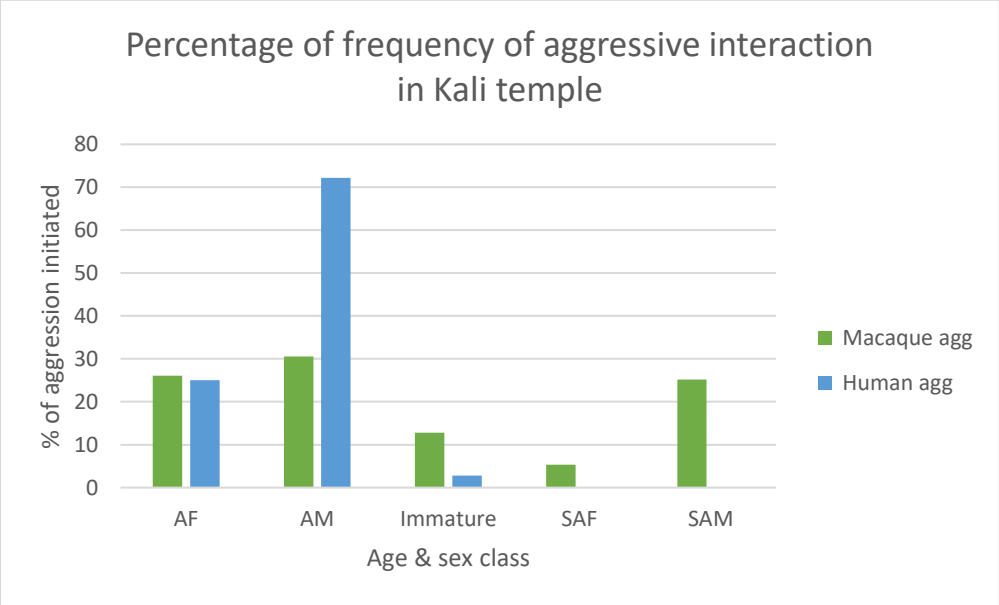

Figure 25. Bar graph showing frequency of interspecific aggression in Kali temple

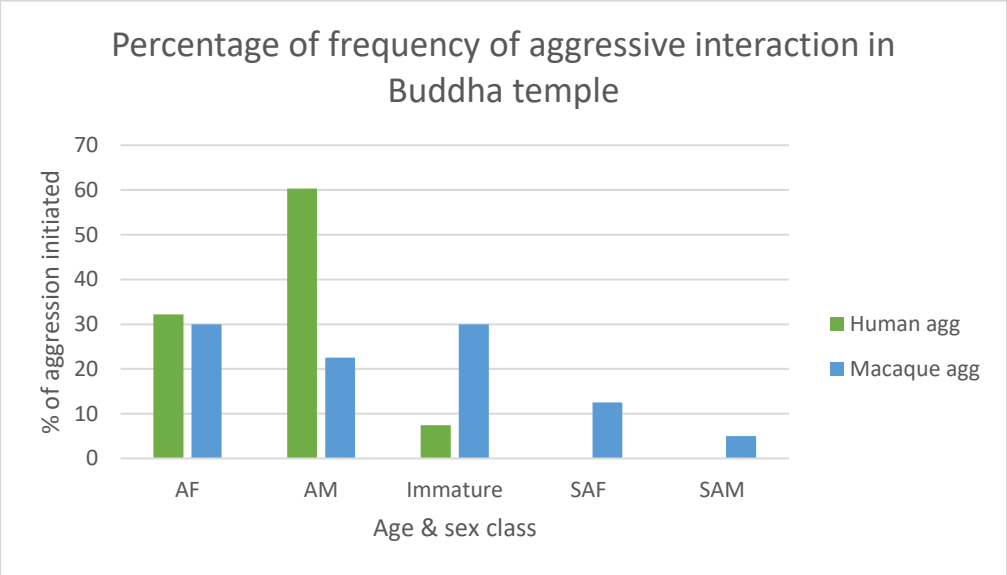

Figure 26. Bar graph showing frequency of interspecific aggression in Buddha temple

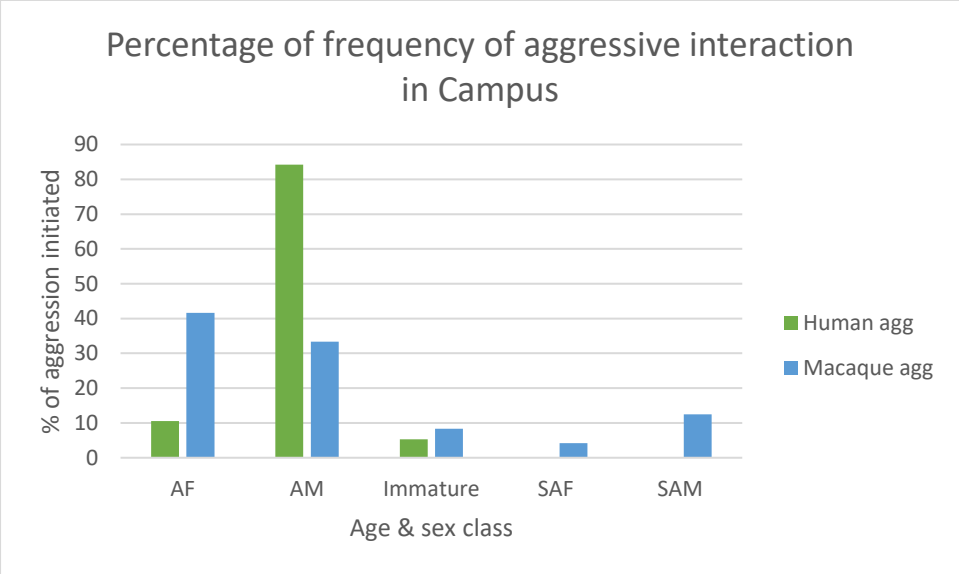

Figure 27. Bar graph showing frequency of interspecific aggression in WII Campus

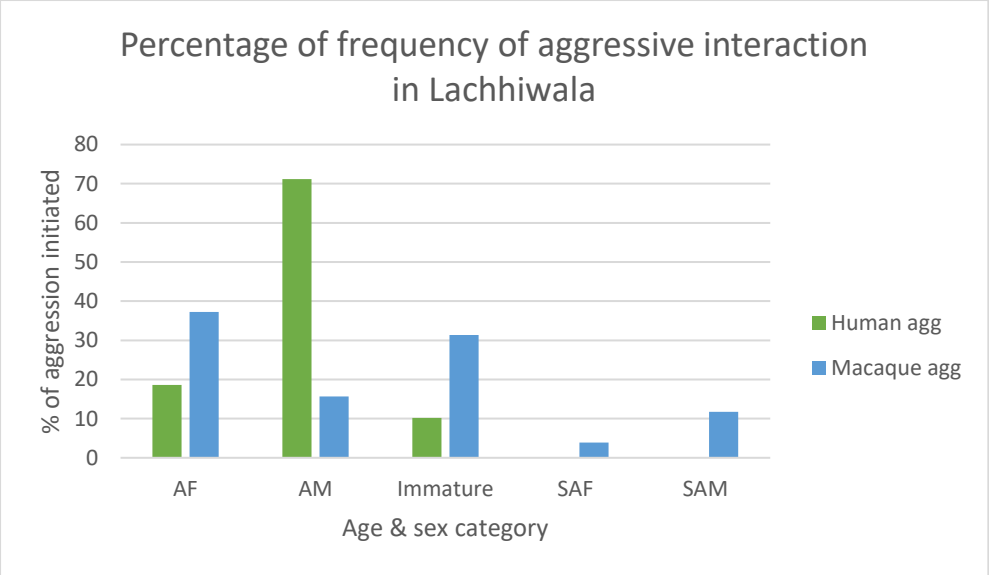

Figure 28. Bar graph showing frequency of interspecific aggression in Lachhiwala

4.3.3 Direction of aggression in each troop

In Kali temple, high weighted interactions have occurred between adult and subadult male macaques towards adult human male (23.0 and 22.0 respectively). From human to macaque, the interactions with high weights were from adult male human to adult female, juvenile and infants (26.0, 23.0 and 20.0 respectively). Least weighted interactions were from human children to subadult male macaques and subadult females to human children. (Figure 29)

In Buddha temple, the most weighted interactions are Adult human male to adult female macaques (58.0) followed by adult male human towards infant macaques (45.0) and towards juvenile macaques (38.0). The least ones are human child to Infant (1.0) and subadult female macaques to infants (1.0). (Figure 30)

In Campus, adult male human to Juvenile macaques (37.0), infants (36.0) and adult female macaques (32.0). There are multiple interactions with least weights like, adult female macaque to adult male human (1.0), subadult male macaque to adult female human (1.0), and a few more. (Figure 31)

In Lachhiwala, interactions of adult male human to infant macaques is more (35.0) followed by juveniles (22.0). least weighted ones include adult female macaque to human child (1.0), child to adult female macaques (1.0). (Figure 32)

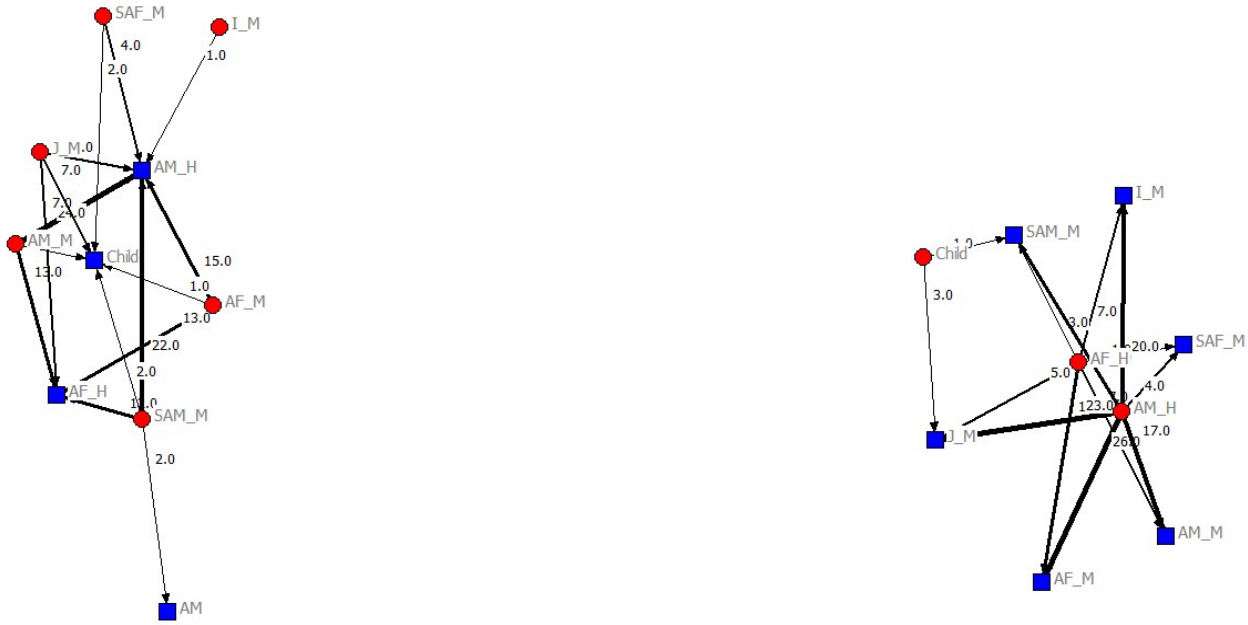

Figure 29. Social network for interspecific aggressive interaction in Kali temple

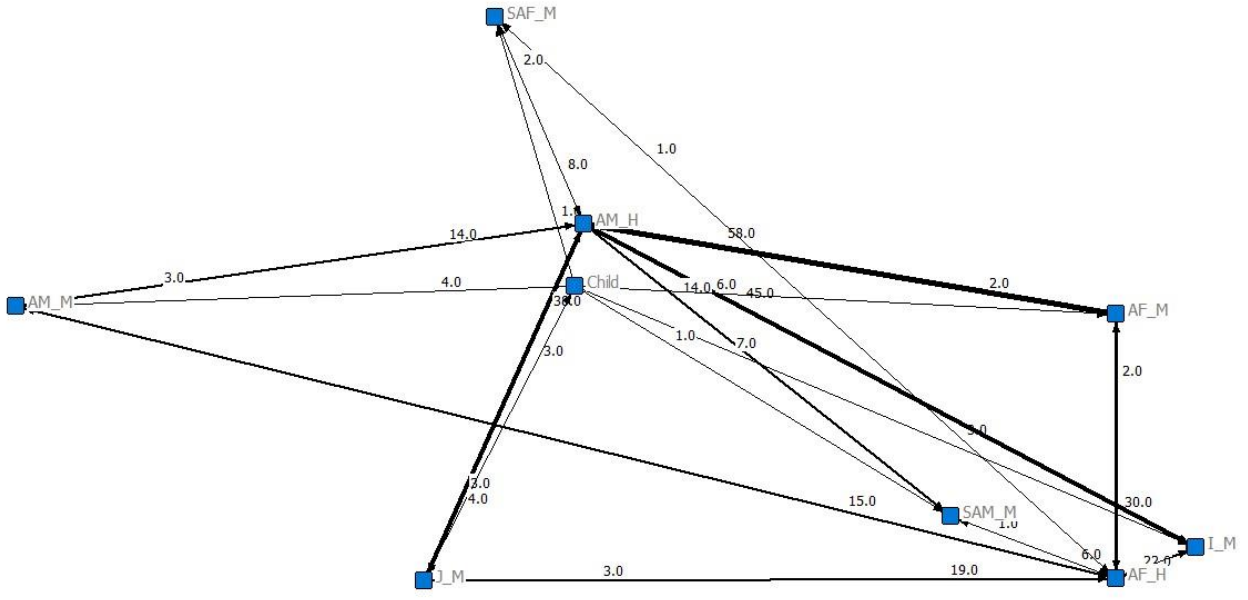

Figure 30. Social network for interspecific aggressive interaction in Buddha temple

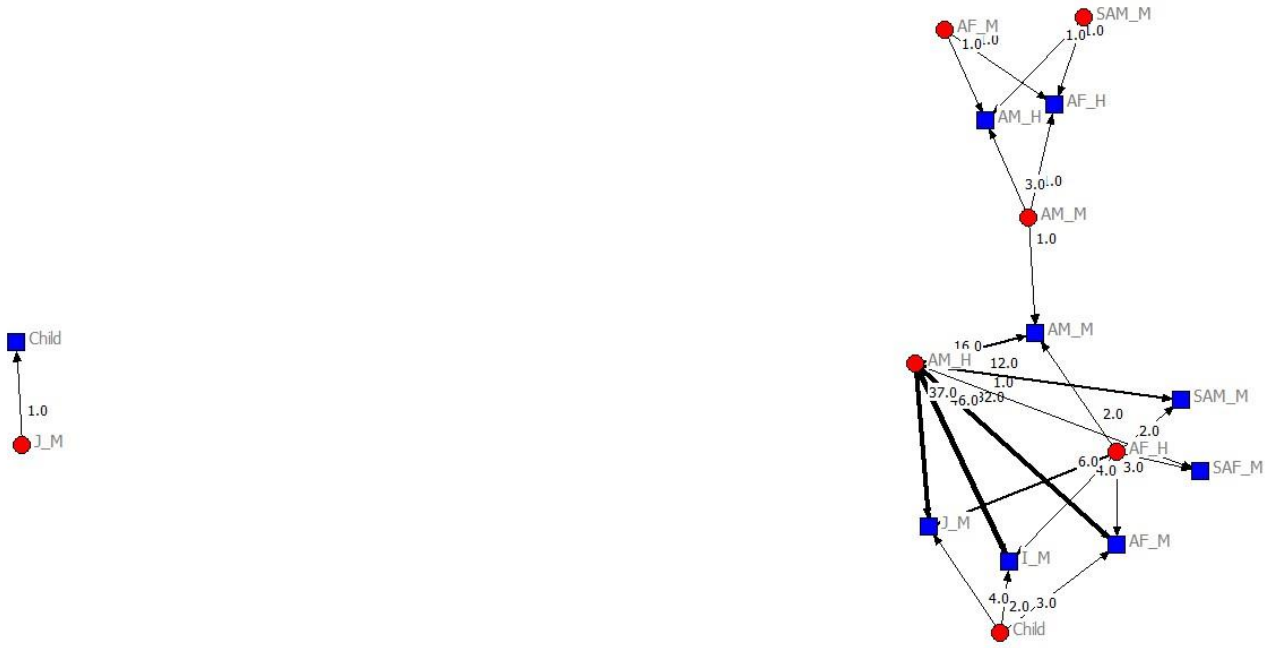

Figure 31. Social network for interspecific aggressive interaction in Campus

Figure 32. Social network for interspecific aggressive interaction in Lachhiwala

4.3.4 Level of aggression across sites

Troops in Kali temple and Lacchiwala showed aggressive behaviours of low level while troops in Buddha temple and Campus showed mid-level aggressive behaviour more. Contact aggressive behaviour were higher in Campus compared to other sites.(G = 78.859, X-squared df = 6, p-value = 6.106e-15) (Figure 33)

4.3.5 Level of aggression across different age and sex classes

In Kali temple, after test for significance, shows slight chances of association. (X-squared = 15.116, df = 8, p-value = 0.05693) Here, most high level behaviours are shown by adult males followed by adult females. (Figure 35)

In Buddha temple, only adult males showed high level behaviours. Females and immatures (infants and juveniles) showed low levels of aggressive behaviours. (X-squared = 13.741, df = 8, p-value = 0.08877). (Figure 36)

In Campus, high levels were showed equally by both adult males and females.(X-squared = 3.7482, df = 8, p-value = 0.8791). (Figure 37)

In Lachhiwala, adult males howed high level behaviours while female exhibited mid-level behaviours. (X-squared = 15.302, df = 8, p-value = 0.05354) (Figure 38)

Across all sites, adult male humans show high level of aggression which consists of behaviours like throwing stone, throwing stick and pushing. In most cases, individuals resorted to behaviours of mid-level aggression like chasing, raising their hand or a stick. Low

level of aggression was mostly seen in Buddha temple, by adult males and females. (Figure 34)

In kali temple, (Pearson's Chi-squared test X-squared = 6.1563, df = 4, p-value = 0.1878) there is no significant association seen between the age and sex class of human individuals and the level of aggression they show. (Figure 39)

Similar situation is seen in Buddha temple (Pearson's Chi-squared test X-squared = 8.1996, df = 4, p-value = 0.08453). (Figure 40)

In Campus, (Pearson's Chi-squared test X-squared = 15.879, df = 4, p-value = 0.003185) there is significant association between the age and sex class of individuals and the level of aggression they display. (Figure 41)

Lachhiwala also shows similar results (Pearson's Chi-squared test (X-squared = 56.756, df = 4, p-value = 1.392e-11) (Figure 42)

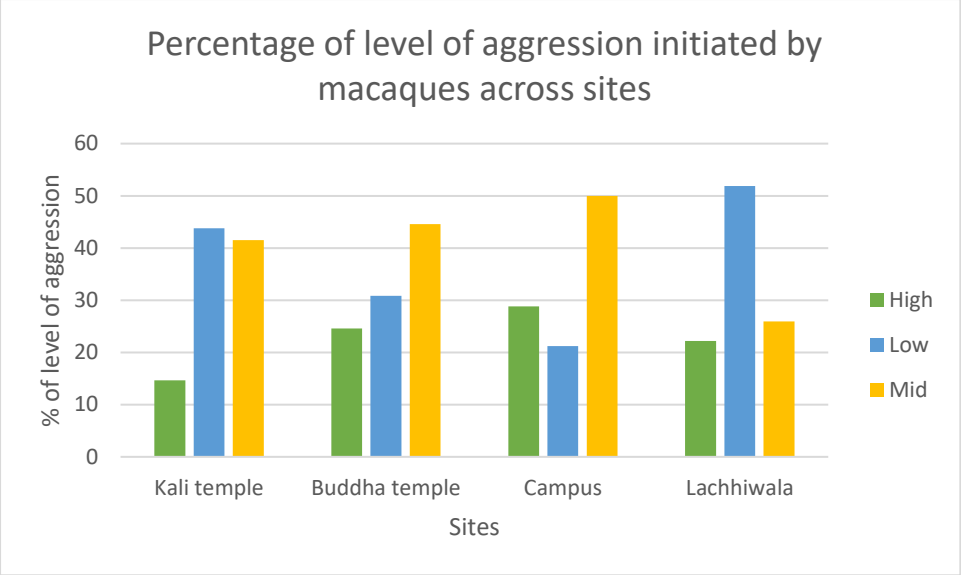

Figure 33. Bar graph showing level of aggression towards humans across sites

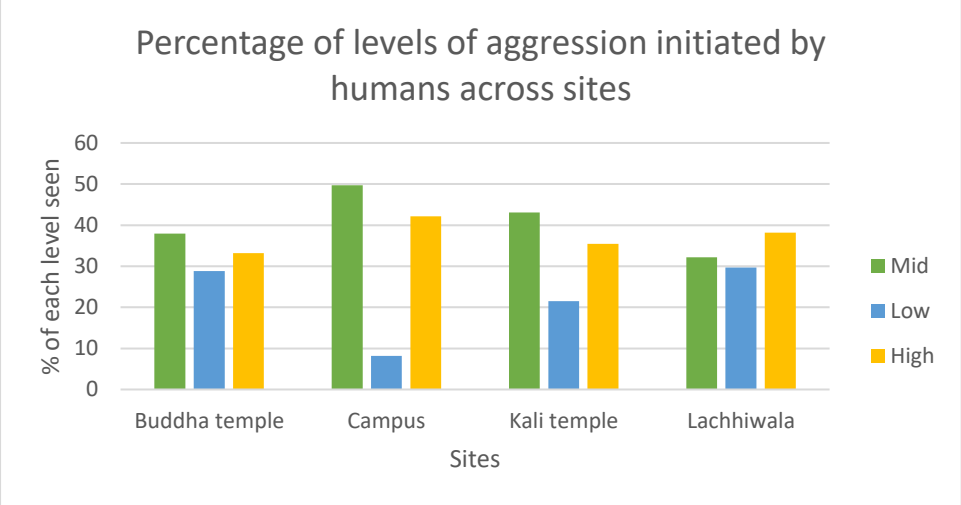

Figure 34. Bar graph showing level of aggression towards macaques across sites

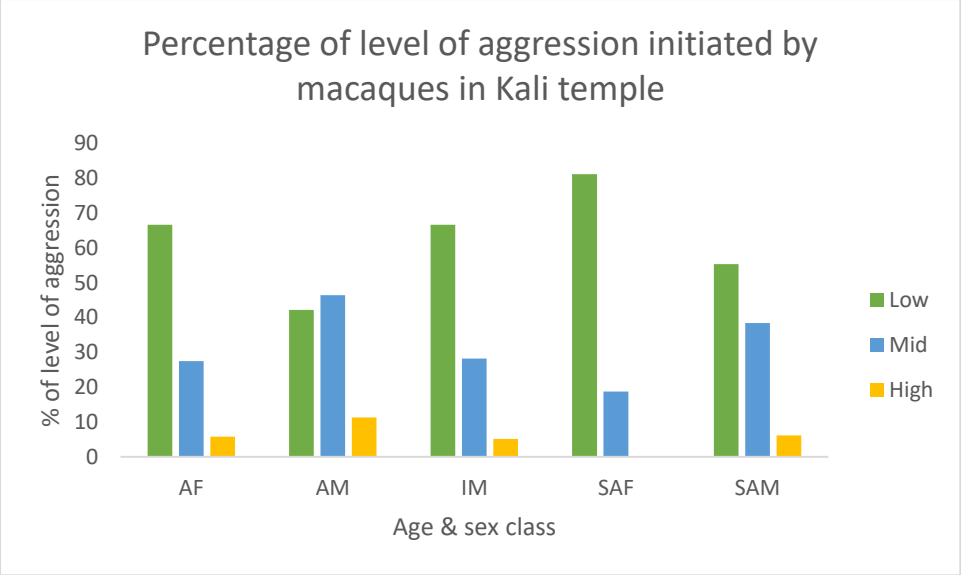

Figure 35. Bar graph showing percentage of level of aggression initiated by macaques in Kali temple

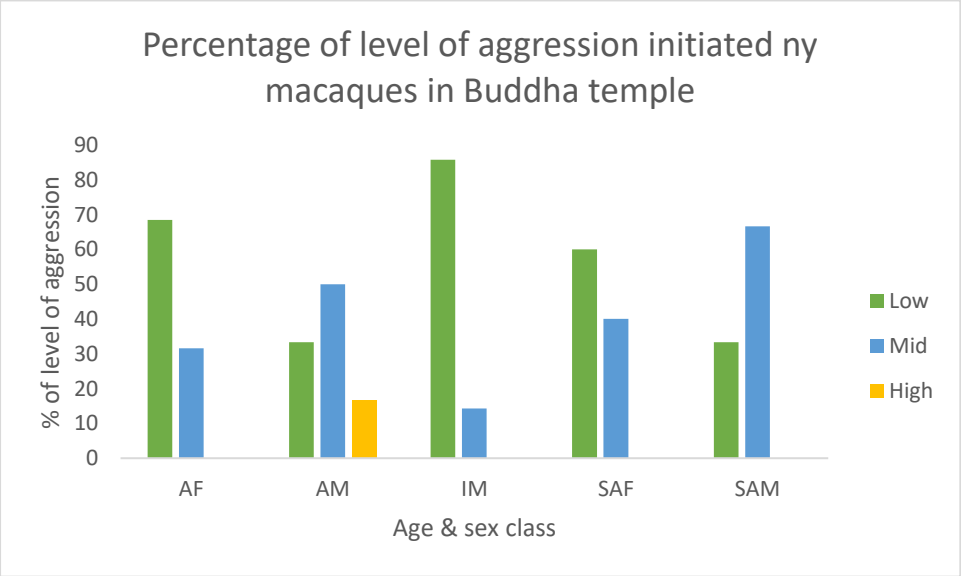

Figure 36. Bar graph showing percentage of level of aggression initiated by macaques in Buddha temple

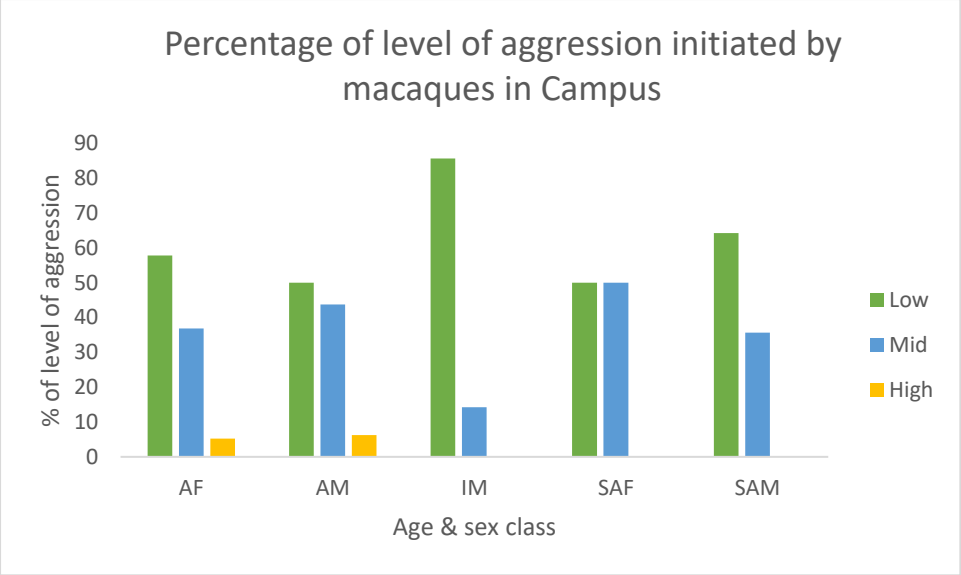

Figure 37. Bar graph showing percentage of level of aggression initiated by macaques in Campus

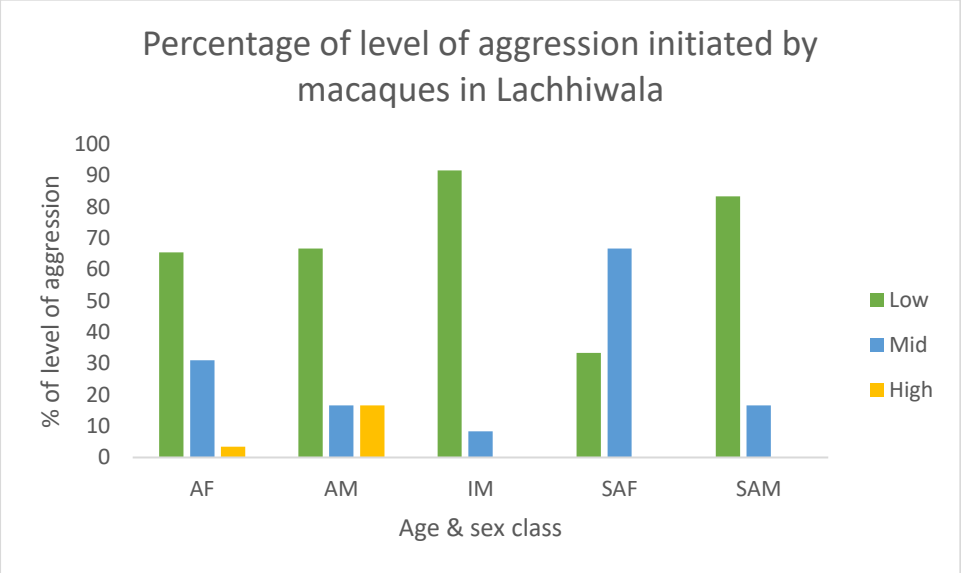

Figure 38. Bar graph showing percentage of level of aggression initiated by macaques in Lachhiwala

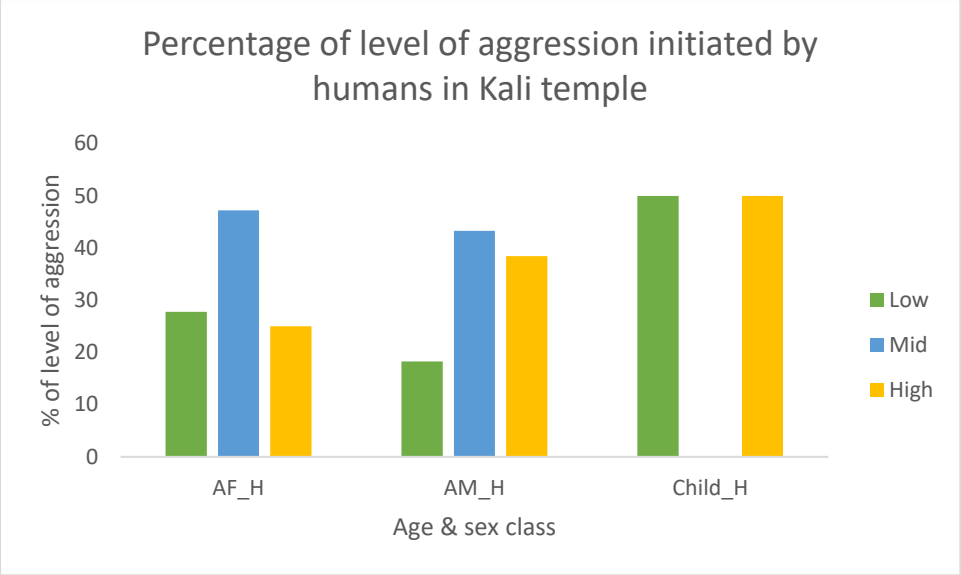

Figure 39. Bar graph showing percentage of level of aggression initiated by humans in Kali temple

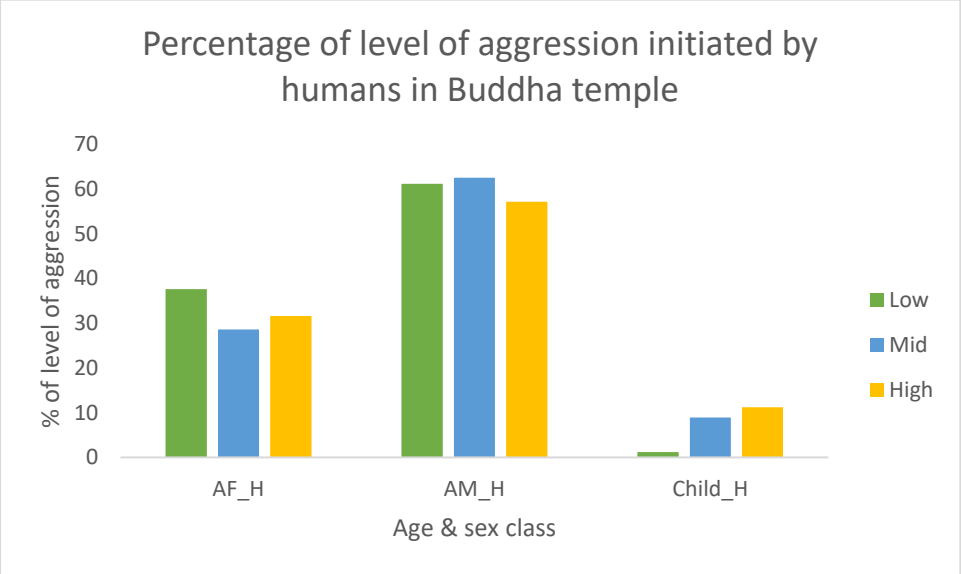

Figure 40. Bar graph showing percentage of level of aggression initiated by humans in Buddha temple

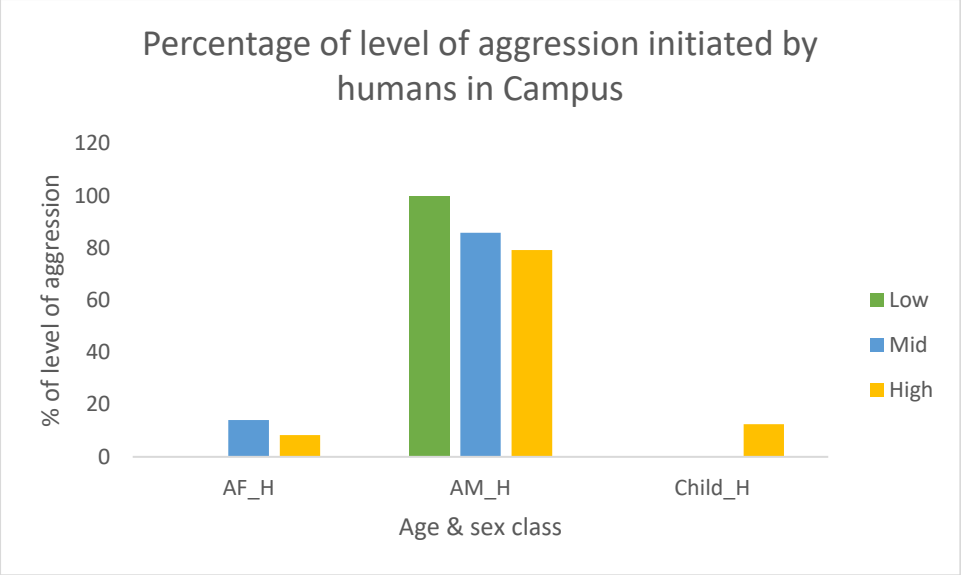

Figure 41. Bar graph showing percentage of level of aggression initiated by humans in Campus

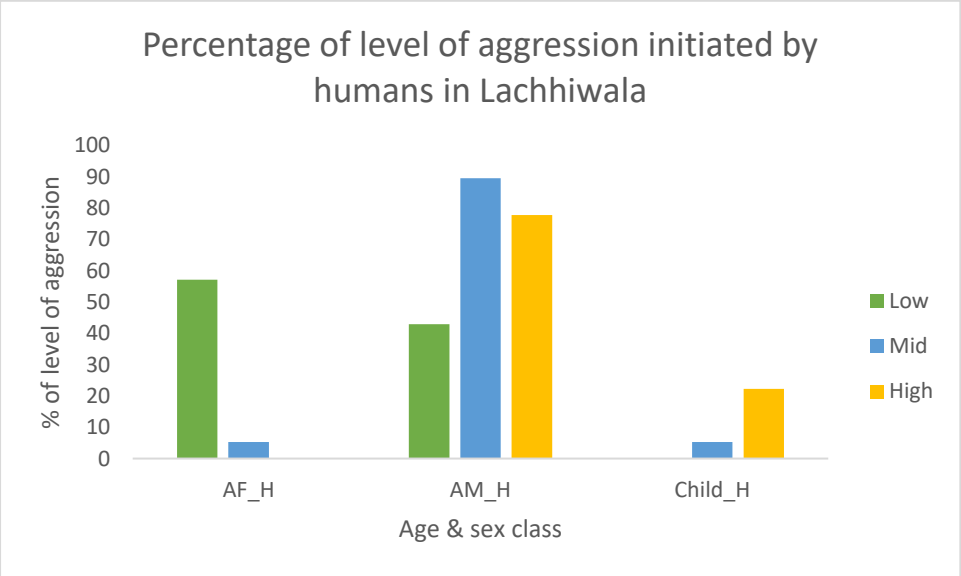

Figure 42. Bar graph showing percentage of level of aggression initiated by humans in Lachhiwala

4.3.6 Proximate factors of aggression across sites

Across the sites, threat is the major factor leading to aggression initiated by macaques. The p-value suggests association between factors leading to aggression in macaques during interaction with humans and sites.(G = 44.819, X-squared df = 9, p-value = 9.965e-07)

Damage to property is the major reason leading to human aggression towards macaques. The p-value indicates strong association between the factors leading to aggression initiated by hu mans during interaction with macaques and different sites.(G = 102.88, X-squared df = 15, p-value = 3.664e-15)

4.3.7 Proximate factors of aggression across different age and sex classes

Juveniles across all sites show high level for this particular reason. In Lacchiwala, adult male aggression was majorly related to dominance and same goes to subadult males of Kali temple. Food was also a factor causing aggression although not seen in Campus.(Figure 43)

In Kali temple, (Pearson's Chi-squared test X-squared = 46.528, df = 15, p-value = 4.38e-05) shows significant association between the age and sex classes of individual macaques and the proximate factors leading to aggression. (Figure 45)

In Buddha temple,(Pearson's Chi-squared test X-squared = 8.986, df = 8, p-value = 0.3435) t here is no association between the two variables. (Figure 46)

Campus (Pearson's Chi-squared test X-squared = 3.9005, df = 5, p-value = 0.5638) shows similar results as Buddha temple and so does Lachhiwala, (Pearson's Chi-squared test X-squared = 15.322, df = 15, p-value = 0.4285). (Figure 47 & 48)

Adult human male-initiated aggression much more than females in cases of property and personal damage whereas, being aggressive towards macaques for ‘fun’ coded as taunt in the graph was shown by children only. (Figure 44)

Buddha temple (X-squared = 263, df = 10, p-value < 2.2e-16) (Figure 46) , Campus, (Pearson 's Chi-squared test X-squared = 27.591, df = 8, p-value = 0.0005586) (Figure 47), Kali templ e, (Pearson's Chi-squared test X-squared = 41.417, df = 8, p-value = 1.742e-06) (Figure 45) a nd Lachhiwala, (Pearson's Chi-squared test X-squared = 116, df = 6, p-value < 2.2e-16) (Figure 48), all four sites show significant association between age and sex class of humans a nd the proximate factors due to which they initiated aggression.

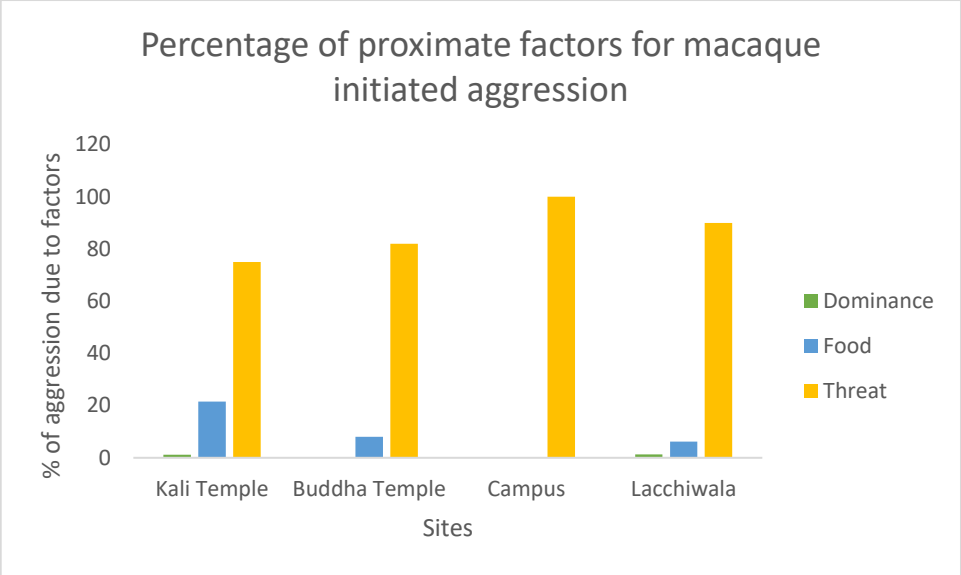

Figure 43. Bar graph showing causal factors of aggression towards human across all sites

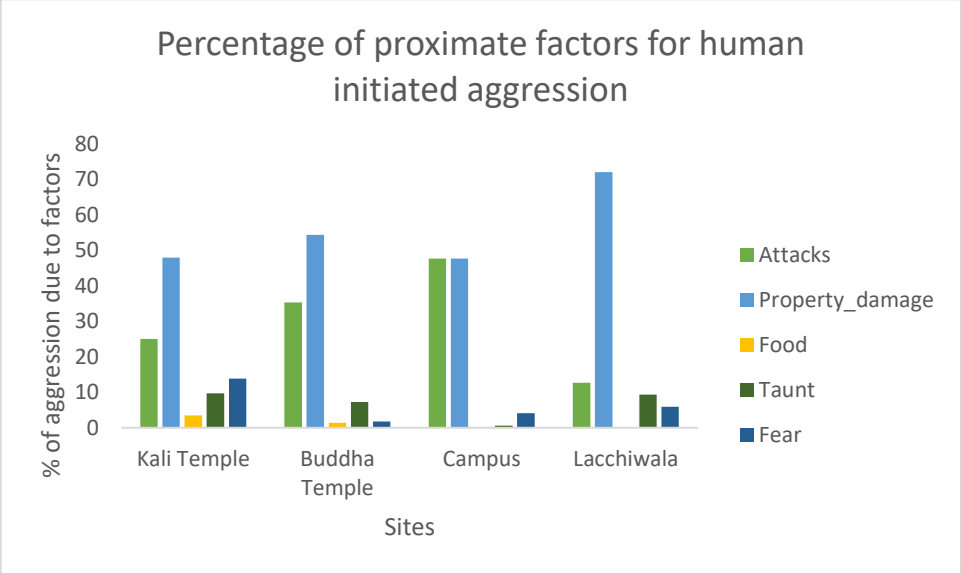

Figure 44. Bar graph showing level of aggression towards macaques all sites

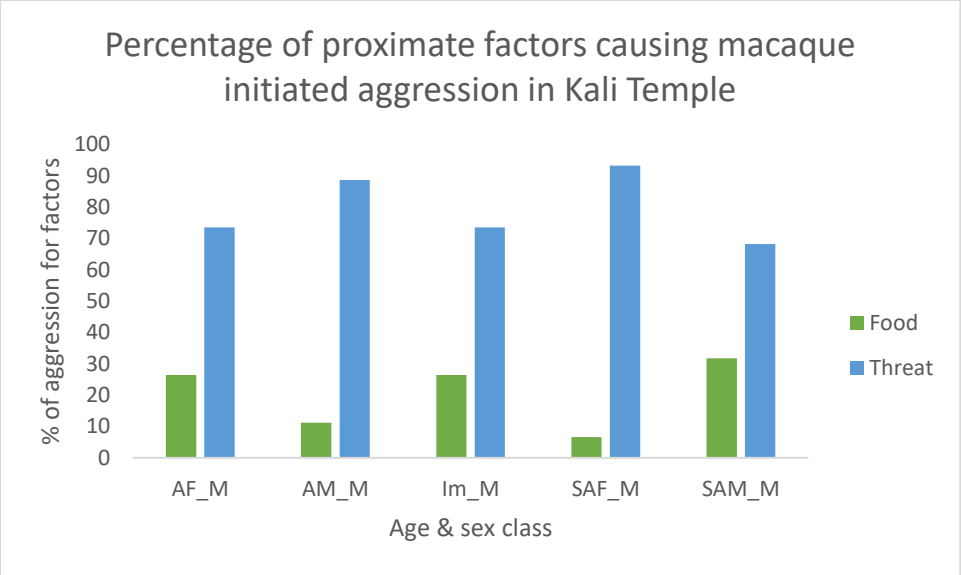

Figure 45. Bar graph showing percentage of proximate factors causing macaque initiated aggression in Kali temple

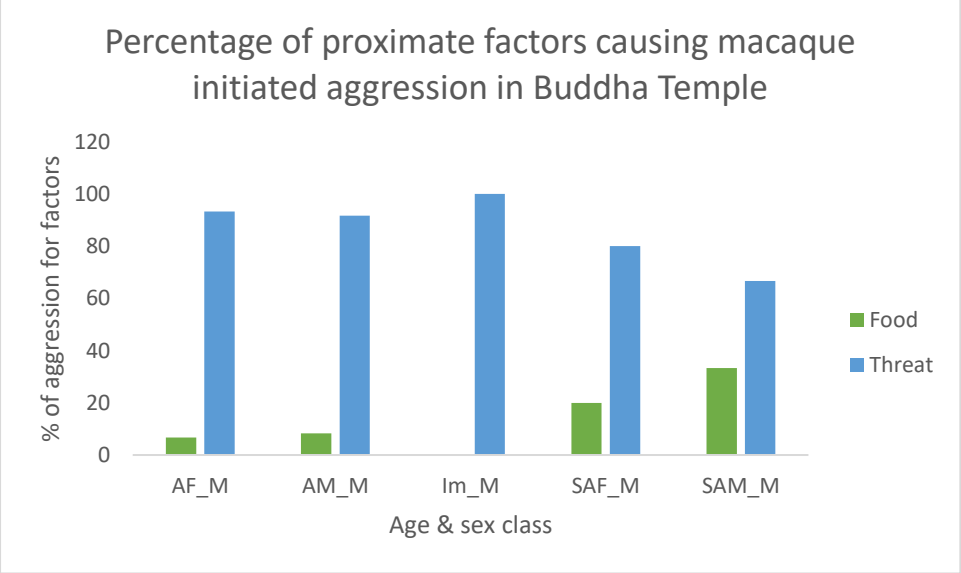

Figure 46. Bar graph showing percentage of proximate factors causing macaque initiated aggression in Buddha temple

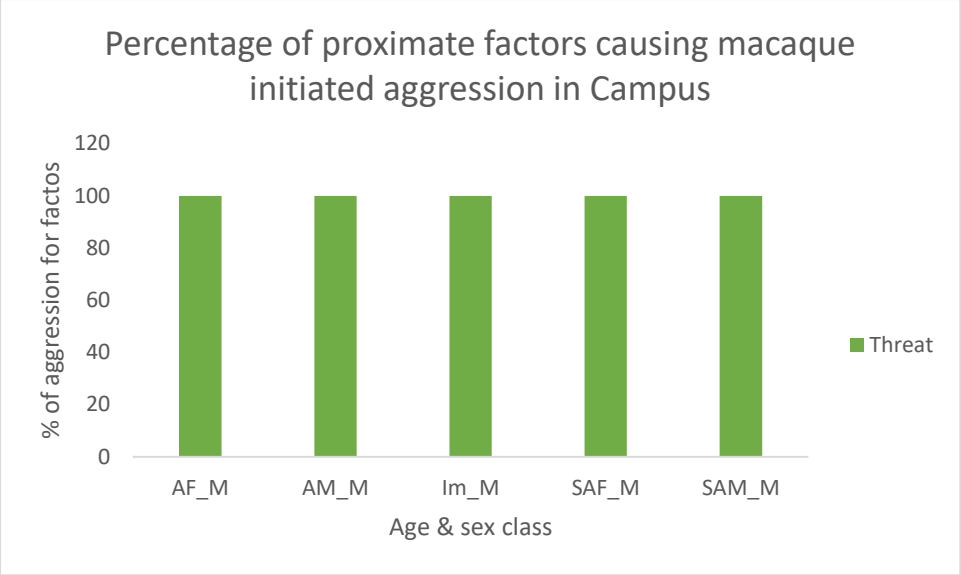

Figure 47. Bar graph showing percentage of proximate factors causing macaque initiated aggression in Campus

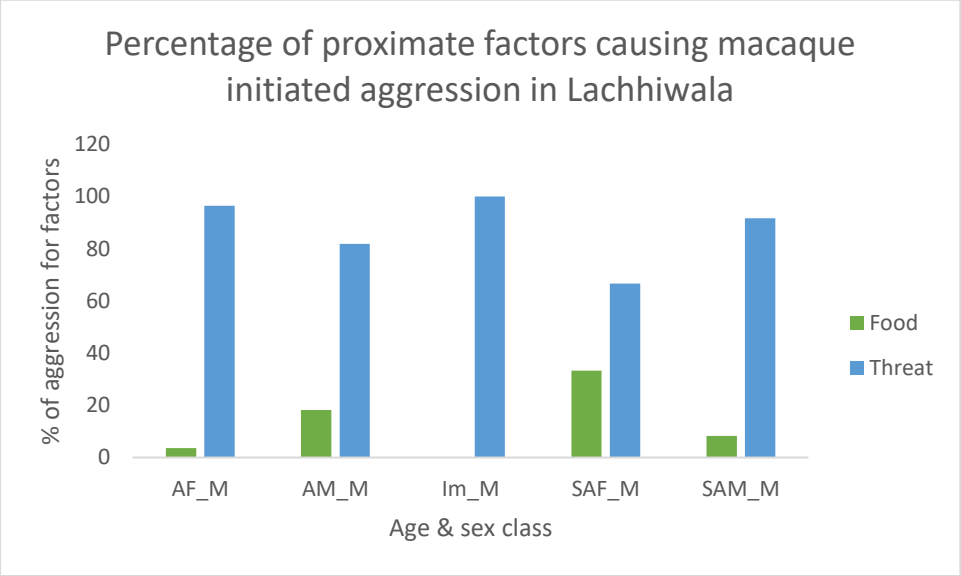

Figure 48. Bar graph showing percentage of proximate factors causing macaque initiated aggression in Lachhiwala

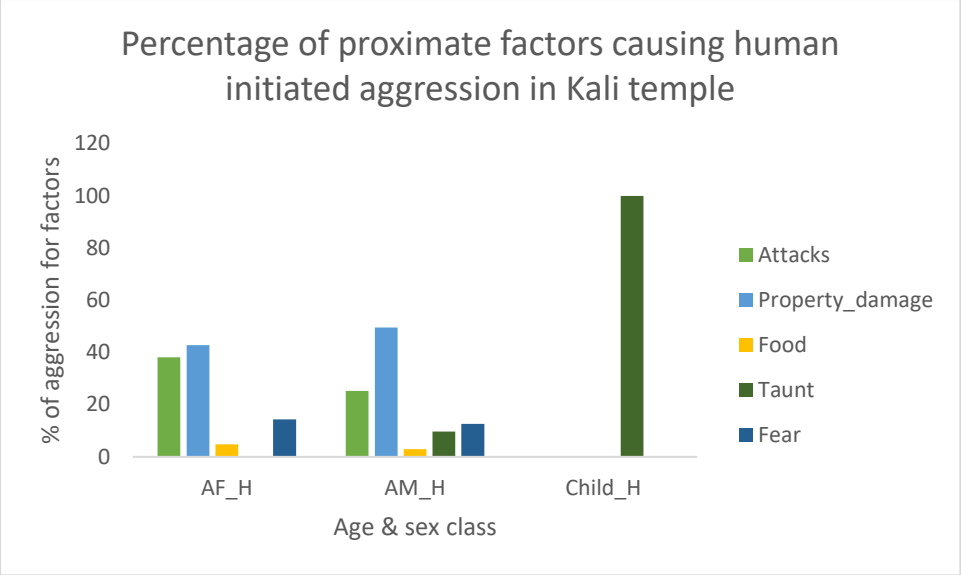

Figure 49. Bar graph showing percentage of proximate factors causing human initiated aggression in Kali temple

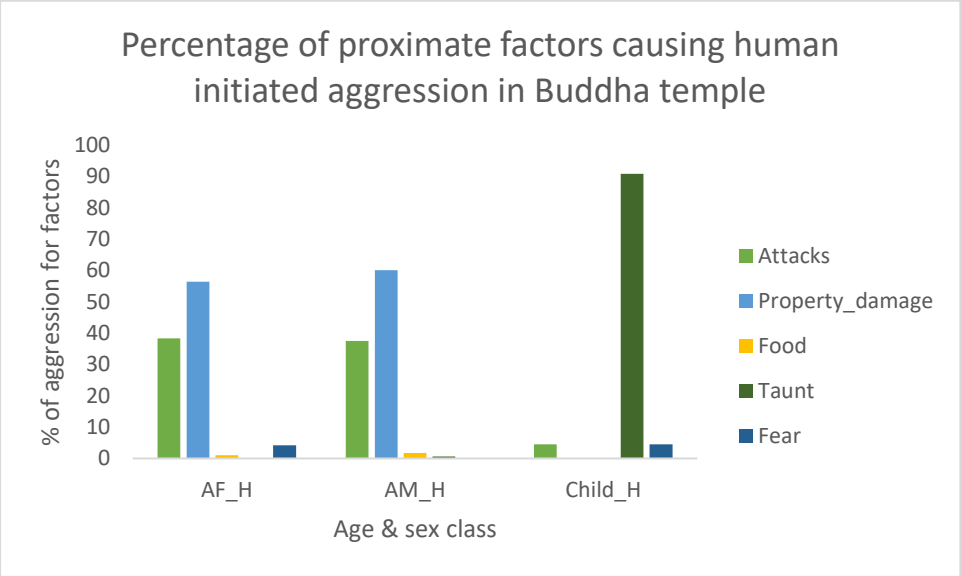

Figure 50. Bar graph showing percentage of proximate factors causing human initiated aggression in Buddha temple

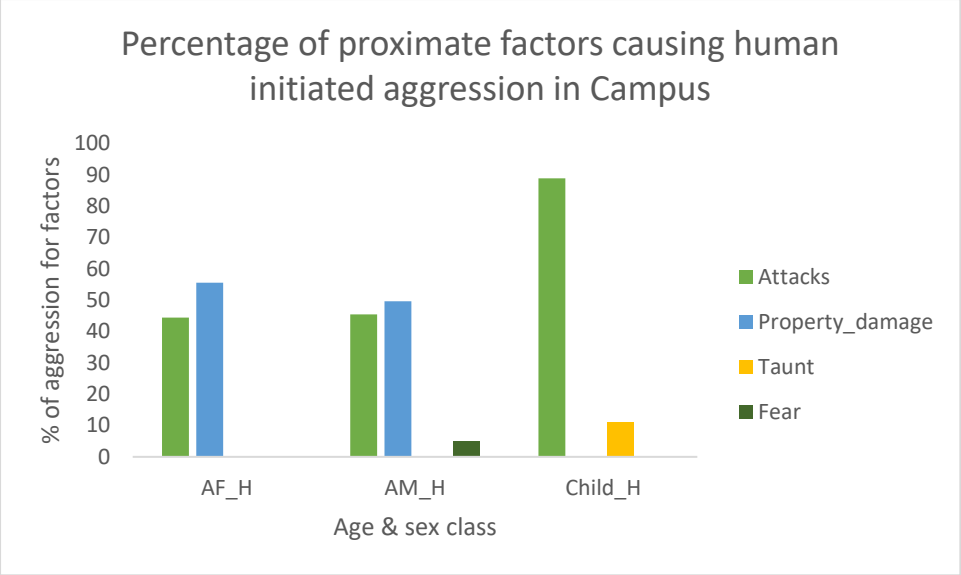

Figure 51. Bar graph showing percentage of proximate factors causing human initiated aggression in Campus

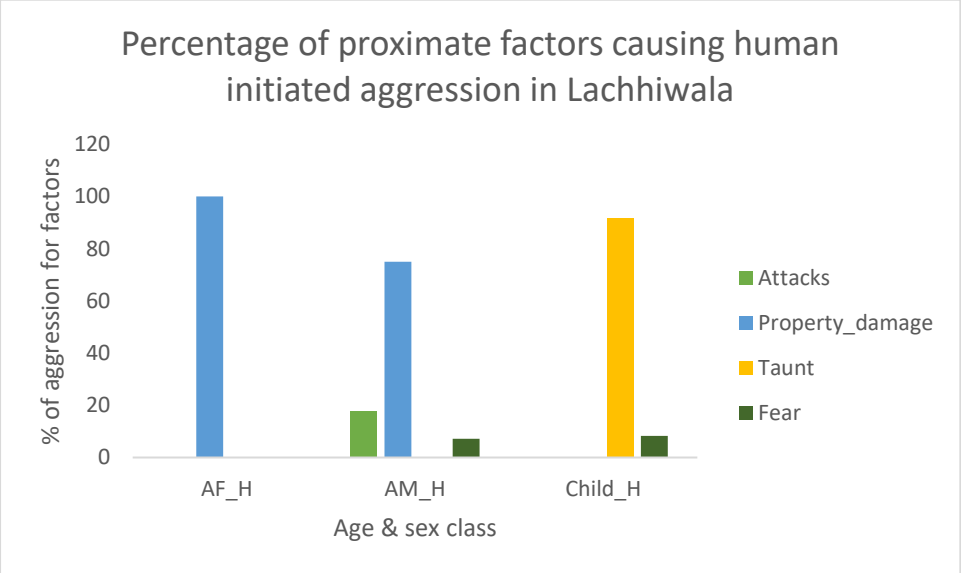

Figure 51. Bar graph showing percentage of proximate factors causing human initiated aggression in Lachhiwala

Chapter 5: Discussion

5.1 Activity budget

Activity budgets of animals can be can be influenced by many factors like seasons, resource availability, troop size, composition and hierarchy (Jaman, 2012). Lately, human presence is also an important factor that shows direct and indirect effects on behaviour of animals. Human bought changes in their environment and interactions with them leads to changes in the natural behaviour of animals (Waterman, 2017). As Rhesus macaques are now present in a commensal relationship with humans (Wang and Quan, 1986), their behavioural activity budgets can give us insight about their adaptability in human dominated landscapes (Jaman, 2012; Saj et al. 1999).

In this study, we can see difference in time spent on various activities by Rhesus macaques. All the troops studied are exposed to humans at multiple levels and its affects can be seen in difference in activities like feeding, movement, resting and social behaviours. In Kali temple, as direct and indirect provisioning is a very frequent observation, resting is the major behaviour seen in the troop living there. Direct provisioning is when people offer macaques with food materials like fruits, bread, sweets, etc. This happens on the pretext of religious sentiments attached to the site and macaques as a descendant of the Hindu mythological character named ‘Hanuman’. The waste generated in the temple (food, sweets, flowers, etc.) is discarded near-by in two areas forming a big garbage dump and a smaller one. Macaques spent a lot of time moving between these garbage dumps, the temple and the temple kitchen in order to forage. Forced provisioning or snatching food items from humans is also a regular occurrence here. Due to easy availability of food, rest of the time is spent in socialising. Within the troop, females of both categories are seen spending more time resting. Infants and juveniles spent more time socialising majorly in the form of play, while subadult males were

least interested in socialising. This also explains how movement was majorly shown by them. This movement is mostly exploratory in nature. Percentage of time spent in feeding was similar between adult males and females, infants and juveniles and subadults of both sex class.

In Buddha temple also, resting was the major behaviour shown by individuals of all age and sex class. Less time was spent on feeding by all classes as indirect provisioning is high in this area. As a tourist place, there are multiple restaurants and food outlets which throw their kitchen waste near the forest edge. A large university canteen also discards their kitchen waste nearby creating a surplus of high calorie food for these primates. Same as before, subadult males spent more time in moving and least in socialising. However, subadult males here are more social than the ones from previous sites as few individuals were seen engaging in play with infants once in a while.

The WII campus offers a more or less similar environment for the macaques, except the incidents of provisioning is much less here. This place offers a more natural diet to macaques compared to the other two. A general trend like the previous two troops regarding resting, moving, socialising and feeding is also seen here.

Lachhiwala troop is least exposed to humans yet not to human disturbance. The troop lives along the highway often putting their life at risk while crossing it. Percentage of time spent feeding is higher across the age and sex classes here owing to both direct and indirect provisioning. People stopping to take a break from travelling often provide the macaques with food for amusement. Moreover, emptying their garbage bags along the road also creates a perfect buffet for the troop. They forage and feed along with cattle, birds, dogs and sometimes domestic pigs. Again, adults and subadults show resting as the most preferred activity while infants and juveniles spent time playing with each other and with discarded

items like clothes, medicine bottles, etc. As Lachhiwala range is present along the high way, they are occasionally seen eating their natural feed like fruits of *Mallotus philippensis, Ficus spp*, etc. Here, adult males show more movement than subadults owning to patrolling as there is presence of two more troops sharing the boundaries of their home range.

5.2 For objective 1: Intraspecific aggression

5.2.1 Frequency of aggression across sites different age and sex class

As social animals, Rhesus macaques are constantly faced with competition for food, space and mate. This competition can be intra-troop or intraspecific in nature. To overcome this strife, natural selection has favoured aggressive behaviours in such animals (Southwick,1969). Aggression in them can be seen in both behavioural and ecological aspects. Behavioural aggression supports them in obtaining food, shelter and mate as mentioned above while ecologically, aggression helps them to penetrate, colonize and exploit new habitats (Southwick,1969).

The frequency of intra-troop aggression in all four study sites: Lachhiwala (N=314), Kali temple (N=305), Buddha temple (N=236) and Campus (N=238), shows that although Kali temple and Lachhiwala are 2 completely different sites the percentage of frequency of aggression is higher there compared to the other sites. High frequency of aggression in Lachhiwala and Kali temple is mostly caused due to high levels of direct and indirect provisioning. As mentioned in the previous section (activity budget), people feed macaques for both amusement and religious purposes. Competition and aggression during feeding usually occurs when resource availability is low or the resources are clumped (Ram, 2003). In a natural setting, resource division is done with respect to their social hierarchy. While feeding macaques, humans have the tendency to distribute the resource among all the age and

sex class of individuals equally. This replicates the scenario of the resources being clumped (as food is with human) and is a major factor which leads to intratroop aggression.

There are multiple studies which report higher rates of aggression within the troop in high anthropogenic areas (Jaman & Huffman, 2013; Kaburu, 2018). Ram et al., (2003), reported that dominant females are known to increase contact aggression towards higher-ranked subordinates while subordinate females show counter aggression in non-contact manner during provisioning.

In WII Campus and Buddha temple, less provisioning is seen and hence aggression due to this particular reason is hardly present. As a result, they resort more towards natural resources available there and also raid garbage dumps. Southwick et al., (1976) provides further evidence on increase in behaviours like threats, chases and attacks during the time of provisioning compared to non-provisioning time.

5.2.2 Direction of aggression in each troop

These social networks help us understand the direction and intensity of aggressive interactions among various age and sex classes in a troop. High intensity of aggression from adult males to adult females in most troops is on account of dominance. As the macaque society lives abiding to a hierarchy, dominance helps in maintaining order in the troop. Adult males may show aggression to convey its dominance for multiple reasons including resting and grooming spots, etc. Adult males are also seen defending lower ranking individuals from the ones having a higher rank. Adult females to juvenile and infant interactions occurs mostly for defending its own infant or juvenile. Aggression for this reason could also be directed towards other females. Adult males' aggression towards subadult males would mostly be due

to dominance. Similar trends across the habitat suggests that presence of humans might not be fully governing the direction of aggressive interactions between individuals of a troop.

5.2.3 Nature of aggression across sites and different age and sex class

Across sites, mid-level of aggression, consisting of behaviours like charge, chase and lunge are more prominent compared to high and low levels. Behaviours in low levels of aggression are contactless expression of aggression, usually conveying a warning to the receiver. High levels of aggression are seen less across the sites. This could be due to the cost of aggression

Within every troop, adult female shows high level of aggression compared to other age and sex class. This is predominantly due to incidents of aggression of other individuals directed towards infants and juveniles. Subadults and juveniles have the habit of restraining infants. Juveniles especially are seen taking infants far from mothers to groom or play with them. Mothers react very aggressively towards such individuals for the safety of their infants (Maestripieri, 1994). Behaviour associated with low levels of aggression are usually seen in case of competition for food as most individuals do follow their natural hierarchy during those times.

5.2.4 Proximate factors of aggression across sites and different age and sex classes

Most aggressive incidents in all sites occurred due to dominance. This is followed by aggression due to food and threat in Kali temple. Intertroop aggression was seen very less here. An opposite trend was seen in the troop in Buddha temple. Here, after dominance, threat has caused more aggression compared to food. Similar trend is seen in Campus. In Lachhiwala, aggression caused with respect to food and threat are at similar levels. These

trends can be understood with the explanation given for frequency of aggression. Due to multiple ways of provisioning in most sites, food becomes a major causal factor for aggression. As dominance is shown even the smallest aspects like for grooming chances, for sitting or resting spots, defending young ones from each other and females which are not its mother. Aggression spillover (showed majorly by adult males in Kali temple) and intertroop aggression were seen only a handful of times. In Lachhiwala, participants of inter-troop aggression were majorly adult and subadult females along with subadult males. As there were more than 2 troops in the surrounding females often came across subadult males of other troops as they are exploratory in nature.

5.3 For objective 2: Interspecific aggression

5.3.1 Frequency of aggression across sites and different age and sex classes

Ethanoprimatologists had started integrating anthropogenic factors into existing ecological models (e.g., socioecological models (Sterck et al., 1997) (Beisner, 2014). As Rhesus macaque is a species which is in constant contact with humans (Southwick & Siddiqi, 1994) they are known to influence each other's behaviour (Beisner, 2014). Across the sites, except for in Kali temple, human initiated aggression surpasses macaque-initiated ones. Here , macaques receive high amount of provisioned food. At times when provisioning is not carried out willingly by humans even though they have food items in their hands, macaques try to snatch it from humans. This causes high number of aggressions from the macaques towards humans. Although there are studies which points out that aggression during provisioning is less (McCarthy et al., 2009), there are multiple other studies which supports the concept of increase in aggression from macaques during provisioning (Beisner, 2014; Fuentes and

Gamerl, 2005). There have been instances of chasing and attempted biting at this site when humans refuse to provide food to the macaques.

Even though provisioning happens in Lacchiwala, prolonged exposure to people carrying food items is not seen. Hence macaque-initiated aggression is lesser here compared to Kali temple. Aggression starting from humans usually are caused due to reason of property or personal damage. Since residents are there in all sites, property and person damage are factors increasing human initiated aggression. This also explains why human initiated aggression is seen more in Buddha temple and Campus.

In Kali temple, human adult males are more aggressive than other classes. This is probably because of the protective nature present in men. While macaques try to beg and snatch food from human irrespective of their gender, human males tend to show counter aggression much more than human adult females. Similar trend is seen in Buddha temple but here, human adult females show higher percent of aggression compared to Kali temple. In Campus, incidents of human aggression are much more initiated by men than women but, the opposite is seen in case of macaques. This is probably due to increased risk to infants and juveniles (Beisner, 2014; Fa, 1992; Fuentes and Gamerl, 2005; Fuentes et al., 2007; Hsu et al., 2009) as the number of residents here are more. As infants and juveniles have more exploratory behaviours, them encountering a close contact from humans would be more. They also get chased for sitting on vehicles, balconies, window sills, etc. All these translates to property damage. Similar trend is seen in Lacchiwala, but the probable reason might be different. The aggression here, could stem from direct food provisioning.

5.3.3 Direction of aggression in each troop

Adult male humans and adult female macaques have highly weighted interactions among them in all sites. The factors leading to such interactions have already been discussed in the section above (frequency of interspecific aggression). In Kali temple, males of both age classes in macaques show high aggression towards adult human males. This could be seen as adult male and subadult male macaques are usually the ones approaching humans to beg or snatch food items from their hands. And while doing so human males also respond with counter aggression. In this site, subadult females, juveniles and children and the individuals that are least weighted.

In Buddha temple, adult human males are seen having more interactions with infants. This could be due to their exploratory nature in an area with high number of residences. Similar trend is seen in Campus and Lachhiwala. Such parallels indicates that direction of aggression would hardly change with different levels of exposure of macaques to humans and vice versa.

5.3.4 Nature of aggression across sites and different age and sex classes

The categories of behaviour classified under high, mid and low levels of aggression are the same as described in the discussion section about level of aggression in intraspecific interaction. In case of aggression from macaques towards humans, in Kali temple and Lachhiwala, behaviours associated with low levels of aggression are seen higher while, in Buddha temple and Campus mid-level aggressive behaviour are seen more. Both places showing high percentage of low-level aggression are area with direct provisioning. The other two sites are riskier as macaques are are mostly encountered with residents. Looking at the trend till now, one would expect high level of aggression to be seen more in Kali temple but, data suggests otherwise. Troops in Campus and Buddha temple show high percentage of mid-

level aggression. In aggression towards macaques, all sites except Lachhiwala, shows mid-level of aggression more. In Lachhiwala high level of aggression is seen more. In Campus, 50% of the time, people interact with mid-level of aggressive behaviour like chasing and action of throwing stones or sticks.

In all these four sites, adult male macaques are showing more behaviours listed as high level of aggression. Except the adult females in Kali temple, all other also showed high level of aggressive behaviour.

5.3.6 Proximate factors of aggression across sites and different age and sex classes

Major factor for human initiated aggression across all sites were due to property damage. Study by Beisner et al.,(2014) also supports this. Climbing onto roofs and windows, destroying or taking away belongings are few examples of the same. This was followed by personal damage which means, being chased or attacked by macaques. Threat is classified differently. It includes situations wherein macaques' signals aggression through facial expressions like brow raise and open mouth threat. Although provisioning was a major cause of interaction in Kali temple and Lacchiwala, food is not a major factor for human initiated aggression. Threat by humans were the major factor eliciting macaque-initiated aggression. This category is followed by food which was high in Kali temple as expected.

Chapter 6: Conclusion

Studies regarding interactions between humans and another species, gives us an insight about how co-existence shapes the behavioural adaptability and ecology of those two. Rhesus macaques have been living alongside humans since decades and there have been a plethora of studies on their activity patterns, behaviours, movement, etc. This study shows how aggression not only depends on the number of individuals present but also on various other behavioural and ecological factors. Provisioning increased the frequency of intraspecific and interspecific aggression irrespective of the level of exposure to people. With respect to age and sex of the individuals of the troop, in most place aggression was shown by adults of the troop. In some cases subadults and immatures also lead the aggression. In humans, adult males were more engaged in interspecific fights compared to other age and sex classes. Intraspecific aggression was more on the context of dominance while it was threat for interspecific. Moreover, human initiated aggression was more due to damage to property. Such behavioural variations can be ever changing and hence become important to study for a better future of co-existing with each other.

References

Ahn, Y. Y., Bagrow, J. P., & Lehmann, S. (2010). Link communities reveal multiscale complexity in networks. nature, 466(7307), 761-764.

Altmann, J. (1974). Observational study of behavior: sampling methods. Behaviour, 49(3-4), 227-266.

Beisner, B. A., Heagerty, A., Seil, S. K., Balasubramaniam, K. N., Atwill, E. R., Gupta, B. K., ... & McCowan, B. (2015). Human–wildlife conflict: Proximate predictors of aggression between humans and rhesus macaques in India. American journal of physical anthropology, 156(2), 286-294.

Beisner, B. A., Jin, J., Fushing, H., & Mccowan, B. (2015). Detection of social group instability among captive rhesus macaques using joint network modeling. Current zoology, 61(1), 70-84.

Bernstein, I. S. (1976). Dominance, aggression and reproduction in primate societies. Journal of Theoretical Biology, 60(2), 459-472.

Bernstein, I. S., Gordon, T. P., & Rose, R. M. (1974). Aggression and social controls in rhesus monkey (Macaca mulatta) groups revealed in group formation studies. Folia primatologica, 21(2), 81-107.

Bolnick, D. I., Amarasekare, P., Araújo, M. S., Bürger, R., Levine, J. M., Novak, M., ... & Vasseur, D. A. (2011). Why intraspecific trait variation matters in community ecology. Trends in ecology & evolution, 26(4), 183-192.

Brody, A. J., & Pelton, M. R. (1989). Effects of roads on black bear movements in western North Carolina. Wildlife Society Bulletin (1973-2006), 17(1), 5-10.

Calvignac-Spencer, S., Leendertz, S. A. J., Gillespie, T. R., & Leendertz, F. H. (2012). Wild great apes as sentinels and sources of infectious disease. Clinical Microbiology and Infection, 18(6), 521-527.

Caro, T. (2007). Behavior and conservation: a bridge too far?. Trends in ecology & evolution, 22(8), 394-400.

Ciani, A. C. (1986). Intertroop agonistic behavior of a feral rhesus macaque troop ranging in town and forest areas in India. Aggressive Behavior, 12(6), 433-439.

Cibot, M., Bortolamiol, S., Seguya, A., & Krief, S. (2015). Chimpanzees facing a dangerous situation: a high-traffic asphalted road in the sebitoli area of kibale national park, Uganda. American Journal of Primatology, 77(8), 890-900.

De Waal, F. B. (2000). Primates--a natural heritage of conflict resolution. Science, 289(5479), 586-590.

Deag, J. M. (1977). Aggression and submission in monkey societies. Animal Behaviour, 25, 465-474.

Duarte, M. H., Vecci, M. A., Hirsch, A., & Young, R. J. (2011). Noisy human neighbours affect where urban monkeys live. Biology letters, 7(6), 840-842.

Dunbar, R. I. (1992). Time: a hidden constraint on the behavioural ecology of baboons. Behavioral ecology and sociobiology, 31, 35-49.

Dunbar, R. I., Korstjens, A. H., Lehmann, J., & British Academy Centenary Research Project. (2009). Time as an ecological constraint. Biological Reviews, 84(3), 413-429.

El Alami, A., Van Lavieren, E., Rachida, A., & Chait, A. (2012). Differences in activity budgets and diet between semiprovisioned and wild-feeding groups of the endangered

Barbary Macaque (Macaca sylvanus) in the Central High Atlas Mountains, Morocco. American journal of primatology, 74(3), 210-216.

Emery Thompson, M. (2013). Comparative reproductive energetics of human and nonhuman primates. Annual Review of Anthropology, 42, 287-304.

Estrada, A., Garber, P. A., Rylands, A. B., Roos, C., Fernandez-Duque, E., Di Fiore, A., ... & Li, B. (2017). Impending extinction crisis of the world's primates: Why primates matter. Science advances, 3(1), e1600946.

Fernandez-Duque, E., Valeggia, C. R., & Mendoza, S. P. (2009). The biology of paternal care in human and nonhuman primates. Annual review of Anthropology, 38, 115-130.

Fuentes, A. (2012). Ethnoprimatology and the anthropology of the human-primate interface. Annual Review of Anthropology, 41, 101-117.

Fuentes, A., & Gamerl, S. (2005). Disproportionate participation by age/sex classes in aggressive interactions between long-tailed macaques (Macaca fascicularis) and human tourists at Padangtegal monkey forest, Bali, Indonesia. American Journal of Primatology: Official Journal of the American Society of Primatologists, 66(2), 197-204.

Gaynor, K. M., Hojnowski, C. E., Carter, N. H., & Brashares, J. S. (2018). The influence of human disturbance on wildlife nocturnality. Science, 360(6394), 1232-1235.

Hare, B. (2011). From hominoid to hominid mind: What changed and why?. Annual Review of Anthropology, 40, 293-309.

Hockings, K. J., McLennan, M. R., Carvalho, S., Ancrenaz, M., Bobe, R., Byrne, R. W., ... & Hill, C. M. (2015). Apes in the Anthropocene: flexibility and survival. Trends in Ecology & Evolution, 30(4), 215-222.

Honess, P. E., & Marin, C. M. (2006). Behavioural and physiological aspects of stress and aggression in nonhuman primates. Neuroscience & Biobehavioral Reviews, 30(3), 390- 412.

Honess, P. E., & Marin, C. M. (2006). Behavioural and physiological aspects of stress and aggression in nonhuman primates. Neuroscience & Biobehavioral Reviews, 30(3), 390-412.

Hsu, M. J., Kao, C. C., & Agoramoorthy, G. (2009). Interactions between visitors and formosan macaques (Macaca cyclopis) at shou-Shan nature park, taiwan. American Journal of Primatology: Official Journal of the American Society of Primatologists, 71(3), 214-222.

Jaman, M. F., & Huffman, M. A. (2013). The effect of urban and rural habitats and resource type on activity budgets of commensal rhesus macaques (Macaca mulatta) in Bangladesh. Primates, 54, 49-59.

Jaman, M. F., & Huffman, M. A. (2013). The effect of urban and rural habitats and resource type on activity budgets of commensal rhesus macaques (Macaca mulatta) in Bangladesh. Primates, 54, 49-59.

Kaburu, S. S., Beisner, B., Balasubramaniam, K. N., Marty, P. R., Bliss-Moreau, E., Mohan, L., ... & McCowan, B. (2019). Interactions with humans impose time constraints on urban-dwelling rhesus macaques (Macaca mulatta). Behaviour, 156(12), 1255-1282.

Kaburu, S. S., Marty, P. R., Beisner, B., Balasubramaniam, K. N., Bliss-Moreau, E., Kaur, K., ... & McCowan, B. (2019). Rates of human–macaque interactions affect grooming behavior among urban-dwelling rhesus macaques (Macaca mulatta). American Journal of Physical Anthropology, 168(1), 92-103.

Kavanagh, M. (1980). Invasion of the forest by an African savannah monkey: behavioural adaptations. Behaviour, 73(3-4), 238-260.

Lott, D. F., & McCoy, M. (1995). Asian rhinos Rhinoceros unicornis on the run? Impact of tourist visits on one population. Biological Conservation, 73(1), 23-26.

Maestripieri, D. (1994). Costs and benefits of maternal aggression in lactating female rhesus macaques. Primates, 35(4), 443-453.

Maréchal, L., MacLarnon, A., Majolo, B., & Semple, S. (2016). Primates' behavioural responses to tourists: evidence for a trade-off between potential risks and benefits. Scientific Reports, 6(1), 32465.

McCarthy, M. S., Lester, J. D., & Stanford, C. B. (2017). Chimpanzees (Pan troglodytes) flexibly use introduced species for nesting and bark feeding in a human-dominated habitat. International Journal of Primatology, 38, 321-337.

McCarthy, M. S., Matheson, M. D., Lester, J. D., Sheeran, L. K., Li, J. H., & Wagner, R. S. (2009). Sequences of Tibetan macaque (Macaca thibetana) and tourist behaviors at Mt. Huangshan, China. Primate conservation, 24(1), 145-151.

McLennan, M. R., & Hill, C. M. (2010). Chimpanzee responses to researchers in a disturbed forest–farm mosaic at Bulindi, western Uganda. American Journal of Primatology, 72(10), 907-918.

McLennan, M. R., Spagnoletti, N., & Hockings, K. J. (2017). The implications of primate behavioral flexibility for sustainable human–primate coexistence in anthropogenic habitats. International Journal of Primatology, 38, 105-121.

Menon, S., & Poirier, F. E. (1996). Lion-tailed macaques (Macaca silenus) in a disturbed forest fragment: activity patterns and time budget. International Journal of Primatology, 17, 969-985.

Menon, V. (2023). Indian mammals: a field guide. Hachette India.

Nowak, K., & Lee, P. C. (2013). “Specialist” primates can be flexible in response to habitat alteration. In Primates in fragments: Complexity and resilience (pp. 199-211). New York, NY: Springer New York.

Phillips, K. A., Bales, K. L., Capitanio, J. P., Conley, A., Czoty, P. W., ‘t Hart, B. A., ... & Voytko, M. L. (2014). Why primate models matter. American journal of primatology, 76(9), 801-827.

Pontzer, H. (2015). Energy expenditure in humans and other primates: a new synthesis. Annual Review of Anthropology, 44, 169-187.

Ram, S., Venkatachalam, S., & Sinha, A. (2003). Changing social strategies of wild female bonnet macaques during natural foraging and on provisioning. Current Science, 780-790.

Richter, C., Mevis, L., Malaivijitnond, S., Schülke, O., & Ostner, J. (2009). Social relationships in free-ranging male Macaca arctoides. International Journal of Primatology, 30, 625-642.

Roos, C., Boonratana, R., Supriatna, J., Fellowes, J. R., Groves, C. P., Nash, S. D., ... & Mittermeier, R. A. (2014). An updated taxonomy and conservation status review of Asian primates. Asian Primates Journal.

Rowe, M. J., Turman, A. B., Murray, G. M., & Zhang, H. Q. (1996). Parallel organization of somatosensory cortical areas I and II for tactile processing. Clinical and experimental pharmacology and physiology, 23(10-11), 931-938.

Sade, D. S. (1973). An ethogram for rhesus monkeys I. Antithetical contrasts in posture and movement. American Journal of Physical Anthropology, 38(2), 537-542.

Saj, T., Sicotte, P., & Paterson, J. D. (1999). Influence of human food consumption on the time budget of vervets. International Journal of Primatology, 20, 977-994.

same of 2014

Sih, A., Ferrari, M. C., & Harris, D. J. (2011). Evolution and behavioural responses to human-induced rapid environmental change. Evolutionary applications, 4(2), 367-387.

Sih, A., Stamps, J., Yang, L. H., McElreath, R., & Ramenofsky, M. (2010). Behavior as a key component of integrative biology in a human-altered world. Integrative and comparative biology, 50(6), 934-944.

Smith, D. G., & McDonough, J. (2005). Mitochondrial DNA variation in Chinese and Indian rhesus macaques (Macaca mulatta). American Journal of Primatology: Official Journal of the American Society of Primatologists, 65(1), 1-25.

Southwick, C. H. (1967). An experimental study of intragroup agonistic behavior in rhesus monkeys (Macaca mulatta). Behaviour, 182-209.

Southwick, C. H., & Siddiqi, M. F. (1994). Population status of nonhuman primates in Asia, with emphasis on rhesus macaques in India. American journal of primatology, 34(1), 51-59.

Southwick, C. H., & Siddiqi, M. F. (1994). Population status of nonhuman primates in Asia, with emphasis on rhesus macaques in India. American journal of primatology, 34(1), 51-59.

Southwick, C. H., Siddioi, M. F., Farooqui, M. Y., & Pal, B. C. (1976). Effects of artificial feeding on aggressive behaviour of rhesus monkeys in India. Animal Behaviour, 24(1), 11-15.

Start, D., & Gilbert, B. (2017). Predator personality structures prey communities and trophic cascades. Ecology letters, 20(3), 366-374.

Theil, J. H., Beisner, B. A., Hill, A. E., & McCowan, B. (2017). Effects of human management events on conspecific aggression in captive rhesus macaques (Macaca mulatta). Journal of the American Association for Laboratory Animal Science, 56(2), 122- 130.

Thierry, B. (2007). Unity in diversity: lessons from macaque societies. Evolutionary Anthropology: Issues, News, and Reviews: Issues, News, and Reviews, 16(6), 224-238.

Tuomainen, U., & Candolin, U. (2011). Behavioural responses to human-induced environmental change. Biological Reviews, 86(3), 640-657.

Wang, S., & Quan, G. (1986). Primate status and conservation in China. In Primates: The Road to Self-sustaining Populations (pp. 213-220). New York, NY: Springer New York.

Waterman, J. O. (2017). Human-macaque encounters in Ifrane National Park, Morocco: behavioural, spatial, and temporal coping strategies of the Barbary macaque (Macaca sylvanus) (Doctoral dissertation, MSc Thesis, University of Lincoln).

Wilson, M. W., Ridlon, A. D., Gaynor, K. M., Gaines, S. D., Stier, A. C., & Halpern, B. S. (2020). Ecological impacts of human-induced animal behaviour change. Ecology Letters, 23(10), 1522-1536.

Wong, B. B., & Candolin, U. (2015). Behavioral responses to changing environments. Behavioral Ecology, 26(3), 665-673.

Appendix I

The ethogram used for this study is adapted from behaviour description by Sade,1973; Hinde,2009 and by observation. Ethogram of both general and aggressive behaviours are done.

A. General behaviours

1. Groom : When an individual is picking parasites, dirt, etc. and brushing the fur with their fingers, sometimes also using mouth. The individual may also lick the fur in the process. Grooming can be of 2 types. Allogrooming where is individual is grooming another individual and auto-grooming when the individual is grooming itself.

2. Rest : When an individual is inactive and sitting on any substrate. Usually keeps their eyes open while resting.

3. Feed : When the individual is ingesting food.

4. Drink : When an individual lays on ground with the support of their hands and ingest water. Some are also seen ingesting water from bottles discarded by humans.

5. Forage : When an individual is actively searching for food.

6. Huddle : When two or more individuals come in close contact while resting or sleeping

7. Locomote : When individual is moving from one place to another or one substrate to another. Locomotion can be in the form of walking which is done slowly or running i.e., moving in a fast pace. 8. Sit : When individual is stationary and resting on their hindquarters on a branch or any other substratum.

9. Stand : When individual is on all fours or on two hindlegs without moving.

10. Sleep : When individual is inactive while laying on a branch, ground, or any other substrate with their eyes closed.

11. Mate : When a male mounts on a female in oestrous and thrusts repeatedly for copulation.

12. Play : When two or more individuals usually infants and juveniles chase, hold, run, mock bite, each other. Adults may sometimes indulge in play with young ones. Object manipulation by infants and juveniles is also considered as play.

13. Scan : When an individual is sitting or standing and surveying the surrounding.

B. Aggressive behaviours : These are behaviours that occur during an agonistic interaction. These behaviours can be shown to conspecifics and to individuals of other species also.

1. Chase : When one individual follows another to attack it by slapping, pushing or biting.

2. Lunge : Sudden, abrupt movement towards another individual but doesn't proceed to have contact. This is done with an aim to scare or warn the other individual.

3. Canine flash : When an individual opens mouth and shows its canine to another individual.

4. Slap : When an individual forcefully swings its forelimbs on another individual's face, body or tail with an intention of showing disagreement.

5. Brow raise : When an individual raises both its eyebrows upwards. Usually, this is done with an open mouth display.

6. Open mouth display : When an individual's mouth is open without exposing the teeth.

7. Charge : When an individual performs a rapid movement towards another.

8. Bite : When an individual bites a body part of another individual forcefully, hurting it. This act can be of mild nature or intense causing injury to the receiver.

9. Push : When an individual exerts a forceful forward movement on another individual, making it move or fall.

10. Bark : A type of vocalization made during aggressive interaction