ECOLOGY AND FEEDING BEHAVIOR OF ASSAMESE MONKEYS (*Macaca assamensis*) IN MID-HILLS OF NEPAL

A THESIS SUBMITTED TO THE

CENTRAL DEPARTMENT OF ZOOLOGY

INSTITUTE OF SCIENCE AND TECHNOLOGY

TRIBHUVAN UNIVERSITY

NEPAL

FOR THE AWARD OF

DOCTOR OF PHILOSOPHY

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BY

SUVAS CHANDRA GHIMIRE

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DECLARATION

Thesis entitled "**Ecology and Feeding Behavior of Assamese Monkeys (*Macaca assamensis*) in Mid-Hills of Nepal**" which is being submitted to the Central Department of Zoology, Institute of Science and Technology (IOST), Tribhuvan University, Nepal for the award of the degree of Doctor of Philosophy (Ph.D.), is a research work carried out by me under the supervision of Prof. Dr. Mukesh Kumar Chalise, Central Department of Zoology, Tribhuvan University.

This research is original and has not been submitted earlier in part or full in this or any other form to any university or institute, here or elsewhere, for the award of any degree.

....
Suvas Chandra Ghimire

RECOMMENDATION

This is to recommend that **Mr. Suvas Chandra Ghimire** has carried out research entitled "**Ecology and Feeding Behavior of Assamese Monkeys (*Macaca assamensis*) in Mid-Hills of Nepal**" for the award of Doctor of Philosophy (Ph.D.) in Zoology under my supervision. To my knowledge, this work has not been submitted for any other degree.

He has fulfilled all the requirements laid down by the Institute of Science and Technology (IOST), Tribhuvan University, Kirtipur for the submission of the thesis for the award of Ph.D. degree.

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Dr. Mukesh Kumar Chalise
Supervisor
(Professor)
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July 2021

LETTER OF APPROVAL

Date: 02/05/2023

On the recommendation of Prof. Dr. Mukesh Kumar Chalise, this Ph.D. thesis submitted by Mr. Suvas Chandra Ghimire, entitled "**Ecology and Feeding Behavior of Assamese Monkeys (*Macaca assamensis*) in Mid-Hills of Nepal**" is forwarded by Central Department Research Committee (CDRC) to the Dean, IOST, T.U.

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....
Suvas Chandra Ghimire
July 2021

ABSTRACT

A study on Assamese monkeys (*Macaca assamensis*) was performed in the Kaligandaki river basin (KRB) of western Nepal and in the Budhigandaki river basin (BRB) of central Nepal. The field study was conducted from February 2015 to January 2016 spending 1804 hours to explore the ecology and feeding behavior of Assamese monkeys.

During the study period, a total of 42 individuals of Assamese monkeys with two troops (Palpa troop n=24 and Syangja troop n=18) with mean group size 21 in KRB and that of 43 individuals with three troops (Rigdikhola troop n=16, Rockybhir troop n=13 and Siurenitar troop n=14) with mean group size 14.33 in BRB were recorded. Pearson's Chi-squared test (χ^2 = 20.5511, p = 0.665) and Fisher's exact test (p = 0.861) show that there is no significant difference in distribution pattern of Assamese monkeys among blocks (Block A, Block B, Block C, Block D and Block E).

Two troops of Assamese monkeys, one from KRB named as Kaligandaki focal Assamese Syangja troop (KFAST) and other from BRB named as Budhigandaki focal Assamese Siurenitar troop (BFAST) were monitored using scan sampling and focal animal sampling methods to understand the ecology and feeding behavior of the monkeys in two different topographical river system of Nepal.

Botanical quadrate sampling (20 m × 20 m) plotted in different altitudinal areas of KRB forest revealed that *Trichilia connaroides* was the dominant plant species with relative density 35.68% and relative frequency 8.38% while *Shorea robusta* was the dominant plant species with relative density 29.75% and relative frequency 8.87% in BRB forest. Different quadrate plots and vegetation analysis revealed that the Assamese monkeys of KRB and BRB were found inhabited in sub-tropical deciduous riverine forest with rocky cliffs habitat. Kaligandaki Assamese monkeys frequently used leaf of *Albizzia chinensis* and that of Budhigandaki used leaf of *Lagerstroemia parviflora* as major food throughout the year. Most of the botanical quadrate plots also included *Albizzia chinensis* species in Kaligandaki area and that of *Lagerstroemia parviflora* species in Budhigandaki area although dominated by *Trichilia connaroides* in Kaligandaki and *Shorea robusta* in Budhigandaki. Further, the sleeping sites of the Assamese monkeys during night time were found on rocky cliffs and rocky outcrops of both the river basin rocks. These rocky cliffs and rocky outcrops were very close with specific food plants of the monkeys in both the sites that might help them to prefer this type of habitat.

Four major behaviors namely feeding, resting, moving and grooming were recorded. During 716 hours of observation period in Kaligandaki, the total feeding time spent by Assamese monkeys was 294.7 hours (41.16%) and in Budhigandaki during 691 hours observation period, the total feeding time spent by the monkeys was 306.5 hours (44.36%), as highest in both sites followed by resting, moving and grooming.

Special emphasis was given to time investment and food intake by the monkeys. They preferred fruits (27.19% in Kaligandaki and 29.54% in Budhigandaki) as the highest intake per year in gram percentage followed by mature leaf and others, however the feeding time spent per year was higher on mature leaf (30.02% in Kaligandaki and 29.04% in Budhigandaki) followed by fruits and others. This shows from the results that food intake amount and time investment on feeding of different plant parts may differ depending on the nutritive value of food availability.

Data from systematic behavioral observations were analyzed with reference to that of the vegetation surveys. Assamese macaques invested more than two-fifths (>40%) of the diurnal time on feeding. The two study troops inhabiting highly similar habitats of food plants (Sorensen's Similarity Index = 0.93) didn't have a significant difference in the selection of food-plant parts. This concludes that food choice and time investment on the feeding of different plant parts differ depending on the availability of food in the area. Macaques living in comparable habitats with similar food plants have analogous food choices and time investments.

Crop raiding by Assamese monkeys is one of the serious problems in both KRB and BRB villages. Maize crop was highly preferred (47.14% in Kaligandaki and 58.43% in Budhigandaki) by the Assamese monkeys as a major crop raid followed by others. Monkeys raid the crops mainly due to the scarcity of natural foods and degradation of their habitats. Therefore, conservation attempts should be focused on this nationally endangered and protected primate species in Nepal in order to provide a practical guide to future conservation.

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LIST OF ACRONYMS AND ABBREVIATIONS

CAMP	Conservation Assessment and Management Plan
IUCN	International Union for Conservation of Nature
DNPWC	Department of National Park and Wildlife Conservation
DoFSC	Department of Forest and Soil Conservation
MoFE	Ministry of Forest and Environment
CITES	Convention on International Trade in Endangered Species
VDC	Village Development Committee
SSC	Species Survival Commission
T/HB	Tail length/head-body length
asl	above sea level
SNNP	Shivapuri Nagarjun National Park
LNP	Langtang National Park
MBCA	Makalu Barun Conservation Area
MBNP	Makalu Barun National Park
mtDNA	mitochondrial deoxyribonucleic acid
GD	Group Density
DM	Dry Matter
GPS	Global Positioning System
RD	Relative Density
RF	Relative Frequency
INGO	International Non Governmental Organization
KRB	Kaligandaki River Basin
BRB	Budhigandaki River Basin
KFAST	Kaligandaki Focal Assamese Syangja Troop
BFAST	Budhigandaki Focal Assamese Siurenitar Troop

LIST OF SYMBOLS

S^2	Variance
CV	Coefficient of Variation
Std	Standard deviation
χ^2	Pearson's Chi-square
H	Kruskal-Wallis
n	Number
%	Percentage
S_s	Sorensen's Similarity Index

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CHAPTER 1

1. INTRODUCTION

1.1 Introduction

Primates are varying according to their activity patterns across taxa and habitats (Chapman & Chapman, 1991; Hanya, 2004; Zhou *et al*., 2007; Fan *et al*., 2008; Dunbar *et al*., 2009; Korstjens *et al*., 2010; Ma *et al*., 2014; Matsuda *et al*., 2014). Many variables determine their activities, including endogenous timing systems (Hut & Beersma, 2011) and natural environments (Lincoln *et al*., 2003). Food-related factors, such as abundance, quality, distribution and seasonal variation of resources, are the determinants shaping the temporal distribution of primates' daily activities (Hanya, 2004; Matsuda *et al*., 2009; Korstjens *et al*., 2010; Sha & Hanya, 2013).

Primates, in general, adjust their diurnal time spent to the four major activities (feeding, resting, moving and socializing) in response to the fluctuation in food abundance (Hanya, 2004; Sha & Hanya, 2013; Fan *et al*., 2013; Bach *et al*., 2017; Guan *et al*., 2018). However, the eastern hoolock gibbons (*Hoolock leuconedys*) increased their resting time and decreased moving time in response to the less fruits available seasons (Fan *et al*., 2013). Animals could reconstruct their activity patterns such as reducing resting times to cope with current environmental changes, thus conserving sufficient time/energy for their social relationships that strongly affect an individual's long term fitness (Dunbar & Dunbar, 1988; Silk *et al*., 2003; Silk, 2007). The shifting of behavior is not always profitable to some species. As demonstrated among gelada baboons (*Theropithecus gelada*), withdrawing from socializing in order to increase foraging times had a negative impact on the group's stability (Dunbar & Dunbar, 1988; Dunbar, 1992). Hence, activity patterns and time budgets can serve as significant predictors of their fates in particular habitats (Dunbar, 1992; Dunbar *et al*., 2009; Korstjens *et al*., 2010). Therefore, a total behavioral study of animal is of great practical importance for the conservation of wild animals itself (Manning & Dawkins, 1998).

Availability of food and influencing other environmental factors, which vary in time and space, impacts the activity budgets of primates (Majolo *et al*., 2013; McFarland *et* *al*., 2014). Seasonal variation in food availability force to many primates altering their activity budget, ranging patterns and dietary flexibility in response to the preferred and fallback foods (Hemingway & Bynum, 2005; Knott, 2005; Grueter, 2017). Furthermore, primates display a wide array of dietary and behavioral adaptations to maintain adequate food during periods of food scarcity (Serckx *et al*., 2015; Clink *et al*., 2017). Among them, frugivores tend to have longer daily travel distances than folivores because fruits are usually more patchily distributed and clumped resources than leaves (Chapman *et al*., 1995; Chalise, 1995).

During seasonal food shortages, primates often display behavioral plasticity by incorporation of alternate plant parts, the human foods from adjoining crop fields and human provisioning. Additionally, they show differences in activity, ranging and grouping patterns (Cabana *et al*., 2017; Frechette *et al*., 2017; McLennan *et al*., 2017). They maximize net energy intake like energy maximizers when high-quality food is available and adopt an energy-conserving strategy during periods of lower energy food availability (Ni *et al*., 2015).

Conventional approaches have mainly examined the influence of climatic conditions, food and nutrient demands, and predation on activity patterns for primates too (Cowlishaw, 1997; Hill & Dunbar, 2002; Hill *et al*., 2004; Hanya, 2004; Zhou *et al*., 2007; Fan *et al*., 2008, 2012; Matsuda *et al*., 2009; Carlson *et al*., 2013; Guan *et al*., 2018). However, the majority of previous studies have examined the annual and/or monthly variations among animals, with limited focus on micro-variations in specific behaviors (Carlson *et al*., 2013). Information regarding such micro-variations is, in fact, crucial for understanding how primates interact with their environment and their energy/time allocate in natural habitats (Raemaekers, 1978; Carlson *et al*., 2013; Ma *et al*., 2014; Matsuda *et al*., 2014).

Temporal distribution of feeding behavior can vary in order to meet the energy needs during different time periods (Raemaekers, 1978; Fan *et al*., 2008; Ma *et al*., 2014). Most primates prefer to consume fruits in the morning to compensate for the energy deficiency from the previous night's rest (Chapman & Chapman, 1991), which is demonstrated by several frugivorous and mixed habit primates, including Cao Vit gibbons (*Nomascus nasutus*) (Ma *et al*., 2014), spider monkeys (*Ateles geoffroyi*) (Chapman & Chapman, 1991), and lar gibbons (*Hylobates lar*) (Raemaekers, 1978).

Among the environmental factors, temperature plays a significant predictor when modeling primates' daily activities and social interactions (Aujard *et al*., 1998; Hill & Dunbar, 2002; Huang *et al*., 2003; Fan *et al*., 2008, 2012; Matsuda *et al*., 2009). As emphasized by Dunbar *et al*. (2009) and Korstjens *et al*. (2010), primates alter their activity patterns in response to thermoregulatory demands, thus indicating that temperature is more important than other ecological factors. For example, the majority of diurnal primates are characterized by two feeding peaks (morning and afternoon) separated by one resting peak at noon if the day length is long (Raemaekers, 1978; Chapman & Chapman, 1991; Huang *et al*., 2003; Fan *et al*., 2008; Ma *et al*., 2014; Matsuda *et al*., 2014). The resting peak is in response to the normally high temperatures around midday (Huang *et al*., 2003, 2016; Hill *et al*., 2004), as demonstrated by the white-headed langurs (*Trachypithecus leucocephalus*) which increase their resting times during hotter months (Huang *et al*., 2003).

The distribution of species is the manner in which a species is spatially arranged. The reasoning behind this is that they share traits that increase vulnerability to extinction because related taxa are often located within the same broad geographical or habitat type where human induced threats are concentrated (Purvis *et al*., 2000).

Food plays crucial primary factor for the regulation of day to day activity profiles of animals (Sarkar *et al*., 2012). Determining the activity patterns and time budgets of animals is essential for understanding their behavioral characteristics (Janson, 1992; Di-Fiore & Rodman, 2001; Kronfeld-Schor & Dayan, 2003; Dunbar *et al*., 2009).

1.1.1 Origin of primates

Evolutionary time scale shows that primates are of very recent origin. It is supposed to be origin of primates around 65-70 million years ago. The first primates were probably small arboreal, quadrupedal omnivores weighing around 150 grams and obtaining their food on the ground and in the lower levels of tropical forests (Fleagle, 1988; Groves, 1993).

The mammals which belong to an order Primate, include the monkeys, apes, humans and other similar forms typically have dexterous hands and feet, binocular vision and a well-developed brain (Tattersall, 1993). They are commonly called monkeys, excluding only the tree shrews, the lemur-like forms, the apes and humans and therefore embody tremendous evolutionary and adaptive arrangements of animals (Tattersall, 1993). Macaques are ecologically extremely adaptive primates which are distributed more widely than any other non-human primate genus. After a split off from the Baboons, Mandrills, and Mangabeys, they moved out of Africa and today only the Barbary macaque (*Macaca sylvanus*) is still found in Africa.

Primates today are found throughout the tropical zones of South America, Africa and Asia. Within those continental areas where they do occur, primates occupy all type of habitat, from climax rain forest and moorland, on high mountain ranges to open savanna and desert habitat (Dunbar, 1998). In broader sense, primates nowadays are confined between 40° N to 40° S of equator in the moderate habitat (Chalise, 1999). Furthermore, macaques are found in tropical rain forests across Asia but may live at high altitudes in the Himalayas and other temperate regions with long snowy winters (Schukle *et al*., 2011; Chalise, 2013a). All other extant *Macaca* species occur in Asia, ranging from Pakistan, India, Nepal and Tibet of China in the west to the northeastern tip of Japan and just south of the Wallace line in the Southeast (Thierry *et al*., 2004).

Living primates are categorized into Prosimians (lemurs, lorises, bushbabies and tarsiers) and Simians or Anthropoids (monkeys, apes and men). The major distinctions between prosimians and the anthropoids are in their sensory anatomy and physiology. Moreover, at the centre of these distinction, the another fact is that the majority of the prosimians are nocturnal and anthropoids are diurnal. Prosimians possess relatively small brain, relatively weak neuromuscular control over their hands and digits as compared to the anthropoids (Bishop, 1964). They have relatively large eyes, sensitive nocturnal vision, large independently movable ears, elaborate tactile hairs and a well developed sense of smell (Bearder, 1987). The anthropoid primates are advance phylogenetically and their sense organs and perceptual abilities are well adapted.

1.1.2 Global primate status and phylogeny

There are 633 identified species of primates and of those 54% of them are threatened, endangered, and critically endangered (IUCN/SSC, 2012) among them 25 primate species are considered to be the most endangered species worldwide (Schwitzer *et al*., 2015). Primates are broadly grouped into Strepsirhines, The New World Monkeys and Platerhines, The Old World Monkeys.

The genus *Macaca* belongs to the subfamily Cercopithecinae which has twelve genera of living species such as Allen's Swamp Monkey, Patas Monkey, Guenons, Mangabeys and possibly more. This subfamily belongs to the family Cercopithecidae which belongs to the superfamily Cercopithecoidea which are called Old World Monkeys; members include Colobus, Langurs, Surilis and Doucs. This superfamily belongs to the Parvorder Catarrhini and there is something very special about this Parvorder.

Catarrhini consists of three families- Cercopithecidae, Hylobatidae and Hominidae (that's ours). In addition to having all of the Old World Monkeys, and the Gibbons, it also named as the Great Apes: Gorillas, Orangutans, Chimpanzees, and Humans (*Homo sapiens sapiens*). Catarrhini belongs to the infraorder Simiiformes. Simiiformes belongs to the suborder Haplorrhini which includes all that has been listed along with the extinct Omomyids. Haplorrhini belongs to the order Primate (Groves, 2001).

1.1.3 Species of monkeys in Nepal

Among the non-human primates, three species of monkeys with their six subspecies (two subspecies of *Macaca* and four subspecies of Langurs) are reported from Nepal (Chalise, 2013). The Rhesus monkeys (*Macaca mulatta* Zimmermann, 1780) are found freely ranging in wild as well as in urban religious places. The Langur monkeys (*Semnopithecus entellus*, former name *Presbytis entellus* Dufresne, 1797) are found freely ranging in wild forest and marginal areas. These two species are common and widely distributed from subtropical (Tarai) to sub-alpine (high mountains upto 12,000 feet) regions of Nepal (Southwick *et al*., 1982; Bishop, 1979). The other macaque species, Assamese monkeys (*Macaca assamensis* McClelland, 1840) are reported from mid-hills and high Montana forest of Nepal, whose ecological and behavioral details are still largely unknown though some population, distribution and habitat use are informed (Chalise, 2006, 2013).

1.1.4 Assamese monkeys

The local vernacular name of Assamese monkeys (*Macaca assamensis*) in Nepal is Pahare Bandar, Pupa, Timnyau or Kala Ganda (Chalise, 2000a). Although the distribution of *Macaca assamensis* is restricted mainly to the Himalayan foothill region, it is also recorded beyond southern parts of churia hills along river basin of Nepal (Chalise, 2016). Because of their distribution pattern, Assamese macaque population would have been more influenced by forest habitat deterioration compared with Rhesus macaque populations (Wada, 2005). The fragmented distribution of the Assamese macaque seems inadequate for maintaining a viable population in Nepal. There has been few studies to estimate the minimal viable population size necessary for the conservation of not only Assamese macaques, but *Macaca* in general (Wada, 2005). Species viability can be measured by evaluating population dynamics and environmental effects (Fa & Linda, 1996).

Assamese macaque is one of the members of polytypic sinica-group of macaques that is characterized by the sagittate-shaped glans penis and that has a fragmented distribution in southern and southeastern Asia. Assamese macaques are medium-sized, arboreal, diurnal, and omnivorous cercopithecine primates that live in multimale-multifemale social groups (Chalise, 1999; Molur *et al*., 2003).

Distribution and conservation status of Assamese monkey in Nepal is not thoroughly documented. Wada (2005) surveyed the distribution of Assamese macaque in Nepal and reported it from only the east of Kaligandaki River. The studies so far in Nepal (Chalise, 1999, 2008, 2013; Chalise *et al*., 2005; Wada, 2005) were confined to surveying the fragmented populations of Assamese macaque at different patches, and found to be presence in west Nepal too. Most of the habitats of the species fall outside the protected areas in mid-hills and site specific detailed documentation of population and distribution was done.

There are two subspecies of the Assamese macaque. These are the Eastern Assamese macaque (*Macaca assamensis assamensis*) and the Western Assamese macaque (*Macaca assamensis pelops*). The distribution ranges of these two subspecies are demarcated by the Brahmaputra River (Groves, 2001; Roos *et al*., 2014).

The Eastern Assamese macaque is located around Bhutan, Southern China, Northeastern India, Lao, Myanmar, Thailand and Vietnam (Groves, 2001). In Thailand, the habitat loss is a threat, and so is a secondary albeit miner threat of hunting, however they are not allowed to be hunted, trapped or harmed in the temples. In Myanmar, they are hunted to make shoes and footwear, while their skins are taken to Tibet for sale; combined with habitat loss this population is facing an imminent threat. In Lao and Vietnam, the threat is hunting for bones to make balm and glue, and although it is not used in Lao, it is exported to Vietnam due to demand.

The Western Assamese macaque is only found in a few populations that are next to each other in India, Nepal, Bhutan and also China. This subspecies, although widely distributed, is threatened by habitat destruction and some populations such as in Nepal are listed as protected species (Chalise, 2000a). The Assamese monkeys of Nepal are considered 'Nepal population' and categorized as "Endangered" by CAMP Workshop 2002 due to taxonomic confusion and shrinking population in their typical natural habitat (Molur *et al*., 2003). This population is different from the Assamese monkeys described up to now from south-east Asia in respect to the head-body length, tail length, T/HB ratio and weight. The body fur and facial coloration also differ in males and females (Chalise, 2003, 2005).

Assamese macaque Nepal population is endemic to Nepal and likely in some way distinct from the two recognized subspecies. Assamese macaque population in Nepal differs in pelage and facial color, relative tail length, and elevation distribution range to their nearest conspecific populations (*Macaca assamensis pelops*) from the adjacent countries such as India and Bhutan. Thus, the Nepalese population of Assamese macaque was doubted for a distinct subspecies status and referred to as '*Macaca assamensis* Nepal population' (Molur *et al*., 2003; Chalise, 2005, 2013; Boonratana *et al*., 2008, 2020).

Nepalese Assamese macaque is categorized as Near Threatened by the IUCN Red List of Threatened Species, as it is experiencing significant declines due to poaching, habitat degradation and fragmentation (Boonratana *et al*., 2008, 2020). This species is listed on Appendix II of CITES. Assamese macaque population of Nepal is listed nationally as endangered species due to its restricted distribution, population threats and small numbers of the population in fragmented patches of the remaining habitat (Chalise, 2013; Khanal *et al*., 2019). Recently, phylogenetic analysis has also suggested that a distinct species status of Assamese macaque population in Nepal emphasizing the need of its conservation intervention (Khanal *et al*., 2021).

Assamese monkeys display variations in both morphological and behavioral patterns at different latitudes and elevations in Nepal due to the isolation by physiographic barriers such as mountains and rivers (Chalise, 2008, 2013; Khanal *et al*., 2018, 2019). This species acts as a crop-raider primate species in many parts of Nepal (Chalise, 2010; Paudel, 2017; Adhikari *et al*., 2018; Ghimire & Chalise, 2018, 2019).

1.1.4.1 Morphology

The common Assamese macaque's pelt is dark to yellowish brown in color. It has hairless face cheek pouches to store food in while foraging. The facial skin is dark brownish to purplish in color. The head has a dark fringe of hair. The hair on the crown is parted in the middle. The adult macaque's body length measures from 50 to 73 cm (20 to 29 inches). Its tail is between 19 and 38 cm (7.5 to 15 inches) in length. The average body weight of the adult male Assamese macaque is between 10 and 14.5 kg (22 to 32 pounds) and the average body weight of the adult female Assamese macaque is between 8 and 12 kg (17 to 26 pounds) (Flannery, 2004).

1.1.4.2 Behavior

The major behaviors of Assamese monkeys consist of foraging, resting, moving, grooming and other social interactions. Searching food, chewing and eating are considered as foraging. Sitting, sleeping and lying are considered as resting. Walking, displacing, playing and swinging are considered as moving. Scratching and searching the lice, ticks, bugs, dirts, etc. on their own body or body of others are considered as grooming. The pattern of behavioral activity is influenced by various factors like availability of food, seasons, habitat, etc. There is no particular time for agonistic and sexual behavior. They can show agonistic and sexual behavior at any time during foraging, resting, moving or grooming. Eating own semen by male after copulation with female is the special feature of Assamese monkeys.

They are omnivorous animals feeding on fruits, leaves, flowers, seeds, cereals and invertebrates especially insect larvae. They live with multi-male and multi-female social troops. They are shy, timid and less aggressive to human beings in comparison to Rhesus monkeys. As a diurnal animal, Assamese macaques are much like human in that during the day they become active and at night they sleep. They live either in trees (arboreal) or on the ground (terrestrial); however it obviously has a preference for the denser areas and is subsequently most frequent in dense forests (Srivastava & Mohnot, 2001).

The study of feeding behavior is essential to the understanding of a species ecological adaptation to the environment, and it is also an important factor to be considered when examining the relationship between ecology and socio-biological problems. Animals must get food to maintain themselves and reproduce. All primates have the same general need to acquire energy, aminoacids, minerals, vitamins, water, and certain fatty acids. However, their specific individual requirements vary and are met in a great variety of ways (Oates, 1987).

Temporal food availability for the particular species drivers their feeding strategies (Bessa *et al*., 2015). Assamese monkeys are habitat specialists preferring a narrow home-range. Their distribution is mainly limited in riverine broad-leaved forests. These forest areas show a remarkable seasonal variation in respect to resource availability. However, in Nepal, the response by monkeys to such variations in food resources accessibility is under studied.

1.1.4.3 Distribution in Nepal

The population of Assamese monkeys in Nepal is distributed in a narrow elevational range of mid-hills (Chalise, 2013; Khanal *et al*., 2019). This species is a habitat specialist preferring broad-leaved riverine forest (Khanal *et al*., 2019). Primarily, they live in subtropical broad-leaved forests. They live on the high canopy and also on the ground (Chalise, 2003). More than half of the population of Assamese macaques currently resides outside the protected area system in Nepal (Khanal *et al*., 2019). The incident of human-macaque conflict through crop-raiding is high. Therefore, the general ecology and socio-ecology of this primate species need to be explored in details that could provide great important information for the conservation of Assamese monkeys in Nepal.

In Nepal, Chalise (2013) reported Assamese monkeys from 284 m in Abukhaireni, Tanahu to 2,350 m asl in Langtang, Rasuwa. They are found in the basin of Arun river around Apsuwa confluence, Bhumlingtar, Haluwabeshi, Tamor river, Bagmati, Trishuli, Sunkoshi, Gandaki and Karnali river basin at higher elevation but warmer valleys. Thus, Nepal population can be located in sub-tropical hill sal forests area to mixed deciduous forest, temperate broad leaved forest with rocky out crops and along the riverside steep sloppy forest of higher altitude. The species confirmed from Kimni Achham, Dadeldhura, Langtang National Park and Helambu area, Makalu Barun National Park, Hariharpur, Nagarjun forest of Kathmandu, Budhigandaki river basin of Dhading and Gorkha districts and Kaligandaki river basin of Palpa and Syangja districts as well as Baglung and Parbat districts. The population of Assamese monkeys in Nepal is recorded during first decade of 2000. Altogether 282 mature individuals were recorded from different sites. The total population was 525 with different age and sex (Chalise, 2006). Later on, 1,099 individuals with 51 different troops of Assamese monkeys were recorded from east Makalu to west Api area of the country (Chalise, 2013).

1.2 Rationale of research

In Nepal, the non-human primates and their multiple behavior dimention are not studied thoroughly. Only few research works have been carried out on population status and distribution of primate species in some ecological zones of Nepal (Chalise & Ghimire, 1998; Chalise, 2006; Khanal *et al*., 2019). No research has been conducted along the Kaligandaki river basin of Palpa and Syangja districts and the Budhigandaki river basin of Dhading and Gorkha districts. These two different topographical zones are also the habitat of Assamese monkeys that lie outside the protected area system of Nepal. The obtained data of population, its composition, distribution pattern, feeding ecology will be contributory for the management and conservation programs of Assamese monkeys in KRB (western Nepal) and BRB (central Nepal).

Assamese monkey (*Macaca assamensis*) is included as protected species by Government of Nepal under the National Parks and Wildlife Conservation Act 1973 (Boonratana *et al*., 2008, 2020; Jnawali *et al*., 2011; Chalise, 2013; Chalise *et al*., 2013). According to Nepal Red List Data Book 1998, it is categorized as nationally endangered species. To balance the natural system of biotic community, every living organism plays a vital role. The Assamese monkeys help for the dispersal of the seeds of the plants and this species is also a part of the ecosystem. So, the Assamese monkeys help in maintaining the natural environment. The population of Assamese macaques is decreasing day by day due to continuous pressure from different human activities like destruction of their habitat, poaching, capturing, killing, etc. (Chalise, 2003). On the other hand, the construction of road alongside the Kaligandaki river (Kaligandaki corridor) and road constructed alongside the Budhigandaki river as well as Budhigandaki hydroelectric project has further threatened the population of Assamese monkeys through rapid loss of their habitats.

This research intends to investigate the status, distribution, habitat preferences, ecology and behavior of this species from two important locations in Nepal which will be helpful to evaluate the conservation status. The outcomes of the research will be beneficial to policy makers to ensure long term conservation and management for Assamese monkeys in Nepal.

1.3 Objectives

General objective:

Study of general ecology and feeding behavior of Assamese monkeys (*Macaca assamensis*) in mid-hills of Nepal especially in Kaligandaki and Budhigandaki river basins.

Specific objectives:

1. Survey of population status and distribution pattern of Assamese monkeys along Kaligandaki river basin (Ramdi to Ranimahal) and Budhigandaki river basin (Benighat to Arughat) of Nepal.
2. Investigation of habitat preference of the monkeys in both study areas.
3. Exploration of general behavior specially feeding behavior of Assamese monkeys in both river basins.
4. Assessment of economic loss status of crop raiding in those areas.

CHAPTER 2

2. LITERATURE REVIEW

2.1 National context

In Nepal, Assamese monkeys are recorded from 284 m asl in Abukhaireni, Tanahu to 2,350 m asl in LNP (Chalise, 2013). Chalise (2007) reported that the primate species Assamese monkeys and langurs are dwellers of riverside forest area as it provides succulent herbs and other food items including insect larvae.

Subba (1998) studied the ecology and habitat of Assamese monkey (*Macaca assamensis*) in MBCA, Nepal. She found that trees with lesser height are not suitable for the night halt and day time resting for the Assamese monkeys. She also reported *Schima wallachi* as the most exploited tree species and *Maesa montana* as the most common plant among the ground vegetation of the macaque's habitat. She concluded that the way in which primate use time and organize activity pattern is an important aspect of behavioral ecology.

Chalise (1999) studied the behavior of Assamese monkey of Makalu Barun Area, Nepal and found that macaque spent 44% of time in foraging, 25% in moving, 13% in grooming and 18% time in resting.

Bhattarai (2002) studied the general behavior and habitat use of Assamese macaque in Sebrubeshi area of LNP. He found that Macaca assamensis used broad-leaved conifer mixed forest and grassland with scattered trees of Urticaceae family abundantly. He recorded the time spent on sitting behavior as highest as 33.3% on followed by 29.6% on feeding, 28.25% on walking, 6.4% on grooming and 1.1% on mating.

Khatiwada *et al*. (2007) studied the population status of Assamese macaque in Kathmandu, Rasuwa and Dhading districts. It was found that the macaques are patchily distributed in the fragmented forests in these areas where macaques are continuously facing the problem of habitat encroachment by the local farmers.

Regmi and Kandel (2008) studied the status of Assamese macaque in Langtang National Park. They reported that a total of 213 Assamese macaques were observed in

9 groups within 113 km^2 in which the group density was found to be 0.0791 groups/km^2 with a population density of 1.8691 individuals/km^2. The mean group size of 23.66 individuals within the total area surveyed of 113 km^2 at Langtang National Park. In addition composition of age-sex of macaque comprised 31% adult females, 16% adult males, 18% young, 16% juveniles and 19% were infants in the study area.

Chalise (2010) studied Assamese monkey in Sebrubeshi of LNP, Nepal. Their habitat revealed that the composition of forest was with 18 species trees and 12 species shrubs and some herbs. According to this study, the monkeys spent time in forest (35%), rocky slope (30%), dry agricultural land (27%), riverbed (4%) and irrigated land (4%) during their activities. The studied troop composition was 14% adult male, 18% adult female, 24% sub-adult male, 20% young adult female, 10% juvenile and 14% infants.

Chalise *et al*. (2013) studied the ecology and behavior of Assamese monkey in Shivapuri Nagarjun National Park. He reported that foraging/eating covered 46% of total observed time while resting 19%, locomotion 16%, sleeping 12%, grooming 6%, and playing 1%. Some other behavior noticed were aggression, copulation, stone licking, coughing and sniffing for short duration. Young and tender leaves as well as adjoining twigs were primary sources of food (38.24%) for winter followed by seeds (35.29%), moss and epiphytes (14.71%), insects (5.88%) and others 5.88% while water drinking was never observed. All troops in Shivapuri forest were found residing on the steep cliffs along the streams bank while Nagarjun forest troops used cliff as well as tall trees.

Adhikari and Chalise (2014) studied the general behavior of Assamese macaque (*Macaca assamensis*) from April 2012 to March 2013 around upper Marsyangdi River in Taghring of Annapurna Conservation Area. A total of 53 Assamese monkeys were recorded in 3 troops. For behavior study 10 minute duration, 2640 scan samples were recorded during the study period covering all four distinct seasons. The studied group spent more than one third (45%) of their total time for foraging purpose, followed by 25% on locomotion, 20% on resting and 10% on grooming. A distinct seasonal variation in activities has been recorded by study troops.

Pandey and Chalise (2015) studied the general ecology and time budgeting for Assamese monkey (*Macaca assamensis*) in SNNP, Nepal. The general ecology and daily time budget of Assamese monkey was accessed in SNNP following Sikre Khola troop. They calculated Assamese monkeys spent 40% time in foraging/feeding, 21% time in locomotion, 16% time in grooming while 15% time inactive. Play and sleeping claimed 6% and 1% time simultaneously.

Crop raiding by monkey species is one of the problem in the village areas of Nepal although they help in dispersal of seeds in the forests (Chalise, 1997, 1999; Ghimire, 2000, 2001). Of equal concern is the fact that these animals are considered as a crop raiding pest in Nepal (Chalise, 2001) and as such conflicts between local farmers and the macaques are on the rise.

2.2 International context

Assamese macaques (*Macaca assamensis*) were observed in central Nepal eastward through the Himalaya to southernmost China and north and central southeast Asia (Fooden, 1982*).* There has been no intensive field study anywhere in southeast Asia, or, barely studied in south Asia (Mitra, 2002, 2003), so little is known about such a widespread monkey (Fooden, 1982; Eudey, 1991; Rowe, 1996).

Assamese macaque has conventionally been seen as a highland species: Lekagul and McNeely (1977), for example, called it "an upland macaque generally found in forested areas above 500 m to as high as 3,500 m." Fooden's (1982) comprehensive review mostly recorded from 150-1,900 m, up to 2,750 m (extended to 3,100 m by Fooden, 1986), and a single, disjunction, record from sea-level.

A survey in Bhutan found Assamese macaques down to 600 m (Kawamoto *et al*., 2006*)*; Choudhury (2008) referred to observation as low as to 100 m. but neither detailed nor discussed the records. Specifically in southeast Asia, records traced by Fooden (1982, 1986) were almost solely in mid-and high-elevation forest, with the lower hill records coming from South Asia.

In contrast with the Arunachal macaque which is unique in its altitudinal distribution, observed largely between 2,000m-3,500m (Kawamoto *et al*., 2006) altitudes whereas Fa (1984) recorded the distribution of the Barbary macaques within the altitudinal range of 600m-2,300m in Morocco and Algeria with the population density of 2-36 individuals/km^2.

Consistent with Fooden's (1982) conclusions, Ruggeri and Timmins (1997) wrote that in the southern two-thirds of Lao PDR, "Assamese macaque is found predominantly in the evergreen forests of the Annamites mountains" but continued "it appears to be the most common species of macaque within areas of Karst." Yet the relevant primary survey reports contain little information on this Karst use in Lao PDR. This habitat use is omitted from some recent compilations (for example, Francis, 2008) and the species was not even mentioned in a review of south-east Asian Karst biota by Clements *et al*. (2006).

The Assamese macaque group seen in Nam Ha NPA was the only macaque sighting firmly identifiable to species in 10 person-weeks, with only two sightings of unidentified macaques (Tizard *et al*., 1997); and there seem to have been to macaque sightings at all in six person-weeks at Nam Xam NPA in 1998 (Showier *et al*., 1998). A roadside survey of pet macaques in several northern highland provinces in May 2006 located 11 in number, of which six were Assamese macaques (Hamada *et al*., 2007). Fooden (1982) concluded that Assamese macaque was ecologically parapatric with, respectively, pig-tailed and Rhesus macaques. In the Hukaung valley of northern Myanmar, along the Tarung HKa (a river), on 21 January 2006 a troop of about 20 Assamese macaques was seen on low bedrock exposed form the river's banks.

Two species of macaques have been reported from Nepal; Rhesus macaque (*Macaca mulatta* Zimmermann, 1780), and the Assamese macaque (*Macaca assamensis* Mc Clelland, 1840) among which the latter one is categorized as 'Vulnerable' in the 2007 IUCN Red List of Threatened Animals. The Assamese macaque (*Macaca assamensis*) of Nepal is fully protected under NPWC Act 1973. Assamese macaques are distributed in Nepal, Sikkim, Bhutan, Assam, Northern Myanmar, Northern Thailand and Yunnan, Southern China (Zhang *et al*., 1981).

There have been few studies to determine the minimal viable population size necessary for the conservation of not only Assamese macaques but also *Macaca* in general (Wada, 2005). Given its restricted extend of occurrences, increasing threats to the individuals and habitat, and decreasing numbers in fragmented patches, the Nepal Assamese macaque population is categorized as 'Endangered' (Molur *et al*., 2003).

Hanya *et al*. (2003) stated that a “group" should be modified to reflect the normal group spread of the species and be defined a group only by distance, and did not distinguish situations when macaques belonging to different social units (troop) stayed within 500m each other. Mehlman (1989) reported that a semi- isolated study population of 162 Barbary macaques (six groups) inhabiting the Ghomaran fir forests of the Moroccan Rif mountains had a density of 6.73 individuals/km^2. Group size ranged from 12 to 59 individuals, with a median value of 24. Southwick *et al*. (1964) reported two troops of Assamese macaques in Darjeeling and estimated group size of 10-25 and the adult sex ratio 1:1.7. Fooden (1982) recorded 11 Assamese macaques' troops and observed troop size varying from 10 to 50 individuals in Kanchanaburi, Thialand.

According to Dunbar and Dunbar (1988) Model, group size in primates is optimized to maximizing net reproductive rate, in relation to the availability-dispersion of food and predation risk. As predation risk is concerned, group size is less important in terms of detection than avoidance of predation (Dunbar & Dunbar, 1988). If early detection is the main anti-predatory strategy as in *Macaca sylvanus*, then group size can be kept small to comfort food availability (Van Schaik *et al*., 1983).

Cooper and Berstein (2002) studied social grooming in Assamese macaque (*Macaca assamensis*) living on the Tukeshwari temple ground in Assam, India. Their study has shown in accordance with social grooming, females as long term inhabitance of this matrifocal group, groomed each other. In addition, males groomed female more often and for longer duration than female groomed males, but both male and female groomed juvenile more often than juveniles groomed them. Juveniles groomed their elders for longer duration. Grooming was concluded as a function to establish and maintain affinitive social bond rather than as a specific mechanism to lure partners for mating.

Cooper *et al*. (2005) studied the reconciliation and relationship quality of Assamese macaque's group living near the Tukeshwari temple near Golpara, Assam, India. Their study stated that animal reconcile are likely to have strong social bonds. In which females reconciled more often with female with which they had stronger grooming and aiding relationship. It was significant for support against aggressors for the victims. This was not found in males. Their study provides evidence that females reconcile most often with valuable and compatible social partners.

Kawamoto *et al*. (2006) studied the distribution of Assamese macaques in the inner Himalayan region of Bhutan and their mtDNA diversity. They recorded no group of Rhesus macaques (*Macaca mulatta*) in their survey, in contrast with the survey results in the Nepalese Himalayas. They concluded that the macaques of the inner Himalayan regions in Bhutan are Assamese macaques which may be a linease distinct from Assamese macaque in the Indo-Chinese region (sub species *Macaca assamensis assamensis*). They also concluded that on the basis of degree of mtDNA the Assamese macaques in Bhutan are of a more ancient ancestry than *Macaca assamensis assamensis*.

Schulke *et al*. (2011) studied about the ecology of Assamese macaque at Phu Khieo Wildlife Sanctuary, Thailand. Unlike Zhou *et al*. (2011) they recorded that Assamese macaque spent large time feeding on fruits. They concluded that Assamese macaque spent about 40% of their activity time on the ground and in the lowest stratum of the forest. The canopy was used rarely by focal troop and they spent a third of their activity time on feeding.

Zhou *et al*. (2011) studied on diet of Assamese macaque in limestone seasonal rain forests at Nonggang Nature Reserve, China. They found that Assamese macaques are highly folivorous, where young leaves were staple food items (74.1% of the diet) and fruit accounted for only 17.4% of the diet.

Sarkar *et al*. (2012) studied activities profile of free ranging forest group of Assamese macaque in Jokai Reserve Forest, Assam, India. They stated that the studied groups spend more than one third (40%) of their total annual time for foraging purpose, followed by 25% on locomotion, 13% on resting, 10% on grooming, 9% on monitoring, 1% on playing and 2% in sexual and other activities. The activities of forest group have revealed that foraging was the crucial factor responsible for the variation in the activities profile. In forest, as the food was randomly distributed, the group arranged their total time cost effectively and spent more time on foraging, locomotion and resting and less time in grooming, monitoring and play activities.

They suggest from their finding that nature of distribution of food resources is the guiding force for allocating time to various activities in various habitats.

Hessen *et al*. (2013) investigated the relationship between food resources, feeding competition, energy intake and reproduction in a group of wild female Assamese macaques in northeastern Thailand. They found that an increase in food availability had a positive effect on female energy intake and conception rates. In addition, it appeared that females incurred energetic costs during lactation and that females with a better physical condition during the mating season were more likely to conceive. Neither energy intake rates nor activity budgets were influenced by female dominance rank, even during periods when the levels of contest competition were predicted to be high.

Animals choose to live in places where they will have the maximum chance of survival or reproductive success. Distribution of species in different habitats may not follow directly from habitat preference or choice; inter- and intraspecific competition can exclude animals from preferred habitats and force them to less suitable areas (Partridge, 1978).

Assamese monkey is a diurnal crop raider. Though the Guarding/Chasing is the most effective method of deterrence in which mainly the women and children engage; it is time expensive and keeps people away from other activities (Southwick & Siddiqi, 1977; Bell, 1984; Southwick & Lindburg, 1986; King & Lee, 1987; Pirta *et al*., 1997; Sekhar, 1998; Knight, 1999; Hill, 2004). It especially consumes the time for educational activities of children in such remote areas which further move the poor people backwards through long lasting impacts.

Conflicts between human and non-human primates are higher in the developing countries of the world than those of the developed countries due to greater biodiversity and lack of prevention measures (Seoraj-Pillai & Pillay, 2016). Further, the behavioral adaptability of the macaques facilitates invading human settlement, and due to which conflicts take place. The conflict between non-human primates and people results the negative impact on the resources and habitats of both human and non-human primates (Hill *et al*., 2002, Hockings & Humle, 2009; Khatun *et al*., 2013; Ahsan & Uddin, 2014).

Human-primates' conflicts occur when the primates raid the crops in the local farmers' crop fields (Hill, 1998). Raiding crops by primates is a major issue for human-primates' conflict (Hill, 1998; Ahsan & Uddin, 2014).

Human-primates' conflicts are increasing day by day because of conversion of natural forest lands to agricultural lands and human settlements. As a result, primates invade the human settlements for food and damage the crops. Some species of primates especially baboons damage unpalatable crops which they do not like to eat but destroy them for their own entertainment and joyful (Hill & Webber, 2010).

CHAPTER 3

3. MATERIALS AND METHODS

3.1 Materials

To obtain the data in the field, different equipments and materials were needed. They were used properly and carefully.

In the field, following equipments and materials were used:

(a) Binocular – Nikon Travelite EX 8x25 6.3° Waterproof 157250 BP

(b) Digital camera – Canon 4x Optical Zoom 6.2-24.8mm 1:2.7-5.6 Mega Pixels 12.1

(c) Timer – Romanson Swiss Quartz NM:2827M

(d) GPS – GARMIN GPSmap 62s

(e) Range finder – Nikon Coolshot 6x21 7.5° Waterproof WY 048822

(f) Data sheet

(g) Measuring tape

(h) Landsite compass

(i) Clip-board

(j) Weighing machine

(k) Topographic map of study area

(l) Stationery

(m) Computer

(n) Field bag

(o) Field gear with logistics

3.2 Study area

Nepal is a mountainous land locked country located between China in the north and India in the south. It is situated between 26° 22' north to 30° 27' north latitude and 80° 40' east to 88° 12' east longitude. The total area of the country is 147,181 km^2. The average length of the country from east to west is 885 km and the width varies from 145 to 241 km with a mean of 193 km north to south. Hills and high mountains cover about 86% of the total land area and the remaining 14% are the flatlands of the Tarai which is less than 300 m in elevation. Altitude varies from some 60 m above sea level in the Tarai to Mount Everest (Sagarmatha) at 8,848 m, the highest point in the world.

Biodiversity of Nepal is a reflection of its unique geographic position, altitudinal and climatic variations. Nepal's location in the central portion of the Himalayas places it in the transitional zone between the eastern and western Himalayas. It incorporates the Palaearctic and the Indo-Malayan biogeographical regions and the major floristic provinces of Asia (the Sino-Japanese, Indian, western and central Asiatic, southeast Asiatic and African Indian desert), creating a unique and rich terrestrial biodiversity.

The mid-hill region covers major portion of Nepal. It accounts for 43% of the total land area of the country. This region is considered the original heartland of Nepal. It is centrally located extending from the southern slopes of the main Himalayan ranges to the Mahabharat ranges, with a varying width of 60 to 110 km running across the length of the country. The location of the region is with an altitudinal range between 400 m to 3000 m. The mid-hill zone is generally made of rugged mountain topography, so the altitude can vary considerably within a short horizontal distance. Thus, the mid-hills include deep river valleys. The climate and vegetation show great variation over a very short distance and give rise to great ecological diversity (Shrestha, 1988).

The Gandaki river system is named as Sapta Gandaki in Nepal after the seven tributaries- the Kaligandaki, Budhigandaki, Marsyangdi, Trishuli, Seti, Madi and Daraundi rivers. Kaligandaki is the longest and the holiest river among Sapta Gandaki, named after the goddess Kali. Budhigandaki river is smaller than Kaligandaki river. Both the rivers are valuable for different purposes like hydropower, scenic beauty, etc. (Source: Kaligandaki Integrated Development Centre 2010). Along the altitudinal and latitudinal differences there are evidences of species variation and also the formation of subspecies in Nepal. Along the river basins, though the Assamese monkeys are dwellers of mid-hills and temperate areas, they are recorded even in lower elevation and subtropical forest type ecosystem. However they are not recorded in subtropical forests of outer Tarai plain (Chalise 2013, 2013a).

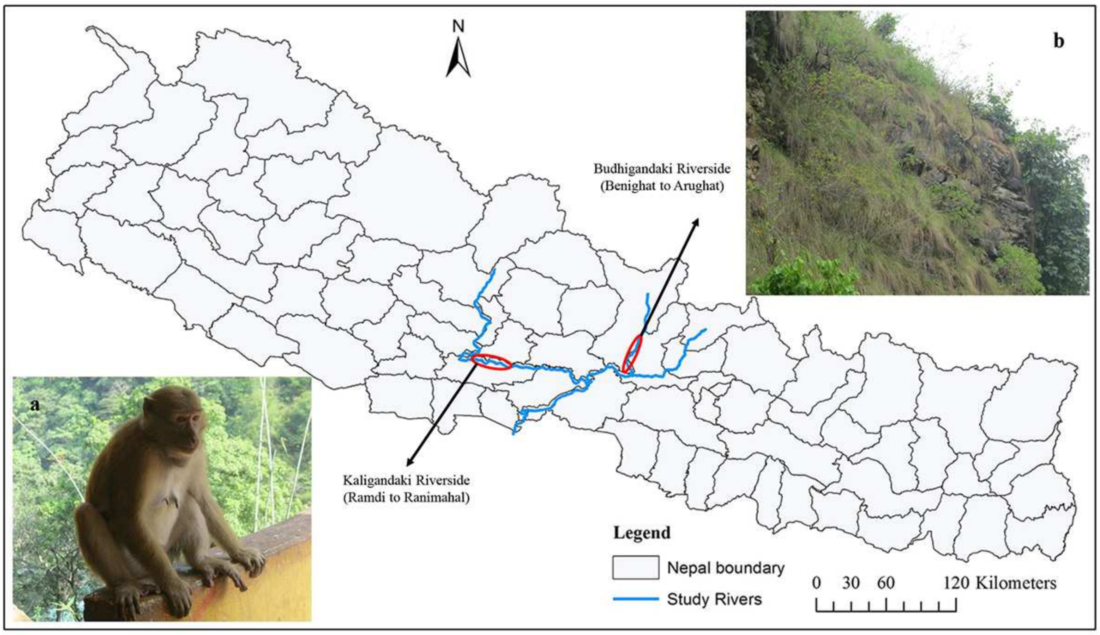

Figure 1: Map of Nepal indicating the study area (Kaligandaki and Budhigandaki River basins). Photos in the inset indicate: a- an adult female Assamese macaque from Kaligandaki focal Assamese Syangja troop; and, b- the Budhigandaki focal Assamese Siurenitar troop resting on their resting site

3.2.1 The research sites in Nepal

Two research sites namely Kaligandaki river basin and Budhigandaki river basin were selected for the behavioral study of Assamese monkeys as these two sites are located in different topography of the country, separated by mountainous and physiographic barriers with two different river systems. These two study sites were choosen in order to explore whether physical barriers might impact to population, behavioral change or not in the same species.

3.2.1.1 Kaligandaki river basin

The study was carried out in KRB (Ramdi to Ranimahal covering about 80 km^2) area of Palpa and Syangja districts (Fig. 1, 2). This area is situated in western part of Nepal. However, according to the constitution of Nepal 2015, Palpa district is situated in Province No. 5 and Syangja district in Province No. 4. The study area located at the mid-point of Siddhartha (Sunauli-Pokhara) Highway lies about 27 km east of Tansen. The coordinates of the study area are 27° 54' 9.34" to 27° 92' 67" north latitude and 83° 38' 3.00" to 83° 52' 78" east longitude. The area covers the altitudinal range from 420 m to 656 m asl. The area occupies rich biodiversity. Mixed forest especially tropical deciduous riverine forest, sub-tropical grassland and sub-tropical evergreen forest occur in this area (Chalise, 2013).

Figure 2: Kaligandaki river basin at Ramdi of Palpa and Syangja districts

3.2.1.2 Budhigandaki river basin

The study was carried out in BRB (Benighat to Arughat covering about 192 km^2) area of Dhading and Gorkha districts (Figs. 1, 3). It is situated in central part of Nepal. However, according to the constitution of Nepal 2015, Dhading district is situated in Province No. 3 and Gorkha district in Province No. 4. The study area is located about 2 km north of Benighat bazaar of Prithvi Highway and it lies about 85 km west of Kathmandu. It is the confluence of Budhigandaki and Trishuli rivers. The coordinates of the study area are 27° 48' 54.48" to 28° 04' 68" north latitude and 84° 46' 33.63" to 84° 81' 25" east longitude. The area covers the altitudinal range from 342 m to 582 m asl. This is biodiversity rich area occupying the mixed forest especially tropical deciduous riverine forest, sub-tropical grassland and evergreen forest (Chalise, 2013).

Figure 3: Budhigandaki river basin at Benighat of Gorkha and Dhading districts

3.2.2 Climate

Both the study areas (Ramdi of Kaligandaki and Benighat of Budhigandaki) lie in between tropical to temperate climatic zone of Nepal. The study areas have both north and south facing topography.

3.2.2.1 Temperature

The summer months are hottest and the winter months are warm during the day while heart chilling cold in early morning and at night. The pleasant months are October and March when the temperature is neither so hot nor so cold. Temperature reached maximum 32.7°C in June and minimum 8°C in December in Ramdi area, Syangja (Table 1) while it reached maximum 33.4°C in June and minimum 8.6°C in December in Benighat area, Gorkha (Table 2) during the study period.

Table 1: Table showing the maximum and minimum temperature (in °C) in Syangja

Month	Maximum	Minimum
January	14.0	8.6
February	19.8	11.1
March	26.6	13.5
April	28.1	14.8
May	32.6	18.1
June	32.7	20.6
July	32.3	22.3
August	31.3	22.2
September	32.3	21.9
October	28.5	17.4
November	24.8	13.7
December	20.0	8.0

Source: Department of Hydrology and Meteorology, Kathmandu, Nepal 2015

Table 2: Table showing the maximum and minimum temperature (in °C) in Gorkha

Month	Maximum	Minimum
January	20.2	8.7
February	23.4	11.1
March	27.2	14.3
April	29.0	16.9
May	33.1	20.6
June	33.4	22.5
July	32.0	23.4
August	31.7	23.4
September	32.0	22.7
October	29.6	18.0
November	25.8	13.7
December	20.4	8.6

Source: Department of Hydrology and Meteorology, Kathmandu, Nepal 2015

3.2.2.2 Relative humidity

The rainy season is normally hot and humid. The winter nights due to the presence of dew are also humid but during the day it is drier. The summer months of April and May are dry and hot. The maximum relative humidity recorded was 96.7% at morning in December and minimum was 72.8% at evening in April in Ramdi area, Syangja (Table 3) while it reached maximum 97.5% at morning in December and minimum 61.1% at evening in March in Benighat area, Gorkha (Table 4) during the study period.

Table 3: Table showing the relative humidity (in %) at morning (8:45) and at evening (17:45) in Syangja

Month	At morning (8:45)	At evening (17:45)
January	94.7	92.6
February	96.0	96.2
March	84.8	77.6
April	82.1	72.8
May	80.6	77.8
June	82.2	75.3
July	86.1	82.2
August	88.9	84.0
September	85.7	84.6
October	91.5	85.5
November	94.1	86.0
December	96.7	88.5

Source: Department of Hydrology and Meteorology, Kathmandu, Nepal 2015

Table 4: Table showing the relative humidity (in %) at morning (8:45) and at evening (17:45) in Gorkha

Month	At morning (8:45)	At evening (17:45)
January	97.0	75.8
February	92.6	67.1
March	85.7	61.1
April	84.9	63.0
May	77.0	61.2
June	84.6	69.4
July	89.2	77.9
August	92.2	79.1
September	91.6	76.5
October	92.8	77.9
November	96.0	77.4
December	97.5	76.8

Source: Department of Hydrology and Meteorology, Kathmandu, Nepal 2015

3.2.2.3 Precipitation

Since the rain bearing winds reach Nepal from the east, the heavy rain occurs in the summer season. The monsoon starts in the last of May and remains till September. About 80% of the total rainfall occurs from June to September and 20% of that occurs in the rest of the year. Rain in Nepal is due to the monsoon wind arising from the Bay of Bengal. The winter monsoon from the Arabian ocean enters from the west part of Nepal and relatively low amounts of scattered showers occur in this area. However, the wind situation of monsoon always changes, so the local weather data may vary each year. The precipitation data of Ramdi area, Syangja shows that the main rainy days were in the months of July and August while that of Benighat area, Gorkha shows that the main rainy days were in the month of June. Maximum rainfall was recorded 727.6 mm in the month of July and minimum was 23.4mm in January, and there were no rainfall in the months of November and December in Ramdi area, Syangja (Table 5) while the maximum rainfall was recorded 301.9mm in the month of June and minimum was 21.3mm in October. There were no rainfall in the months of November and December in Benighat area, Gorkha (Table 6).

Table 5: Table showing the monthly rainfall (in mm) in Syangja

Month	Rainfall
January	23.4
February	26.0
March	*DNA
April	119.5
May	325.3
June	422.8
July	727.6
August	691.3
September	284.1
October	94.7
November	0.0
December	0.0

Source: Department of Hydrology and Meteorology, Kathmandu, Nepal 2015

*DNA = data not available

Table 6: Table showing the monthly rainfall (in mm) in Gorkha

Month	Rainfall
January	57.7
February	23.5
March	83.7
April	57.0
May	76.6
June	301.9
July	241.4
August	240.8
September	46.6
October	21.3
November	0.0
December	0.0

Source: Department of Hydrology and Meteorology, Kathmandu, Nepal 2015

3.2.3 Flora and fauna in the study area

3.2.3.1 Flora

Both Kaligandaki and Budhigandaki river basin forests are rich in plant diversity. Mixed type of forest is found in the study area. Tropical deciduous riverine forest, sub-tropical grassland and sub-tropical evergreen forest are the forest types in the study area (Chalise, 2013b). From the collection of plant herbarium and identification from National Herbarium and Plant Lab. Godawari, the following plant species known and found in and around the home range of Assamese macaques are listed according to Bentham and Hooker System (1882-83) of classification (Appendix V). The dominant plant species of Kaligandaki river basin forest are *Trichilia connaroides*, *Schima wallichii*, *Woodfordia fruiticosa*, *Aegle marmelos*, *Holarrhena pubescens* and *Ficus hispida* whereas the dominant plant species of Budhigandaki river basin forest are *Shorea robusta*, *Adina cardifolia*, *Lagerstroemia parviflora*, *Spondias pinnata*, *Terminalia alata*, *Phyllanthus emblica* and *Mallotus philippensis* (Field visit, 2015-2016).

3.2.3.2 Fauna

The fauna of Kaligandaki river basin and Budhigandaki river basin can be divided into two major types, namely wild animals and domestic animals. The forest of the study area shows the impact not only by human beings but also due to the presence of domestic animals. The herbivore animals are direct competitors of the Assamese monkeys for food and carnivore animals are the predators.

(a) Wild animals: The forest of both the study areas harbour a variety of wild animals. Different species of mammals have been recorded in and around the study area. The most abundant species among them is squirrel (*Callosciurus pygerythrus*), a herbivore. Three species of monkeys, namely Rhesus monkey (*Macaca mulatta*), Assamese monkey (*Macaca assamensis*) and common Langur (*Semnopithecus entellus*) have been recorded. The other common species of wild animals are rufous-tailed hare (*Lepus nigricollis*), yellow-throated marten (*Martes flavigula*) and forest rat (*Bandicota bengalensis*). They are some of the herbivore competitors of Assamese monkeys. The carnivores include the common mongoose (*Herpestes edwardsii*), leopard (*Panthera pardus*), jackal (*Canis aureus*), jungle cat (*Felis chaus*), porcupine (*Hystrix indica*), wild dog (*Cuon alpinus*) and fox (*Vulpes benghalensis*). The big carnivores like tiger (*Panthera tigris tigris*), sloth bear (*Melursus ursinus*) are not found in the study area.

(b) Domestic animals: The domestic animals include cows, oxes, buffaloes and goats. These animals are fully dependent for green fodder on the forest area around the village. The local farmers are of low economic status, so they only feed forest products to these animals. Besides this, they also exploit the forest for other domestic uses such as collection of firewood, timber, etc. There are some tamed dogs in Ramdi village and Benighat area, which accompany with villagers while going to the forest. These dogs sometimes chase and even kill the Assamese monkeys.

(c) Birds: The bird species found inside both the study area are kalij pheasant (*Lophura leucomelana*), eagle (*Spilornis cheela*), great-horned owl (*Bubo bubo*), jungle crow (*Corvus macrorhynchus*), heron (*Ardeola ralloides*), black kite (*Milvus migrans*), long-billed vulture (*Gyps indicus*), ring-necked parakeet (*Psittacula krameri*), cuckoo (*Cuculus canorus*), common koel (*Eudynamys scolopacea*), woodpecker (*Picus viridis*), barn swallow (*Hirundo rustica*), house crow (*Corvus splendens*), common myna (*Acridotheres tristis*), house sparrow (*Passer domesticus*), jungle nightjar (*Carprimulgus indicus*), common tailor bird (*Orthotomus sutorius*) and jungle fowl (*Gallus gallus*). Some migratory birds also appear in the forest from time to time.

(d) Reptiles: The reptilian species found in the forest of both the study area are garden lizard (*Calotes versicolor*), wall lizard (*Hemidactylus flaviviridis*), monitor lizard (*Varanus varius*), salamander (*Salamandra salamandra*) and snakes like nag (*Naja naja*), green viper (*Trimeresurus stejnegeri*), pit viper (*Crotalus horridus*), etc.

(e) Amphibians: There are some amphibians in the forest. The most common amphibians found in both the study areas are common frog (*Rana tigrina*), tree frog (*Hyla arborea*) and toad (*Bufo melanostictus*).

(f) Arthropods: There are some arthropods in the forest. The most common arthropods found in both the study area are centipede (*Scolopendra* sp.), millipede (*Julus* sp.), spider (*Aranea* sp.), butterfly (*Pieris* sp.), dragonfly, wasps, grasshoppers, ants, termites, ticks and beetles.

(g) Annelids: There are some annelids in the forest. The most common annelids found in both the study area are earthworm (*Pheretima posthuma*) and three types of blood-sucking ectoparasitic leeches called *Hirudinaria granulosa*, *Hirudo medicinalis* and *Haemopis sanguisuga*, which are adundant in the rainy season.

(Source: District Forest Office of Syangja and Gorkha)

3.3 Methods

3.3.1 Data collection

3.3.1.1 Preliminary field survey

A preliminary field survey was carried out with research supervisor from 1st January, 2015 to 15th January, 2015. Study area was visited on foot. The survey process included mainly field observation and discussion with local villagers of KRB and BRB. Information about location and species were gathered by interacting with expert and local people. Primary data were collected using direct observation and secondary data were collected from published and unpublished literature. Animals were observed using binoculars and behavioral data collection methods were practiced with experts.

3.3.1.2 Block design

The study areas were divided into five blocks; two for KRB and three for BRB. Block A and Block B were designed for KRB in which Block A (N 27° 54' 29", E 83° 37' 90") covered the Darlamdanda and Khanichhap VDCs that lie in Palpa district (west of Kaligandaki river) at an altitude 456 m asl. Block B (N 27° 54' 12", E 83° 38' 20") covered the Malunga Tunibot VDC which lies in Syangja district (east of Kaligandaki river) at an altitude 420 m asl. Block C, Block D and Block E were designed for BRB in which Block C (N 27° 50' 41", E 84° 46' 42") covered the Salang VDC that lies in Dhading district (east of Budhigandaki river) at an altitude 461 m asl, and Block D (N 27° 50' 79", E 84° 45' 66") and Block E (N 27° 49' 25", E 84° 46' 52") covered the Ghyalchok VDC which lies in Gorkha district (west of Budhigandaki river) with altitudes 582 m and 342 m asl respectively. Each block area for KRB and BRB covered about 10 km^2 . Blocks were designed according to habitat character and distribution pattern of the Assamese monkeys. The field work was carried out from February 2015 to January 2016 covering 1804 hours. Monthly schedule for data collection in the field was made 9 to 10 days per month for each research site.

3.3.1.3 Population status

3.3.1.3.1 Population survey

The population surveys of Assamese monkeys were carried out following the line-transect survey method from all the possible trails in KRB and BRB. The trails were performed walking slowly 0.5 km/hr covering 6 km/day. In every 100 m walking trail complete, observer stopped to walk and searched the area for ½ hour by applying both visual and auditory cues simultaneously as described in Altmann (1974) and practiced by Chalise (2003). When the macaques were encountered, the following data were recorded: detection time, duration of observation, locality and its coordinates, activities and age-sex composition of group. Age and sex were categorized properly with the help of binocular. Counting was repeated several times in an observation session to minimize the bias in distinguishing age and sex of the groups.

3.3.1.3.2 Population density

Population density of Assamese monkeys was calculated as the total number of individuals per unit area. The formula to obtain the population density of Assamese monkeys is:

$$\text{Population Density (D)} = \frac{\text{Total number of individuals in an area (N)}}{\text{Total area (A)}}$$

$$\text{Group Density (G.D.)} = \frac{\text{Total number of troops}}{\text{Total area}}$$

Similarly, sex ratio was taken as the number of males in 100 females.

3.3.1.3.3 Troop composition and age-sex ratio

Troop composition was determined by the direct counting the individuals in each group and age-sex ratios were distinguished by their coloration, body proportion, height and body size (Roonwal & Mohnot, 1977). Assessing age require study of the age classes used by previous researchers and some practice (Ross & Reeve, 2003), the study followed to distinguish the age and sex of the macaques and practiced with the supervisor in the field. Group size and individual were counted and, if groups were stable, then recorded estimation should lead to increasingly accurate counts. However, these records may be inaccurate if some classes behave more conspicuously or avoid humans (e.g. mothers with infants) or because the group is widely dispersed and not all animals can be located (Ross & Reeve, 2003). All areas were surveyed starting at 06:00 a.m. and finishing at 18:00 p.m. Following descriptions were used to distinguish individual Assamese monkeys among troops (Ross & Reeve, 2003).

(a) Adults: Adults are those who attained maximum height and body maturity. Their facial skin is dark brownish to purplish. The head has a dark fringe of hair on the cheeks directed backwards to the ears. Adult males are distinguished by descended scrotal sacs and penis, large skull and prominent sitting pads while adult females by protruded nipple and sexual swelling in estrus period.

(b) Young and sub-adults: Young and sub-adults are those who attained the height of adulthood, however, not matured enough in body fitness and reproductive activities. They are grown up and independent, without hanging scrotal sac in male and no protruded nipple in female.

(c) Juveniles: Juveniles are the individuals that are left nipple contact (weaned) and depend on natural foods. They play a lot between the same age groups. Male try to stay far from mother while female follow her mostly.

(d) Infants: Infants are in the stage that still depends on nipple feeding for their main food. The very young infants are always clinging on breast while a little grown up one are frequently clinging to their mothers for movement and security and sometime ride on her back.

3.3.1.4 Distribution of Assamese monkeys

Five different blocks (Block A, Block B, Block C, Block D and Block E) were designed according to habitat character to determine the distribution pattern of the Assamese monkeys in Kaligandaki and Budhigandaki river basins. Block A (with high human interference, the monkey habitat was frequently fragmented by newly constructed Kaligandaki corridor, dominated by *Trichilia connaroides* and *Ficus hispida* forest, and east facing rocky cliffs and rocky outcrops) and Block B (having less human interference and habitat was dominated by *Ficus hispida*, *Ficus sarmentosa* and *Premna barbata* forest and this area was occupied by west facing rocky cliffs and rocky outcrops) were designed for KRB and Block C (with low human interference and habitat was dominated by *Adina cardifolia* forest with west facing rocky cliffs and rocky outcrops), Block D (having less human interference and habitat was dominated by *Adina cardifolia* forest and this area was occupied by large sized big rocks with east facing rocky cliffs and rocky outcrops) and Block E (having more human interference and habitat was dominated by *Shorea robusta* forest and this area was occupied by east facing rocky cliffs and rocky outcrops) were designed for BRB.

Standard deviation (Std) to mean ratio also called Coefficient of Variation (CV) ratio in Statistics was performed. Higher value of this ratio indicates more variability or less consistency. To further test if blocks differ by distribution, Pearson's Chi-squared test (χ^2) and Fisher's exact test were run in STATA to find significant difference in the distribution pattern of Assamese monkeys among blocks.

3.3.1.5 Habitat analysis

Quadrates of 20 m × 20 m sized were used to analyze the vegetation pattern of Assamese monkey habitat. Altogether 32 quadrates were laid down randomly in the possible habitat of Assamese monkeys of which 16 quadrates for KRB and 16 quadrates for BRB were carried out. The species diversity of trees was calculated. The collected vegetation data were quantitatively analyzed (Ross & Reeve, 2003).

To understand the characteristics and the productivity of the habitat, different parameters such as density, relative density, frequency, relative frequency and dominance of tree plants were determined (Zobel *et al.*, 1987). The local names of the plants were identified with the help of experienced local persons. Herbaria were prepared for unidentified plants in the field and were identified at National Herbarium Center, Godawari, Lalitpur.

$$\text{Density of a species} = \frac{\text{Total number of individuals of a species}}{\text{Total number of quadrates} \times \text{Area of a quadrate}}$$

$$\text{Relative Density of a species} = \frac{\text{Density of a species}}{\text{Total density of all species}} \times 100$$

Frequency of a species is the percentage of quadrates in which the particular species is observed. It gives an index on the spatial distribution of a species and is a measure of relative abundance (Krebs, 1978).

$$\text{Frequency of a species} = \frac{\text{Number of quadrate in which of a species occurs}}{\text{Total number of quadrates}} \times 100$$

$$\text{Relative Frequency of a species} = \frac{\text{Frequency value of species}}{\text{Total frequency value of all species}} \times 100$$

3.3.1.6 Observation methods

Assamese monkeys were observed daily from 06:00 a.m. to 18:00 p.m. during summer months and from 07:00 a.m. to 17:00 p.m. during winter months. Daily observation was scheduled into 4 shifts: early morning 06:00 to 08:30, late morning 09:00 to 11:30, afternoon 12:30 to 15:00 and evening 15:30 to 18:00 during summer months. For winter months it was early morning 07:00 to 08:30, late morning 09:00 to 11:30, afternoon 12:30 to 15:00 and evening 15:30 to 17:00. Daily 10 hours observation during summer months and daily 08 hours observation during winter months were performed with the help of field helpers. Direct ocular observation method was carried out for cataloguing the behavior. The ocular observation was employed with binocular and camera.

3.3.1.6.1 Sampling method

Assamese group size of 18 individuals of Syangja troop of KRB and that of 14 individuals of Siurenitar troop of BRB were selected for the behavioral sampling record of the monkeys as these two troops were more habitual than the other troops in the field. Field work was performed from February 2015 to January 2016. Total time spent on research work was 1804 hours. However, the monkey contact time was 1407 hours. Out of the 1804 hours, 911 hours was spent in KRB and 893 hours was spent in BRB. Out of 1407 hours of monkey contact time, 716 hours was spent for the behavioral data collection in KRB and 691 hours was spent for the behavioral data collection in BRB. Monthly schedule for data collection in the field was made 9 to 10 days per month for each research site.

3.3.1.6.1.a Scan sampling

Scan sampling method is the process of data collection in which behavioral protocols will be taken each day for each animal or group of animals (Altmann, 1974). The behavioral data were collected by this method in which the behaviors of monkey were recorded in every 10 minutes time interval (Altmann, 1974; Martin & Batson, 1993; Chalise, 1997) with the help of timer and aided by binocular. Each observation period consisted of sixty minutes. Systematic scan sampling was done in every 10 minutes during observation period and a continuous record was kept in the protocol paper. Total of 4296 scan samples were recorded from the focal Syangja troop of KRB and total of 4146 scan samples were recorded from the focal Siurenitar troop of BRB, so the grand total of 8442 scan samples were recorded from two study troops of two different river basins. Following behaviors of Assamese monkeys were observed (Appendix I) in the study area.

(a) Foraging/Feeding: In this behavioral activity, the monkey searches for food or eating any substance, geophagy, licking stone or drinking water. Engulfing any food while walking whether chewing or not is considered as feeding/foraging.

(b) Moving: In this activity, the monkey moves from one place to another place with legs and arms or by legs only.

(c) Resting: This is a state of behavior in which the monkey rests on to a supporting surface. It may be monkey sitting any surface, lying or sleeping with eyes closed.

(d) Grooming: This is a behavioral phenomenon where monkeys search their own fur/hair or fur/hair of others for any lice or bugs or dirts or for any compromise.

3.3.1.6.1.b Focal animal sampling

Focal animal sampling is needed in order to collect monkey's behavioral data continuously for certain time period that help to determine the accuracy of behavior of single individual monkey. Scan sampling was followed by focal animal sampling. Focal animal protocols are the core of the data collection. Focal animal sampling means that one individual is observed for a specific amount of time (in this case 60 minutes). The behavioral data were obtained by this method (Altmann, 1974). One focal individual was observed continuously for 60 minutes in one session. During this time, all the behavioral activities of the focal animal were recorded in data sheet and all the behaviors directed towards this focal animal by troop members were also obtained. The selection of individual was randomly taken among the adult monkeys prior to the observation. If the focal animal under observation was partially or completely out of sight, then the behavioral recording of that individual was stopped until this individual was again visible (Altmann, 1974; Martin & Batson, 1993).

This method (Appendix II) was followed but if the focal animal did not reappear within the respective block-hour period a new protocol on a different animal was started. In such cases, the already taken protocols (if at least 30% were completed) were finished after two days.

3.3.1.6.2 Identification of focal animals

To obtain the behavioral pattern of free ranging Assamese monkeys, three adult males (M_1, M_2, M_3) and five adult females (F_1, F_2, F_3, F_4, F_5) were taken as focal animals of Syangja troop in KRB (Table 8) and two adult males (M_1, M_2) and four adult females (F_1, F_2, F_3, F_4) were taken as focal animals of Siurenitar troop in BRB (Table 9). Syangja troop was considered as the focal troop of Assamese monkeys in Kaligandaki river basin and Siurenitar troop was considered as the focal troop of Assamese monkeys in Budhigandaki river basin as they were more habitual than the other troops.

Focal troop members were identified by their morphological characters like facial features, color of skin, cut marks, color of fur and other specific activities as well as walking style. The adult females were bearing colorful sex-skin mark which helped a lot to identify the females in early days of study. In adult males no colorful sex-skin was noticed so other characters as tail carriage, body size and structure, fur color and activity patterns were on accounted to identify them. Later it was possible to recognize them by facial structure and activity pattern also. Some of the identifying characters of focal animals of focal troop were as follows:

Table 7: Table showing the abbreviation and characters of focal animals of Syangja troop

Abbreviation for focal animals	Identifying characters
M_1	Male with heavy body
M_2	Male with protruded forward face
M_3	Male with fractured left hind limb
F_1	Female with heavy body
F_2	Female with red color on the face
F_3	Female with colorful sex-skin
F_4	Female with small infant
F_5	Female with larger nipple

Table 8: Table showing the abbreviation and characters of focal animals of Siurenitar troop

Abbreviation for focal animals	Identifying characters
M_1	Male with protruded forward face
M_2	Male with white spot on the back
F_1	Female with colorful sex-skin
F_2	Female with small infant
F_3	Female with red color on the face
F_4	Female with cut right nose

3.3.1.6.3 Feeding behavior

Data on feeding behavior of Assamese monkeys were collected by direct observation in the field area of KRB and BRB. Feeding items, feeding time and quantity of food of Assamese monkeys from different habitat were collected by direct observation in the field following the methods as in Chalise *et al*. (2013). The food plant parts such as young leaf, mature leaf, fruit, flower, seed, young shoot, bark, and others, which were eaten by the Assamese monkeys, were noted in data sheet (Appendix III). The food plant species and their parts were listed daily as a food list of Assamese monkeys. The feeding time was calculated and expressed in terms of percentages. The total time spent for feeding by the monkeys was considered 100% to calculate the time on different food items. The calculation was as follows:

$$\% \text{ time spent on particular food item} = \frac{\text{Total time spent on a particular food}}{\text{Total time spent on feeding}} \times 100$$

For the similarity in food preference by two study troops, Sorensen's Similarity Index (S_s) was performed as follows:

$$S_s = \frac{2a}{2a + b + c}$$

Where:

S_s : Sorensen's Similarity Coefficient

a : Number of food plants in both communities (joint occurrences)

b : Number of food plants in Kaligandaki but not in Budhigandaki

c : Number of food plants in Budhigandaki but not in Kaligandaki

For the observation of Assamese monkeys feeding behavior, the following definitions were applied:

– Eating or feeding: It means chewing any item. Assamese monkeys chewing were considered as eating, regardless whether they engulf the item through their oesophagus or not, occasionally they chew and threw the chewed object, which was also counted as eating.
– Licking: It means licking any item (e.g. stone licking, honey licking) by tongue.

Assamese monkeys were taking their food in different positions, either sitting, lying (supported by the legs), during movements, while running, clinging, hanging, and standing. In most of the cases, they were feeding while sitting or lying; few cases were observed for other positions.

For each food item eaten by monkeys, at least 100 grams fresh material of exactly the same condition that was eaten by the monkeys were collected, distinguishing species, part, size, color, maturity, rejected parts and others. The samples collected were airtight in plastic bags and kept in the shade to avoid direct sunlight and reactions. The samples collected were carried to the field station and the fresh weight was taken. Thereafter they were submitted to the laboratory of Livestock Department, Khumaltar, Lalitpur. In the laboratory electric ovens were used to dry the fresh material. The dry weight obtained for each item was then calculated for dry matter percentage. The following equation was utilized for calculation:

$$\text{Dry matter percentage (DM \%)} = \frac{\text{Dry weight}}{\text{Fresh weight}} \times 100$$

Intake in gram of one component was calculated on the dry matter basis. Therefore, the intake in gram, percentage dry matters and percentage component were multiplied. This was done for each food item for each monkey and for each month or statistical day. Afterwards food items were added to find out total intake in gram of one component per monkey per month; similarly it was calculated for other component too. Only intake in gram percentage of food items on the dry matter basis was calculated and could not carry out chemical analysis of food due to several limiting factors.

3.3.1.7 Crop raiding

Crop raiding data were collected from local household villagers of KRB and BRB as per the pre-set questions format. Stratified random sampling method was performed to select respondent for the questionnaire survey. Although crop loss was made by several wild animals like wild boars, porcupines, squirrels, rats, birds, etc., but the major loss according to the villagers was by the Assamese monkeys. So the questionnaire survey (Appendix IV) was applied to calculate loss of crop by the Assamese monkeys. More than 200 respondents for each study area were randomly selected as sample size. The questions format was designed to obtain the people's perceptions towards monkeys and crop raiding aspects such as types of crop damaged, frequency, time of day, annual crop loss amount and preventing measures. In order to minimize biasness, questionnaires were asked to local villagers regarding on the expected production of crops with and without raiding. The crop raiding data were calculated in quintals (a unit of weight equal to 100 kilograms) and percentages.

3.3.1.8 Statistical analysis

Besides adding and multiplication of data mentioned above, and average calculations, the processing and analysis of data were based mainly on the following statistical procedures:

(a) All the data were entered in the Microsoft Excel and then analysis was carried out primarily with descriptive statistics using the program Statistica for Windows release 7.0.

(b) Pearson's Chi-squared test (χ^2) and Fisher's exact test were run in STATA to find significant difference in the distribution pattern of Assamese monkeys among blocks.

(c) Variance (S^2) and Coefficient of Variation (CV) ratio also called Standard deviation (Std) to mean ratio were used for monthly distribution of food categories in time spent feeding as well as food intake by Assamese monkeys.

(d) Paired t-test was performed to find significant difference between Kaligandaki focal Assamese Syangja troop (KFAST) and Budhigandaki focal Assamese Siurenitar troop (BFAST) in monthly time spent feeding as well as per individual food intake.

(e) Kruskal-Wallis H test was performed to find significant difference between equal sample medians of food plant parts eaten by Assamese monkeys.

(f) Sorensen's Similarity Index (S_s) was performed for the calculation of similarity in food preference between the two study troops.

CHAPTER 4

4. RESULTS AND DISCUSSION

4.1 Results

4.1.1 Population status

4.1.1.1 Total population

A total of 42 individuals of Assamese monkeys (*Macaca assamensis*) were recorded in two troops in the study area along the KRB in which Palpa troop consisted of 24 individuals and Syangja troop consisted of 18 individuals. In the BRB, a total of 43 individuals of Assamese monkeys were recorded in three troops in which Rigdikhola troop towards Dhading district consisted of 16 individuals and Rockybhir troop and Siurenitar troop towards Gorkha district consisted of 13 individuals and 14 individuals respectively. The minimum number was in Rockybhir troop of BRB whereas the maximum number was in Palpa troop of KRB (Table 9).

Table 9: Population of Assamese monkeys in different blocks of KRB and BRB at 2015-2016

Block	Co-ordinates	Name of troop	Altitude (m)	No. of troop	Troop size
A	N $27^0$54'29" E $83^0$37'90"	Palpa troop	456	1	24
B	N $27^0$54'12" E $83^0$38'20"	Syangja troop	420	1	18
C	N $27^0$50'41" E $84^0$46'42"	Rigdikhola troop	461	1	16
D	N $27^0$50'79" E $84^0$45'66"	Rockybhir troop	582	1	13
E	N $27^0$49'25" E $84^0$46'52"	Siurenitar troop	342	1	14
			Total	5	85

4.1.1.2 Population density

Assamese monkey total population counted along the KRB was 42 individuals which were existing in two different troops and total study area was 80 km^2, therefore the crude density was calculated to be 0.52 individuals/km^2. However, the groups found were two so the group density of the Assamese monkey population of KRB was calculated to be 0.025 groups/km^2. The mean group size was found to be 21 individuals.

In BRB, the total population of Assamese monkeys was 43 individuals with three different troops and total study area was 192 km^2, so the crude density was calculated to be 0.22 individuals/km^2. However, the groups found were three so the group density of the Assamese monkey population of BRB was calculated to be 0.015 groups/km^2. The mean group size was found to be 14.33 individuals.

4.1.1.3 Troop composition and age-sex ratio

The total population of Assamese monkeys (i.e., 42 individuals) in the KRB was composed of 2 troops namely Palpa troop and Syangja troop. The Palpa troop (Block A) was composed of 24 individuals in which 3 adult males, 6 adult females, 2 sub adult males, 1 young adult female, 3 juvenile males, 2 juvenile females, 3 infant males and 4 infant females were found (Table 10). This shows the adult male female ratio as 1:2, sub adult males and young adult females 2:1, juvenile males and juvenile females 1.5:1 and infant males and infant females 1:1.33. The percentage of Palpa troop composition was calculated as adult males 12.5%, adult females 25%, sub adult males 8.3%, young adult females 4.2%, juvenile males 12.5%, juvenile females 8.3%, infant males 12.5% and infant females 16.7%. The Syangja troop (Block B) was composed of 18 individuals in which 3 adult males, 5 adult females, 2 sub adult males, 1 young adult female, 1 juvenile male, 1 juvenile female, 3 infant males and 2 infant females were found (Table 10). This shows the ratio of adult males and adult females was 1:1.66, sub adult males and young adult females 2:1, juvenile males and juvenile females 1:1 and infant males and infant females 1.5:1. The percentage of Syangja troop composition was calculated as adult males 16.7%, adult females 27.8%, sub adult males 11.1%, young adult females 5.6%, juvenile males 5.5%, juvenile females 5.5%, infant males 16.7% and infant females 11.1%.

Out of 42 individuals of Assamese monkeys in KRB, the adult females occupied the highest percentage 26.2% followed by adult males 14.28%, infant males 14.28%, infant females 14.28%, sub adult males 9.52%, juvenile males 9.5%, juvenile females 7.14% and young adult females 4.8%.

In BRB, the total population of Assamese monkeys (i.e., 43 individuals) was composed of 3 troops. The Rigdikhola troop (Block C) was composed of 16 individuals in which 3 adult males, 4 adult females, 1 sub adult male, 1 young adult female, 2 juvenile males, 2 juvenile females, 1 infant male and 2 infant females were found (Table 11). This shows the adult male female ratio as 1:1.33, sub adult males and young adult females 1:1, juvenile males and juvenile females 1:1 and infant males and infant females 1:2. The percentage of Rigdikhola troop composition was calculated as adult males 18.75%, adult females 25%, sub adult males 6.25%, young adult females 6.25%, juvenile males 12.5%, juvenile females 12.5%, infant males 6.25% and infant females 12.5%. The Rockybhir troop (Block D) was composed of 13 individuals in which 3 adult males, 4 adult females, 1 sub adult male, 1 young adult female, 2 juvenile males and 2 infant females were recorded (Table 11). This shows the ratio of adult males and adult females was 1:1.33, sub adult males and young adult females 1:1 and there were no juvenile females and infant males to take the age-sex ratio with same categories. The percentage of Rockybhir troop composition was calculated as adult males 23.1%, adult females 30.76%, sub adult males 7.69%, young adult females 7.69%, juvenile males 15.38% and infant females 15.38%. The Siurenitar troop (Block E) was composed of 14 individuals in which 2 adult males, 4 adult females, 2 sub adult males, 2 young adult females, 1 juvenile male, 2 juvenile females and 1 infant male were found (Table 11). This shows the adult male female ratio as 1:2, sub adult males and young adult females 1:1, juvenile males and juvenile females 1:2 and there were no infant females to take the age-sex ratio with same category. The percentage of Siurenitar troop composition was calculated as adult males 14.29%, adult females 28.57%, sub adult males 14.29%, young adult females 14.29%, juvenile males 7.14%, juvenile females 14.28% and infant males 7.14%.

Out of 43 individuals of Assamese monkeys in BRB, the adult females also occupied the highest percentage 27.91% followed by adult males 18.6%, juvenile males 11.63%, sub adult males 9.3%, young adult females 9.3%, juvenile females 9.3%, infant females 9.3% and infant males 4.66%.

Table 10: Troop composition and age-sex ratio of Assamese monkeys (*Macaca assamensis*) population in KRB at 2015-2016

Age-sex	Palpa troop	Syangja troop	Total number	Percentage (%)
Adult male	3	3	6	14.28
Adult female	6	5	11	26.2
Sub adult male	2	2	4	9.52
Young adult female	1	1	2	4.8
Juvenile male	3	1	4	9.5
Juvenile female	2	1	3	7.14
Infant male	3	3	6	14.28
Infant female	4	2	6	14.28
Total	24	18	42	100

Table 11: Troop composition and age-sex ratio of Assamese monkeys (*Macaca assamensis*) population in BRB at 2015-2016

Age-sex	Rigdikhola troop	Rockybhir troop	Siurenitar troop	Total number	Percentage (%)
Adult male	3	3	2	8	18.6
Adult female	4	4	4	12	27.91
Sub adult male	1	1	2	4	9.3
Young adult female	1	1	2	4	9.3
Juvenile male	2	2	1	5	11.63
Juvenile female	2	-	2	4	9.3
Infant male	1	-	1	2	4.66
Infant female	2	2	-	4	9.3
Total	16	13	14	43	100

The age-sex structure of the Assamese monkeys shows that the adult females were higher in number as compared to the adult males in both KRB and BRB. However, the sub adult males and juvenile males were more in number than the young adult females and juvenile females in KRB. In BRB the juvenile males and infant females were more in number than the juvenile females and infant males. The infant males and the infant females of KRB were equal in number. The sub adult males and young adult females of BRB were equal in number.

4.1.2 Distribution of Assamese monkeys

In Block A (10 km^2), one troop namely Palpa troop with 24 individuals were found in which 3 adult males, 6 adult females, 2 sub adult males, 1 young adult female, 3 juvenile males, 2 juvenile females, 3 infant males and 4 infant females were recorded in Siddhababa Gupha forest of Darlamdanda Village Development Committee of Palpa district, west of Kaligandaki river with high human interference and the monkey habitat was frequently fragmented by newly constructed Kaligandaki corridor.

In Block B (10 km^2), one troop namely Syangja troop with 18 individuals were found in which 3 adult males, 5 adult females, 2 sub adult males, 1 young adult female, 1 juvenile male, 1 juvenile female, 3 infant males and 2 infant females were recorded in Malunga Tunibot forest of Malunga Tunibot Village Development Committee of Syangja district, east of Kaligandaki river having less human interference and habitat with west facing rocky out crop.

In Block C (10 km^2), one troop namely Rigdikhola troop with 16 individuals were found in which 3 adult males, 4 adult females, 1 sub adult male, 1 young adult female, 2 juvenile males, 2 juvenile females, 1 infant male and 2 infant females were recorded in Rigdikhola of Sigrepakha community forest of Salang Village Development Committee of Dhading district, east of Budhigandaki river with low human interference and moderate of food and water sources.

In Block D (10 km^2), one troop namely Rockybhir troop with 13 individuals were recorded in which 3 adult males, 4 adult females, 1 sub adult male, 1 young adult female, 2 juvenile males and 2 infant females were found in Kalo Rockybhir of Sandkhola of Benigam community forest of Ghyalchok Village Development Committee of Gorkha district, west of Budhigandaki river having less human interference and habitat with east facing rocky out crop.

In Block E (10 km^2), one troop namely Siurenitar troop with 14 individuals were found in which 2 adult males, 4 adult females, 2 sub adult males, 2 young adult females, 1 juvenile male, 2 juvenile females and 1 infant male were recorded in Siurenitar forest of Ghyalchok Village Development Committee of Gorkha district, west of Budhigandaki river having more human interference and habitat with east facing rocky out crop.

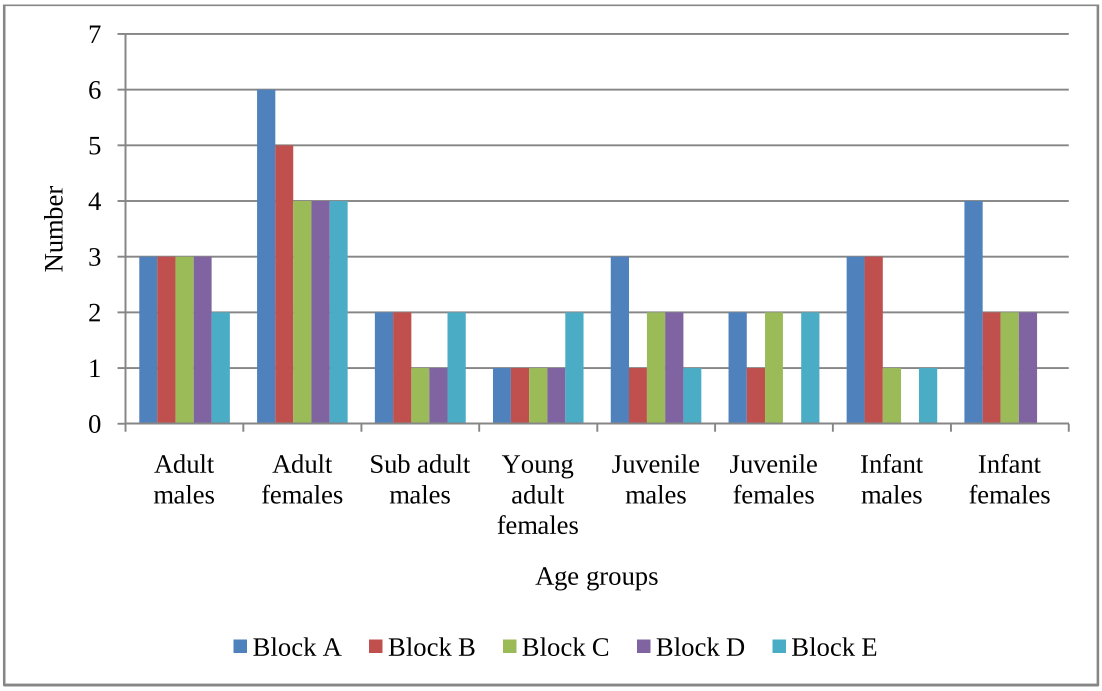

Figure 4: Distribution pattern of Assamese monkeys in different blocks of KRB and BRB at 2015-2016

Table 12: Summary Statistics of distribution pattern of Assamese monkeys among five different study blocks

Blocks	N	Mean	Std. Dev.	Std-to-mean ratio (CV)
A	8	3.00	1.51	50.40
B	8	2.25	1.39	61.72
C	8	2.00	1.07	53.45
D	8	1.63	1.41	86.64
E	8	1.75	1.16	66.57

Standard deviation (Std) to mean ratio also called Coefficient of Variation (CV) ratio in Statistics was performed. Higher value of this ratio indicates more variability or less consistency. By distribution pattern, monkeys belonging to Block D (CV = 86.64) were found most variant and Block A (CV = 50.40) least variant (a variant of a particular thing is something that has a different form to that thing, although it is related to it). This indicates that analysis for the highly variant Blocks such as Block D, Block E and Block B need high caution than the less variant Blocks such as Block A and Block C (Table 12).

To further test if blocks differ by distribution, Pearson's Chi-squared test (χ^2 = 20.5511, p = 0.665) and Fisher's exact test (p = 0.861) were run in STATA that show there is no significant difference among blocks.

4.1.3 Habitat analysis

4.1.3.1 Quadrate plots

In KRB, the highest number of trees i.e 79 was found in quadrate plot number 6 at an altitude of 482 m asl (Table 13). This quadrate plot was dominated by *Trichilia connaroides* species with its 16 number, however the maximum number 26 of this species was recorded in quadrate plot number 14 at an altitude of 497 m asl. The vegetation sampling data shows that the majority of the quadrate plots in KRB were dominated by *Trichilia connaroides* species. In BRB, the highest number of trees i.e. 72 was found in quadrate plot number 9 at an altitude of 443 m asl (Table 14). This quadrate plot was dominated by *Adina cardifolia* species with its 16 number. But, the maximum number 28 of *Shorea robusta* species was recorded in quadrate plot number 7 at an altitude of 393 m asl. The vegetation sampling data shows that the majority of the quadrate plots in BRB were dominated by *Shorea robusta* species.

The majority of the quadrate plots were found covering rocky cliffs and rocky outcrops in both KRB and BRB. Assamese monkeys were found in these rocky cliffs and rocky outcrops during sleeping time at night. The first encountered Syangja troop of Assamese monkeys (n=18) was found at an altitude of 420 m asl. In this point, we took a quadrate plot of size 20 m $\times$ 20 m and found that the total number of trees was 14, dominated by *Ficus hispida*, *Ficus sarmentosa* and *Premna barbata*, and this area was occupied by west facing rocky cliffs and rocky outcrops. Likewise, the first encountered Palpa troop of Assamese monkeys (n=24) was found at an altitude of 456m asl. By using same quadrate plot size in this point, the total number of trees was found 46, dominated by *Trichilia connaroides* and *Ficus hispida,* and east facing rocky cliffs and rocky outcrops were also recorded here. The first encountered Siurenitar troop of Assamese monkeys (n=14) was found at an altitude of 342 m asl. We took a quadrate plot of size 20 m $\times$ 20 m in this point and found that the total number of trees was 40, dominated by *Shorea robusta*, and this area was occupied by east facing rocky cliffs and rocky outcrops. The Rigdikhola troop of Assamese monkeys (n=16) during its first encountered was recorded at an altitude of 461 m asl. By using same quadrate plot size in this point, the total number of trees was found 49, dominated by *Adina cardifolia*, and west facing rocky cliffs and rocky outcrops were recorded here. Likewise, the first encountered Rockybhir troop of Assamese monkeys (n=13) was found at an altitude of 582 m asl. By using same quadrate plot size in this point, the total number of trees was found 31, dominated by *Adina cardifolia*, and this area was occupied by large sized big rocks with east facing rocky cliffs and rocky outcrops.

Table 13: Vegetation sampling of the Assamese monkey habitat in the study area of KRB forest by using quadrate size 20 m × 20 m (Total number of plant species in each quadrate plot according to altitude)

Common Name	Scientific Name	420 m (Q.1)	534 m (Q.2)	637 m (Q.3)	456 m (Q.4)	647 m (Q.5)	482 m (Q.6)	656 m (Q.7)	442 m (Q.8)	515 m (Q.9)	616 m (Q.10)	468 m (Q.11)	551 m (Q.12)	578 m (Q.13)	497 m (Q.14)	564 m (Q.15)	599 m (Q.16)	Total
Aankha taruwa	*Trichilia connaroides*		14	3	8	4	16	3	2	21	8	24	17	18	26	17	15	196
Amala	*Phyllanthus emblica*	1			1				1									3
Amaru	*Spondias pinnata*		1							1					1			3
Bahunkath	*Hymenodictyon excelsum*				2		1		2			1			2			8
Bakaino	*Melia azedarach*	1					2								2			5
Bar	*Ficus benghalensis*								1									1
Barro	*Terminalia bellirica*			2		1		1		2	1		1			1		9
Bel	*Aegle marmelos*		4	3		2	8	5	1	7		5	4	6	5	4		54
Bhalayo	*Semecarpus anarcardium*	1		2		2	3	1	4	2		1	2		1	2	1	22
Botdhayaro	*Lagerstroemia parviflora*		1	1		1				2	1			1	1	1		9
Chilaune	*Schima wallichii*		3	4	7	8	7	12		5	8	6	9	11	8	8	7	103
Chiuri	*Diploknema butyracea*									1			1					2
Gidari	*Premna barbata*	2			1										2			5
Harro	*Terminalia chebula*		1			1		1					1					4
Jamun	*Syzygium cumini*				1		1					1			1			4
Kafal	*Myrica esculenta*	1							1			1						3
Kalikath	*Aporusa octandra*		2		4	3	5		2	6		5	3	3		1	1	35
Karam	*Adina cardifolia*									1			1	1				3
Katus	*Castanopsis indica*	1			2				1			2			2			8
Khair	*Acacia catechu*		1			2		2		1		1	1			1	2	11
Khanyo	*Ficus sarmentosa*	2			1		1								2			6
Mahua	*Madhuca longifolia*		5	4		2	4	2		3	2	3	1	2	3	2	3	36
Neem	*Azadirachta indica*			1		1				1		2						5
Nilo tanki	*Uraria lagopodioides*			2			1	1	2	1	1		1	1	1			11
Pakhuri	*Ficus hederacea*	1	2		3	2		1	3		1	4		1	2		1	21
Palas	*Butea minor*	1	2		1	2			1		1	1	1	1		1	1	13
Phaledo	*Erythrina variegata*	1			1		2		2			1				1		8
Pipal	*Ficus religiosa*				1		1											2
Reetha	*Sapindus mukorossi*		1	1						1	1		1				1	6
Saj	*Terminalia alata*			1		1		1										3
Sal	*Shorea robusta*						1					2			1			4
Sigane	*Lannea coromandelica*			4		3	2	3		2	1		2		1	1		19
Simal	*Bombax ceiba*				1		1		1									3
Sindure	*Mallotus philippensis*				1		1		1									3
Sirish	*Albizzia chinensis*		4	3	1		6	4	2		5		7	3		3	4	42
Thotne	*Ficus hispida*	2	3	4	8		9	1	2		3	2		4	2	4	3	47
Tuni	*Toona ciliata*		3	4	2		7	1		4	2	2		2	2		2	31
Total		14	47	39	46	35	79	39	29	61	35	64	53	54	65	47	41	748

Note: Q. = Quadrate plot

Table 14: Vegetation sampling of the Assamese monkey habitat in the study area of BRB forest by using quadrate size 20 m × 20 m (Total number of plant species in each quadrate plot according to altitude)

Common Name	Scientific Name	342m (Q.1)	431m (Q.2)	461m (Q.3)	367m (Q.4)	510m (Q.5)	491m (Q.6)	393m (Q.7)	569m (Q.8)	443m (Q.9)	582m (Q.10)	378m (Q.11)	547m (Q.12)	452m (Q.13)	526m (Q.14)	351m (Q.15)	414m (Q.16)	Total
Aankha taruwa	*Trichilia connaroides*				3	1	1	2	2	3		2	1		2		1	18
Amala	*Phyllanthus emblica*	2	2	1	1		3			4		3		4		2	4	26
Amaru	*Spondias pinnata*			2		6	5		7	9	2		3	4	7			45
Barro	*Terminalia bellirica*		2				1			1			1		1	2	2	10
Bel	*Aegle marmelos*								2		1		1		2			6
Bhalayo	*Semecarpus anarcardium*		1	1					2		1		1		1			7
Botdhayaro	*Lagerstroemia parviflora*		3	8	6		7	2	4	8		5	2	6	3	2	5	61
Champ	*Michelia champaca*					1			1				1					3
Chhatiwan	*Alstonia scholaries*		1				1				1				1			4
Chilaune	*Schima wallichii*		3	4		3			3		1	1	2	1	3	2		23
Chiuri	*Diploknema butyracea*		1			1					1			1				4
Harro	*Terminalia chebula*		1				2		3				1	1			1	9
Kadam	*Anthocephalus chinensis*			1			1								1		1	4
Kafal	*Myrica esculenta*	1				1		1		1				1			1	6
Kalikath	*Aporusa octandra*		3		2	2		1	1	1		2	3			1	3	19
Karam	*Adina cardifolia*		14	11		4	9	2	2	16	5	1	6	8	7		12	97
Kavro	*Ficus lacor*									1							1	2
Khair	*Acacia catechu*			2				1		4			1	1			2	11
Khanyo	*Ficus sarmentosa*	2		1			1						1	1		1		7
Koiralo	*Bauhinia variegata*					1			1		1		1					4
Mahua	*Madhuca longifolia*	1	2	4	1		2	1		2	1	1		1	1	1		18
Neem	*Azadirachta indica*		1		1		1					1				2		6
Nilo tanki	*Uraria lagopodioides*	1		1		1								2			1	6
Pakhuri	*Ficus hederacea*	1	1	1	1				1		2	1			2			10
Palas	*Butea minor*	2			4					2		2		2				12
Phaledo	*Erythrina variegata*	2			1	1		1		1	1	1			1			9
Reetha	*Sapindus mukorossi*			1	1	1			2		2	1		1				9
Saj	*Terminalia alata*			1		2	3		8	2	3		1	1	2		3	26
Sal	*Shorea robusta*	27	11	6	22	7	8	28	3	10	3	24	7	16	7	26	18	223
Simal	*Bombax ceiba*			1			1					1						3
Sindure	*Mallotus philippensis*					3	2		2	5	2		3		3		4	24
Sirish	*Albizzia chinensis*		1	2	1		2	2			2	2	1	3	2	2	2	22
Thotne	*Ficus hispida*	1			1			1		2		1				1		7
Tuni	*Toona ciliata*		3	1		2	1		1		2		1	2	1	1		15
Total		40	50	49	45	37	51	42	45	72	31	49	38	56	47	43	61	756

Note: Q. = Quadrate plot

4.1.3.2 Vegetation analysis

Botanical quadrate sampling (20 m × 20 m) plotted in different altitudinal areas of KRB forest revealed that *Trichilia connaroides* was the dominant tree species in the forest. This species was followed by *Schima wallichii*, *Aegle marmelos*, *Ficus hispida* and others. But in BRB forest, *Shorea robusta* was found the dominant tree species in the forest. This species was followed by *Adina cardifolia*, *Lagerstroemia parviflora*, *Spondias pinnata*, *Terminalia alata*, *Phyllanthus emblica*, *Mallotus philippensis* and others. A total of 37 tree species with 748 numbers were recorded in KRB forest and 34 tree species with 756 numbers were recorded in BRB forest. This study revealed that *Trichilia connaroides* as dominating tree species with relative density 35.68% and relative frequency 8.38% in KRB forest (Table 15) while *Shorea robusta* with relative density 29.75% and relative frequency 8.87% in BRB forest (Table 16).

Table 15: Vegetation analysis of the Assamese monkey habitat in the study area of KRB forest

SN	Common Name	Scientific Name	Total	%	D.	R.D.	F.	R.F.
1.	Aankha taruwa	*Trichilia connaroides*	196	26.20	0.0306	35.68	87.50	8.38
2.	Amala	*Phyllanthus emblica*	3	0.40	0.00046	0.53	12.50	1.19
3.	Amaru	*Spondias pinnata*	3	0.40	0.00046	0.53	12.50	1.19
4.	Bahunkath	*Hymenodictyon excelsum*	8	1.07	0.00125	1.45	25.00	2.39
5.	Bakaino	*Melia azedarach*	5	0.67	0.00078	0.90	18.75	1.79
6.	Bar	*Ficus benghalensis*	1	0.14	0.00015	0.17	6.25	0.59
7.	Barro	*Terminalia bellirica*	9	1.20	0.0014	1.63	31.25	2.99
8.	Bel	*Aegle marmelos*	54	7.22	0.0084	9.79	56.25	5.38
9.	Bhalayo	*Semecarpus anarcardium*	22	2.94	0.0034	3.96	37.50	3.59
10.	Botdhayaro	*Lagerstroemia parviflora*	9	1.20	0.0014	1.63	31.25	2.99
11.	Chilaune	*Schima wallichii*	103	13.77	0.01609	18.76	68.75	6.58
12.	Chiuri	*Diploknema butyracea*	2	0.27	0.0003	0.34	6.25	0.59
13.	Gidari	*Premna barbata*	5	0.67	0.00078	0.90	18.75	1.79
14.	Harro	*Terminalia chebula*	4	0.54	0.0006	0.69	12.50	1.19
15.	Jamun	*Syzygium cumini*	4	0.54	0.0006	0.69	12.50	1.19
16.	Kafal	*Myrica esculenta*	3	0.40	0.00046	0.53	12.50	1.19
17.	Kalikath	*Aporusa octandra*	35	4.68	0.00546	6.36	43.75	4.19
18.	Karam	*Adina cardifolia*	3	0.40	0.00046	0.53	12.50	1.19
19.	Katus	*Castanopsis indica*	8	1.07	0.00125	1.45	25.00	2.39
20.	Khair	*Acacia catechu*	11	1.47	0.0017	1.98	37.50	3.59
21.	Khanyo	*Ficus sarmentosa*	6	0.80	0.0009	1.04	18.75	1.79
22.	Mahua	*Madhuca longifolia*	36	4.81	0.0056	6.53	43.75	4.19
23.	Neem	*Azadirachta indica*	5	0.67	0.00078	0.90	18.75	1.79
24.	Nilo tanki	*Uraria lagopodioides*	11	1.47	0.0017	1.98	37.50	3.59
25.	Pakhuri	*Ficus hederacea*	21	2.81	0.00328	3.82	37.50	3.59

26.	Palas	*Butea minor*	13	1.74	0.00203	2.36	37.50	3.59
27.	Phaledo	*Erythrina variegata*	8	1.07	0.00125	1.45	25.00	2.39
28.	Pipal	*Ficus religiosa*	2	0.27	0.0003	0.34	6.25	0.59
29.	Reetha	*Sapindus mukorossi*	6	0.80	0.0009	1.04	18.75	1.79
30.	Saj	*Terminalia alata*	3	0.40	0.00046	0.53	12.50	1.19
31.	Sal	*Shorea robusta*	4	0.54	0.0006	0.69	12.50	1.19
32.	Sigane	*Lannea coromandelica*	19	2.54	0.00296	3.45	37.50	3.59
33.	Simal	*Bombax ceiba*	3	0.40	0.00046	0.53	12.50	1.19
34.	Sindure	*Mallotus philippensis*	3	0.40	0.00046	0.53	12.50	1.19
35.	Sirish	*Albizzia chinensis*	42	5.61	0.00656	7.65	50.00	4.79
36.	Thotne	*Ficus hispida*	47	6.28	0.0073	8.51	50.00	4.79
37.	Tuni	*Toona ciliata*	31	4.14	0.0048	5.59	43.75	4.19
Total			748	100	0.08574		1043.75	

Note: D.=Density, R.D.=Relative Density, F.=Frequency and R.F.=Relative Frequency

Table 16: Vegetation analysis of the Assamese monkey habitat in the study area of BRB forest

SN	Common Name	Scientific Name	Total	%	D.	R.D.	F.	R.F.
1.	Aankha taruwa	*Trichilia connaroides*	18	2.38	0.0028	2.39	37.50	3.55
2.	Amala	*Phyllanthus emblica*	26	3.44	0.004	3.41	43.75	4.14
3.	Amaru	*Spondias pinnata*	45	5.95	0.007	5.98	50.00	4.73
4.	Barro	*Terminalia bellirica*	10	1.32	0.00156	1.33	31.25	2.95
5.	Bel	*Aegle marmelos*	6	0.79	0.0009	0.76	18.75	1.77
6.	Bhalayo	*Semecarpus anarcardium*	7	0.93	0.001	0.85	18.75	1.77
7.	Botdhayaro	*Lagerstroemia parviflora*	61	8.07	0.0095	8.12	50.00	4.73
8.	Chanp	*Michelia champaca*	3	0.40	0.00046	0.39	12.50	1.18
9.	Chhatiwan	*Alstonia scholaries*	4	0.53	0.0006	0.51	12.50	1.18
10.	Chilaune	*Schima wallichii*	23	3.04	0.00359	3.06	43.75	4.14
11.	Chiuri	*Diploknema butyracea*	4	0.53	0.0006	0.51	12.50	1.18
12.	Harro	*Terminalia chebula*	9	1.19	0.0014	1.19	25.00	2.36
13.	Kadam	*Anthocephalus chinensis*	4	0.53	0.0006	0.51	12.50	1.18
14.	Kafal	*Myrica esculenta*	6	0.79	0.0009	0.76	18.75	1.77
15.	Kalikath	*Aporusa octandra*	19	2.51	0.00296	2.53	37.50	3.55
16.	Karam	*Adina cardifolia*	97	12.83	0.015	12.82	68.75	6.50
17.	Kavro	*Ficus lacor*	2	0.27	0.0003	0.25	12.50	1.18
18.	Khair	*Acacia catechu*	11	1.46	0.0017	1.45	31.25	2.95
19.	Khanyo	*Ficus sarmentosa*	7	0.93	0.001	0.85	18.75	1.77
20.	Koiralo	*Bauhinia variegata*	4	0.53	0.0006	0.51	12.50	1.18
21.	Mahua	*Madhuca longifolia*	18	2.38	0.0028	2.39	37.50	3.55
22.	Neem	*Azadirachta indica*	6	0.79	0.0009	0.76	18.75	1.77
23.	Nilo tanki	*Uraria lagopodioides*	6	0.79	0.0009	0.76	18.75	1.77
24.	Pakhuri	*Ficus hederacea*	10	1.32	0.00156	1.33	31.25	2.95
25.	Palas	*Butea minor*	12	1.59	0.00187	1.59	37.50	3.55

26.	Phaledo	*Erythrina variegata*	9	1.19	0.0014	1.19	25.00	2.36
27.	Reetha	*Sapindus mukorossi*	9	1.19	0.0014	1.19	25.00	2.36
28.	Saj	*Terminalia alata*	26	3.44	0.004	3.41	43.75	4.14
29.	Sal	*Shorea robusta*	223	29.50	0.0348	29.75	93.75	8.87
30.	Simal	*Bombax ceiba*	3	0.40	0.00046	0.39	12.50	1.18
31.	Sindure	*Mallotus philippensis*	24	3.17	0.0037	3.16	43.75	4.14
32.	Sirish	*Albizzia chinensis*	22	2.91	0.0034	2.90	43.75	4.14
33.	Thotne	*Ficus hispida*	7	0.93	0.001	0.85	18.75	1.77
34.	Tuni	*Toona ciliata*	15	1.98	0.0023	1.96	37.50	3.55
Total			756	100	0.11696		1056.25	

Note: D.=Density, R.D.=Relative Density, F.=Frequency and R.F.=Relative Frequency

4.1.3.3 Sleeping sites

In both the KRB and BRB, sleeping sites of the Assamese monkeys during night time were found on rocky cliffs and rocky outcrops in steepy as well as slope areas of the river basin rocks. During the entire field study period, sleeping of the Assamese monkeys at night on the trees in both the river basins were never observed. During the day time, they were found on the trees for short sleep. The colour of the rocks in both the river basins was found to resemble with the Assamese monkeys' body colour. This might be the adaptation of the Assamese monkeys with the habitat environment. These rocky areas were usually devoid of trees and shrubs. These might be presumably selected to minimize risk of attack by predators. During staying in rocky habitat, the monkeys performed stone-licking that might help their digestive system.

4.1.3.4 Habitat preference

Different quadrate plots and vegetation analysis revealed that the Assamese monkeys of KRB and BRB inhabited in sub-tropical deciduous riverine forest with rocky cliffs habitat. The habitat of the Kaligandaki Assamese monkeys was dominated by the trees like *Trichilia connaroides* followed by *Schima wallichii*, *Aegle marmelos*, *Ficus hispida* and others (Table 15) while that of Budhigandaki with *Shorea robusta* followed by *Adina cordifolia*, *Lagerstroemia parviflora*, *Spondias pinnata* and others (Table 16). Kaligandaki Assamese monkeys used leaf of *Albizzia chinensis* and that of Budhigandaki used leaf of *Lagerstroemia parviflora* as a major food plant throughout the year though they ate other plant species and their parts available seasonally in both the research sites. Most of the botanical quadrate plots also included *Albizzia chinensis* tree species in Kaligandaki area and that of *Lagerstroemia parviflora* tree species in Budhigandaki area. Further, the sleeping sites of the Assamese monkeys during night time were found on rocky cliffs and rocky outcrops in steeply as well as slope areas of both the Kaligandaki and Budhigandaki river basin rocks. These rocky cliffs and rocky outcrops were very close with specific food plants of the Assamese monkeys in both the research sites. So the Assamese monkeys preferred that habitat.

4.1.3.5 Home range

The daily home range mean path-length of Assamese monkeys was found 3403 m for Palpa troop (n=24) along the side of the river basin of Kaligandaki at Ramdi area towards Palpa district. The Syangja troop (n=18) was recorded 2692 m home range along the side of the river basin of Kaligandaki at Ramdi area towards Syangja district. It was found 2411 m for Rigdikhola troop (n=16) along the side of the river basin of Budhigandaki at Sigrepakha community forest towards Dhading district. The Rockybhir troop (n=13) was recorded 2108 m home range in Benigam community forest towards Gorkha district and the Siurenitar troop (n=14) was found 2267 m home range along the side of the river basin of Budhigandaki at Siurenitar area towards Gorkha district.

Home range overlap of Assamese monkeys in both the research sites was not detected. This may be due to the presence of river barrier for two basin sides of each river. During the entire field study period, the monkey troop crossing Kaligandaki and Budhigandaki rivers was not seen. Even in KRB area it was observed that both the Palpa troop and the Syangja troop reaching at the mid-point of the Kaligandaki bridge and then they backed to their respective sides. So, all Assamese troops were mostly found in their horizontal path-length along their respective sides of the river with their non overlapping home range.

4.1.4 Behavior

4.1.4.1 Feeding behavior

Assamese monkeys' 3 adult males and 5 adult females from group size 18 of Syangja troop of KRB and 2 adult males and 4 adult females from group size 14 of Siurenitar troop of BRB were selected as the focal animals for the study of feeding behavior in two topographical variable river basins.

4.1.4.1.1 Food plants of Assamese monkeys

The investigated focal Syangja troop was found to utilize 71 plant species for food in which 45 tree species, 11 shrub species, 10 herb species and 5 climber species were recorded while the investigated focal Siurenitar troop was found to utilize 69 plant species for food in which 43 tree species, 12 shrub species, 10 herb species and 4 climber species were recorded. Among them, 65 food plants were similar in both study areas that resulted Sorensen's Similarity Index of 0.93. Majority of plant species were fruit bearing plants. Assamese monkeys utilized the different parts (fruit, mature leaf, young leaf, seed, petiole, leafbud, bark, flower, rhizome, young shoot and inflorescence) of the different plant species for feeding (Tables 17, 18).

Table 17: Plant species and their parts eaten by the Assamese monkeys in the study area of the KRB forest

SN	Local Name	Scientific Name	Part eaten as food
1.	Aankha taruwa	*Trichilia connaroides*	Fruit
2.	Ainselu	*Rubus ellipticus*	Fruit
3.	Amala	*Phyllanthus emblica*	Fruit, mature leaf
4.	Amaru	*Spondias pinnata*	Fruit
5.	Amliso	*Thysanolaena maxima*	Young shoot
6.	Amp	*Magnifera indica*	Fruit
7.	Angeri	*Melastoma malabathricum*	Fruit
8.	Archal sano	*Antidesma acidum*	Mature leaf
9.	Archal thulo	*Antidesma ghaesembilla*	Mature leaf
10.	Asuro	*Justicia adhatoda*	Flower
11.	Bakaino	*Melia azedarach*	Mature leaf
12.	Bamboo	*Dendrocalamus strictus*	Young shoot
13.	Ban paiyun	*Prunus cerasoides*	Fruit, mature leaf
14.	Bandargeda	*Ardisia solanacea*	Fruit
15.	Banmara	*Eupatorium odoratum*	Young leaf, petiole
16.	Bar	*Ficus benghalensis*	Fruit
17.	Barro	*Terminalia bellirica*	Fruit
18.	Bel	*Aegle marmelos*	Fruit
19.	Bhorla	*Bauhinia vahlii*	Seed
20.	Bilaune	*Maesa montana*	Mature leaf, young shoot
21.	Chanp	*Michelia champaca*	Young leaf
22.	Chhatiwan	*Alstonia scholaries*	Young leaf
23.	Chiuri	*Diploknema butyracea*	Fruit
24.	Chutro	*Berberis asiatica*	Fruit
25.	Dhurseli	*Colebrookea oppositifolia*	Inflorescence
26.	Dubo	*Cynodon dactylon*	Mature leaf
27.	Dudhelahara	*Hedyotis lineata*	Bark, petiole
28.	Fern	*Dryopteris filix-mas*	Mature leaf
29.	Gabjolahara	*Milletia extensa*	Mature leaf
30.	Gidari lahara	*Premna scandens*	Mature leaf, young leaf
31.	Goru ainselu	*Rubus rugosus*	Fruit
32.	Guyalo	*Callicarpa arborea*	Mature leaf
33.	Harro	*Terminalia chebula*	Fruit, mature leaf
34.	Jamun	*Syzygium cumini*	Fruit, leafbud, young leaf

35.	Jangali kera	*Musa superfa*	Fruit
36.	Kadam	*Anthocephalus chinensis*	Young leaf, inflorescence
37.	Kafal	*Myrica esculenta*	Fruit, mature leaf
38.	Kalikath	*Aporusa octandra*	Young leaf, inflorescence
39.	Kalo dumri	*Ficus nervosa*	Young leaf
40.	Karkale	*Colocasium esculenta*	Young leaf
41.	Katus	*Castanopsis indica*	Seed
42.	Kavro	*Ficus lacor*	Young leaf
43.	Khair	*Acacia catechu*	Mature leaf
44.	Khanyo	*Ficus sarmentosa*	Fruit
45.	Koiralo	*Bauhinia variegata*	Flower, bark
46.	Lasune	*Sphaerosacme decandra*	Mature leaf
47.	Magarkanche	*Begonia picta*	Mature leaf
48.	Mahua	*Madhuca longifolia*	Mature leaf
49.	Mayal	*Pyrus pashia*	Fruit
50.	Mulberry	*Morus macroura*	Fruit, mature leaf
51.	Musurekatus	*Castanopsis tribuloides*	Seed
52.	Nigalo	*Arundinaria intermedia*	Young shoot
53.	Nundhiki	*Osyris wightiana*	Mature leaf
54.	Phanir	*Syzygium jambos*	Fruit
55.	Pipal	*Ficus religiosa*	Fruit
56.	Ratpate	*Odina wodier*	Mature leaf
57.	Saj	*Terminalia alata*	Young leaf, seed, bark
58.	Sal	*Shorea robusta*	Young leaf, inflorescence
59.	Samipipal	*Ficus benjamina*	Fruit
60.	Sano gabjo	*Milletia fruticose*	Mature leaf
61.	Sanodhayaro	*Woodfordia fruiticosa*	Mature leaf, young leaf, flower
62.	Sarpa makai	*Arisaema tortuosum*	Seed
63.	Seto dumri	*Ficus racemose*	Young leaf
64.	Sigane	*Lannea coromandelica*	Young leaf, inflorescence
65.	Simal	*Bombax ceiba*	Young leaf
66.	Sindure	*Mallotus philippensis*	Mature leaf
67.	Sirish	*Albizzia chinensis*	Mature leaf, young leaf
68.	Tanki	*Bauhinia purpurea*	Fruit, young shoot
69.	Tarul	*Dioscorea bulbifera*	Rhizome, young leaf, petiole
70.	Thotne	*Ficus hispida*	Fruit, bark
71.	Tuni	*Toona ciliata*	Mature leaf

Table 18: Plant species and their parts eaten by the Assamese monkeys in the study area of the BRB forest

SN	Local Name	Scientific Name	Part eaten as food
1.	Aankha taruwa	*Trichilia connaroides*	Fruit
2.	Ainselu	*Rubus ellipticus*	Fruit
3.	Amala	*Phyllanthus emblica*	Fruit, mature leaf
4.	Amaru	*Spondias pinnata*	Fruit
5.	Amliso	*Thysanolaena maxima*	Young shoot
6.	Amp	*Magnifera indica*	Fruit
7.	Angeri	*Melastoma malabathricum*	Fruit
8.	Archal sano	*Antidesma acidum*	Mature leaf
9.	Asuro	*Justicia adhatoda*	Flower
10.	Bakaino	*Melia azedarach*	Mature leaf
11.	Bamboo	*Dendrocalamus strictus*	Young shoot
12.	Ban paiyun	*Prunus cerasoides*	Fruit, mature leaf
13.	Bandargeda	*Ardisia solanacea*	Fruit
14.	Banmara	*Eupatorium odoratum*	Young leaf, petiole
15.	Bar	*Ficus benghalensis*	Fruit
16.	Barro	*Terminalia bellirica*	Fruit
17.	Bel	*Aegle marmelos*	Fruit
18.	Bhorla	*Bauhinia vahlii*	Seed
19.	Bilaune	*Maesa montana*	Mature leaf, young shoot
20.	Botdhayaro	*Lagerstroemia parviflora*	Young leaf
21.	Chanp	*Michelia champaca*	Young leaf
22.	Chhatiwan	*Alstonia scholaries*	Young leaf
23.	Chiuri	*Diploknema butyracea*	Fruit
24.	Chutro	*Berberis asiatica*	Fruit
25.	Dhurseli	*Colebrookea oppositifolia*	Inflorescence
26.	Dubo	*Cynodon dactylon*	Mature leaf
27.	Dudhelahara	*Hedyotis lineata*	Bark, petiole
28.	Fern	*Dryopteris filix-mas*	Mature leaf
29.	Gabjolahara	*Milletia extensa*	Mature leaf
30.	Goru ainselu	*Rubus rugosus*	Fruit
31.	Guyalo	*Callicarpa arborea*	Mature leaf
32.	Harro	*Terminalia chebula*	Fruit, mature leaf
33.	Jamun	*Syzygium cumini*	Fruit, leafbud, young leaf
34.	Kadam	*Anthocephalus chinensis*	Young leaf, inflorescence
35.	Kafal	*Myrica esculenta*	Fruit, mature leaf
36.	Kalikath	*Aporusa octandra*	Young leaf, inflorescence
37.	Kalo dumri	*Ficus nervosa*	Young leaf
38.	Karam	*Adina cardifolia*	Young leaf
39.	Karkale	*Colocasium esculenta*	Young leaf
40.	Katus	*Castanopsis indica*	Seed
41.	Kavro	*Ficus lacor*	Young leaf
42.	Khair	*Acacia catechu*	Mature leaf
43.	Khanyo	*Ficus sarmentosa*	Fruit
44.	Koiralo	*Bauhinia variegata*	Flower, bark

45.	Mahua	*Madhuca longifolia*	Mature leaf
46.	Mayal	*Pyrus pashia*	Fruit
47.	Mulberry	*Morus macroura*	Fruit, mature leaf
48.	Musurekatus	*Castanopsis tribuloides*	Seed
49.	Nigalo	*Arundinaria intermedia*	Young shoot
50.	Nundhiki	*Osyris wightiana*	Mature leaf
51.	Phanir	*Syzygium jambos*	Fruit
52.	Pipal	*Ficus religiosa*	Fruit
53.	Saj	*Terminalia alata*	Young leaf, seed, bark
54.	Sal	*Shorea robusta*	Young leaf, inflorescence
55.	Samipipal	*Ficus benjamina*	Fruit
56.	Sano bayar	*Zizyphus mauritiana*	Fruit
57.	Sano gabjo	*Milletia fruticose*	Mature leaf
58.	Sanodhayaro	*Woodfordia fruiticosa*	Mature leaf, young leaf, flower
59.	Sarpa makai	*Arisaema tortuosum*	Seed
60.	Seto dumri	*Ficus racemose*	Young leaf
61.	Sigane	*Lannea coromandelica*	Young leaf, inflorescence
62.	Simal	*Bombax ceiba*	Young leaf
63.	Sindure	*Mallotus philippensis*	Mature leaf
64.	Sirish	*Albizzia chinensis*	Mature leaf, young leaf
65.	Tanki	*Bauhinia purpurea*	Fruit, young shoot
66.	Tarul	*Dioscorea bulbifera*	Rhizome, young leaf, petiole
67.	Thotne	*Ficus hispida*	Fruit, bark
68.	Thulo bayar	*Zizyphus rugose*	Fruit
69.	Tuni	*Toona ciliata*	Mature leaf

The food plants such as *Zizyphus mauritiana*, *Zizyphus rugose*, *Adina cardifolia* and *Lagerstroemia parviflora* were not found in KRB forest and that of *Odina wodier*, *Musa superfa*, *Premna scandens*, *Begonia picta*, *Sphaerosacme decandra* and *Antidesma ghaesembilla* were not found in BRB forest, while other food plants were recorded similar in both the research sites (Tables 17, 18). It was recorded that the Kaligandaki Assamese monkeys frequently used leaf of *Albizzia chinensis* and that of Budhigandaki Assamese monkeys frequently used leaf of *Lagerstroemia parviflora* as a major food plant throughout the year though they ate other plant species and their parts available seasonally in both the study areas.

4.1.4.1.2 Food preference and feeding percentage

The focal Assamese troops were found eating different parts of different food plant species. The percentage amount of eating each part of plant species by the focal Assamese troops was calculated in both the river basin forests based on Table 17 and Table 18 and found that fruit 27.08% was the highest food plant part in KRB followed by mature leaf 26.04%, young leaf 18.76%, seed 5.21%, young shoot 5.21%, inflorescence 5.21%, bark 4.17%, flower 3.12%, petiole 3.12%, leafbud 1.04% and rhizome 1.04% (Fig. 5) and in BRB it was found that fruit 29.03% was the highest food plant part followed by mature leaf 21.50%, young leaf 20.43%, seed 5.38%, young shoot 5.38%, inflorescence 5.38%, bark 4.30%, flower 3.23%, petiole 3.23%, leafbud 1.07% and rhizome 1.07% (Fig. 5).

The feeding data of two topographical variable river system shows that the Assamese monkeys of both the river system preferably like to eat fruit in priority followed by mature leaf and others (Fig. 5). The focal Syangja troop members that utilized the mature leaf (26.04%) for feeding seems to be the higher as compared to the mature leaf (21.50%) eaten by the focal Siurenitar troop members. However, the fruit (29.03%) and young leaf (20.43%) eaten by the focal Siurenitar troop members seem to be slightly higher as compared to the fruit (27.08%) and young leaf (18.76%) eaten by the focal Syangja troop members, and other parts seem to be more or less similar (Fig. 5).

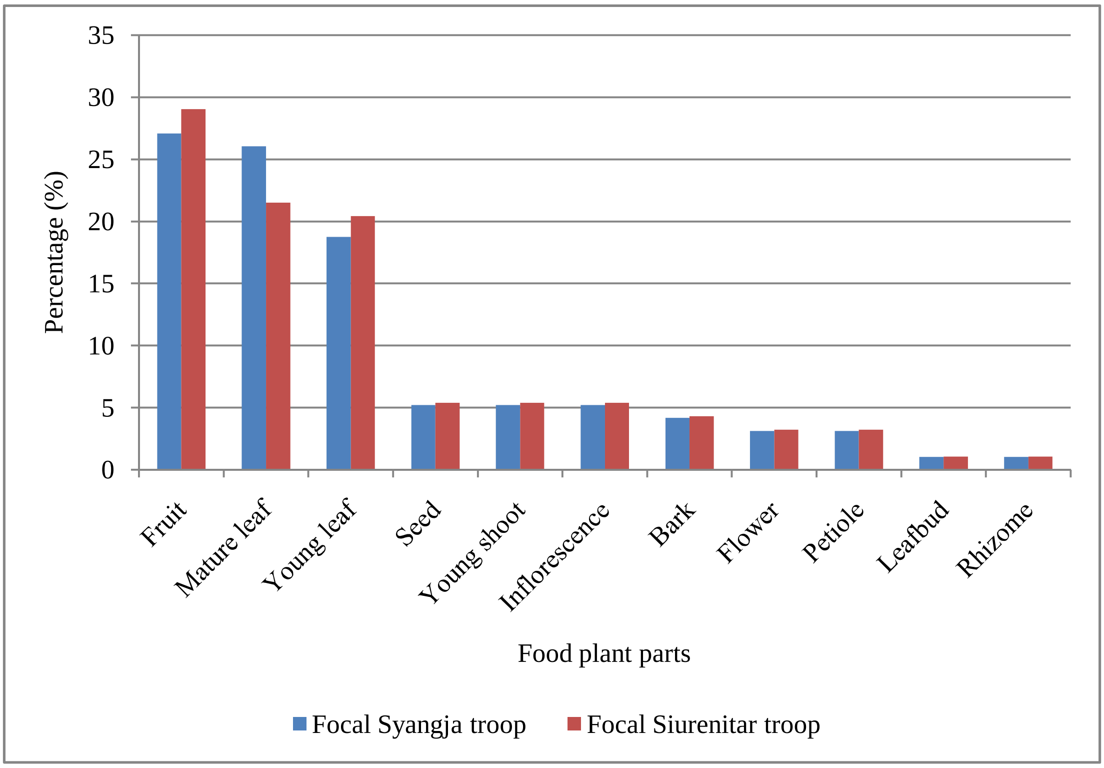

Figure 5: Percentage of food plant parts eaten by the focal Assamese Syangja troop and the focal Assamese Siurenitar troop in the study area of KRB and BRB forest

Kruskal-Wallis H test (H = 0.3891, Hc = 0.3918, p = 0.5314) was performed for equal medians of food plant parts eaten by Assamese monkeys. This test shows there is no significant difference between sample medians.

4.1.4.1.3 Seasonal variation and availability of food

The forest of both the study area (KRB and BRB) shows high seasonal variation in the production of different plant parts. The life of young leaves, buds, flowers and fruits is short, whereas seeds and mature leaves' life is comparatively long. Specially insects appear and algae and mosses bloom in specific seasons. The forest of KRB is dominated by *Trichilia connaroides* and the BRB forest is dominated by *Shorea robusta*. Different species of plants were recorded inside and outside of plotted botanical squares. The seasonal distributions of different vegetative and reproductive parts were recorded according to their availability.

Leafbuds: Leafbuds were mainly available during March to June and the peak-month was April. In several plants, some leafbuds were abundant from May to August and the remaining months only few were seen. The patterns and since the time of leaf sprouting is different in different plant, the distribution of leafbuds was never zero.

Young leaves: Young leaves and leafbuds occurred simultaneously in the same season. In most of the plants availability peaks in April and some young leaves and leafbuds were present during May to August. Besides this, few were available in some plants throughout the year. From October to March only few young leaves were available.

Mature leaves: Mature leaves consist of more fiber and less water and are thus less palatable in comparison to young leaves. According to the availability, the mature leaves were always present in larger amounts. They were abundant during the winter months specially in January. Mature leaves started decline in March to April.

Old leaves: According to the nature of this deciduous forest and a rhythmic defoliation of the plants, few old leaves were present throughout the year. Only from February to May old leaves occurred somewhat often. Most mature leaves turned yellow and started falling covering the forest floor with leaf-litter.

Flower buds: Flowering is highly seasonal in both the study area. The highest peak of flower bud abundance was observed during March and a considerable amount in

September, indicating the two flowering seasons in spring and in autumn. The amount of flower buds in September was observed small. From October to January flower buds were not available and small amounts were present during other months.

Flowers: According to the availability of flower buds, flowers were available. The peak, however, lower as many arboreal herbivores utilized heavily the flower buds resulting in a smaller amount of flowering. Flowers were abundant in April, and some in May and July. There were almost no flowers during November to February.

Unripe fruits: Green fruits were always available in a small amount in both the study forest. A very small peak of abundance occurred in June, August and October.

Ripe fruits: Ripe fruits were not available in August and one peak during April was present. From December to March also ripe fruit's availability was in considerable amount. It was correlated with the green fruit availability.

Other food items: Besides above mentioned food categories, other food items such as seeds, young shoots, inflorescences, barks, petioles and rhizomes of different plant species were available seasonally. Furthermore, insects, stone licking, soil eating, water and waste were also available in both the study areas.

4.1.4.1.4 Time spent in feeding

The total observation time for Kaligandaki focal Assamese Syangja troop (KFAST) was 716 hours, of which the total feeding time was recorded 294.7 hours and in percentage it was calculated as 41.16% (Table 25) of total observation time. The total observation time for Budhigandaki focal Assamese Siurenitar troop (BFAST) was 691 hours, of which the total feeding time was recorded 306.5 hours and in percentage it was calculated as 44.36% (Table 26) of total observation time. The mean feeding time spent of two study troops was 300.6 hours and in percentage it was 42.76%.

4.1.4.1.5 Monthly variation in feeding time

Most of the trees and the plants produce more leaves than flowers or fruits. They bear foliage for much longer periods than they bear reproductive parts. The mature leaf's life is usually considerably longer than the growth phase, patches of mature leaves will be more frequently encountered in space and time in a forest than patches of other plant items, and with patches leaves will usually have a higher density than will flowers or fruits (Oates, 1987).

The seasonal aspects of the feeding behavior were investigated for KFAST (3 adult males – M_1, M_2, M_3 and 5 adult females – F_1, F_2, F_3, F_4, F_5) and BFAST (2 adult males – M_1, M_2 and 4 adult females – F_1, F_2, F_3, F_4) separately. The young leaves, fruits, flowers, insects were available for short period in hot and rainy seasons (April to September), so the time spent by monkeys for feeding during this period were short. In the less hot and colder months (October to March), as there were more mature leaves and fewer fruits, the monkeys had to feed for long time. Thus, the monthlies feeding time percentage from October to March were higher and significantly difference to the time percentage of months April to September.

The feeding time percentage of the monkeys was negatively correlated with the temperature of the month. They need more energy in the cold month. Therefore, they found investing more time on feeding. The data from October to March stand on 1^{st} to 6^{th} rank on feeding while the temperature ranked from 7^{th} to 12^{th}. The data of feeding rank from the month of April to September stand on 7^{th} to 12^{th} while the temperature from the same month ranked from 1^{st} to 6^{th}.

Table 19: Monthly feeding time (in % of the total observation time) for KFAST and BFAST

Month	KFAST (%)	BFAST (%)
February, 2015	52.61	56.42
March	55.23	57.64
April	32.65	34.96
May	31.46	33.83
June	34.33	38.71
July	30.54	34.33
August	24.45	25.92
September	32.42	34.22
October	42.12	46.26
November	48.11	54.72
December	53.64	57.12
January, 2016	56.34	58.18
Mean (%)	41.16	44.36

The monthly distribution of feeding time was analyzed separately for both the troops. The paired t-test shows that, there was significant difference (p = .000) between them. Also as the left test shows significant, indicating the Syangja troop average is significantly smaller than Siurenitar troop average.

4.1.4.1.5.a Monthly variation of time spent in fruit eating

Fruits can be considered a highly seasonal food item. The fruits eaten from different plant species and acceptance by Assamese monkeys were different. The mean time spent for fruit eating was 23.80% (S^2 = 226.5, CV = 63.2) per year by KFAST and 25.96% (S^2 = 195.3, CV = 53.8) per year by BFAST. The most time spent with the fruits were during July 49.14%, June 43.37%, December 42.55% and November 36.15% (Fig. 6, Table 20) for KFAST and July 47.12%, June 45.23%, December 41.43% and November 39.12% (Fig. 6, Table 21) for BFAST. The lowest time spent for fruits were observed during spring in the months of March 04.62% and April 03.98% for KFAST and April 06.17% for BFAST. So, there were significant differences between the months.

The months June-July and November-December were the high peaks while that of August-September and January-April were low peaks for fruit eating (Fig. 6). The months May and October were near an average time. The availability of fruit shows that altogether fruit green or ripe to some extent were present during the months of whole year. The seasonal influence of fruit-eating time percentage was significant. The two peaks were significantly higher than the two faults (Fig. 6).

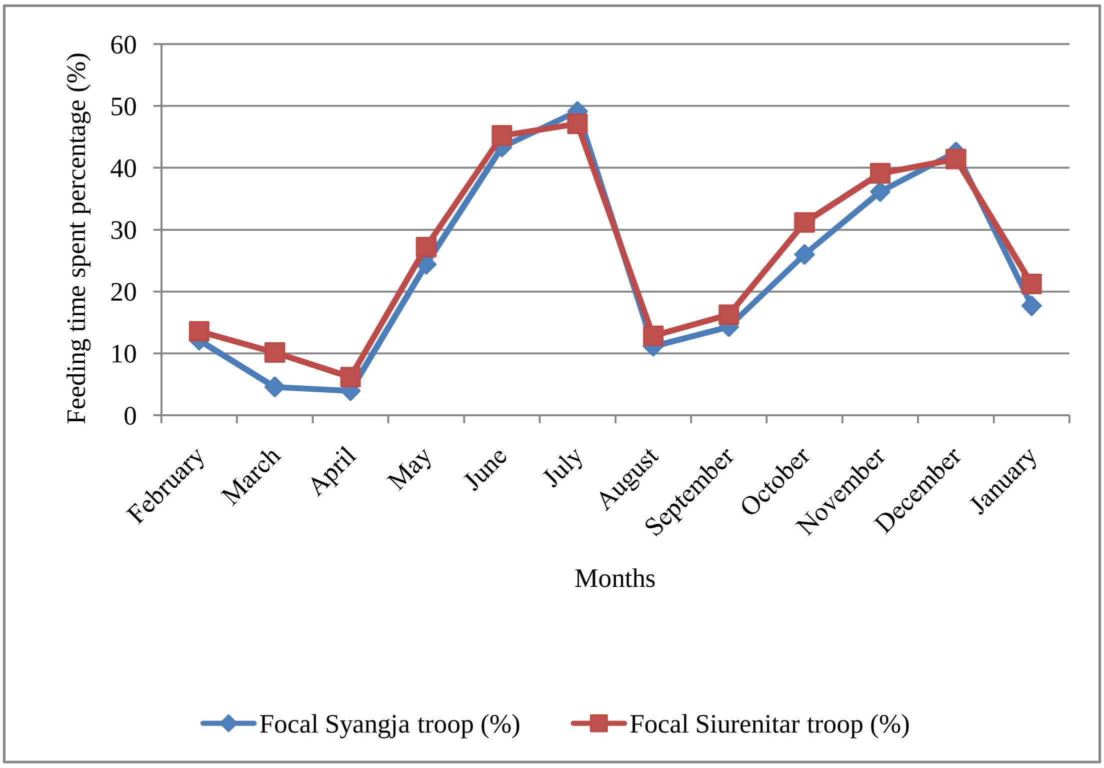

Figure 6: Monthly distribution of fruit eating time in percentage for KFAST and BFAST

4.1.4.1.5.b Monthly variation of time spent in mature leaf eating

Leaves are the main food of the Assamese macaques. The mean time spent for mature leaf eating was 30.02% (S^2 = 389.6, CV = 65.7) per year by KFAST and 29.04% (S^2 = 396.9, CV = 68.6) per year by BFAST. On no other food category did they invest so much time. For the mature leaves, the feeding time per month never dropped below 06.43% (Fig. 7, Table 20) in Kaligandaki and 05.46% (Fig. 7, Table 21) in Budhigandaki. The monthly feeding time significantly differ over the year. In KRB forest, the time spent on mature leaves was highest in January (63.18%), and in November was 53.32%, February 49.63%, December 46.17% while the lowest time devoted for mature leaves in the month of April (06.43%). In BRB forest, the time spent on mature leaves was highest in January (61.90%), and in November was 50.76%, December 48.11%, October 48.09%, February 47.12% while the lowest time devoted for mature leaves in the month of July (05.46%).

Mature leaves were always available in the forest of both the study sites. Even though the forest was deciduous type, the defoliation was rhythmic. The stages and qualities of mature leaves were naturally different in accordance to the seasons. In small quantity new young leaves and in reasonable amount mature leaves were always present in the forest. The young leaves are of high nutritive quality while mature and old leaves are less. As the folivorous habit, they mostly depend on leaves of different age. Therefore, Assamese monkeys have to spend more time for less quality mature leaves to obtain optimum amount of nutrition. The mature leaf eating time was higher during winter months as there were more mature leaves while the time spent was less in spring and rainy season (Fig. 7).

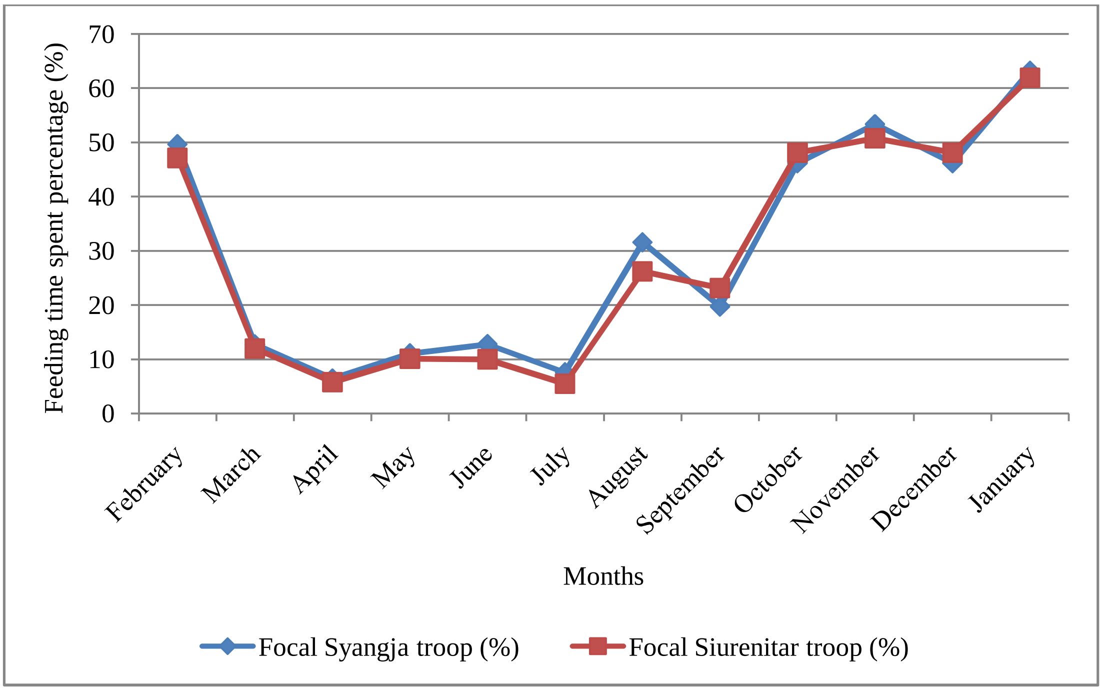

Figure 7: Monthly distribution of mature leaf eating time in percentage for KFAST and BFAST

4.1.4.1.5.c Monthly variation of time spent in young leaf eating

The mean time spent for young leaf eating was 19.56% (S^2 = 170.4, CV = 66.7) per year by KFAST and 20.70% (S^2 = 218.6, CV = 71.4) per year by BFAST. The monthly feeding time significantly differ over the year. In KRB forest, the time spent on young leaves was highest in August 41.50% (Fig. 8, Table 20), and in May was 37.31%, July 30.52%, June 29.95%, April 27.87%, March 24.16% while the lowest time devoted for young leaves in the month of November (04.46%). In BRB forest, the time spent on young leaves was highest in August 42.10% (Fig. 8, Table 21), and in May 39.22%, July 34.18%, June 33.13%, April 31.69%, March 29.98% while the lowest time devoted for young leaves in the month of November (03.89%).

In spring season, generally new young leaves emerged. The young leaves were available in the months of March, April, May, June, July and August. In other months, a little amount of young leaves was available in the forest. The young leaves are of high nutritive quality while mature and old leaves are less. As the folivorous habit, they mostly depend on leaves of different age. Therefore, Assamese monkeys get sufficient spending less time for high quality young leaves. The time spent on young leaf eating was higher during the rainy season and spring season when there were more young leaves. The time spent was less in the winter months (Fig. 8).

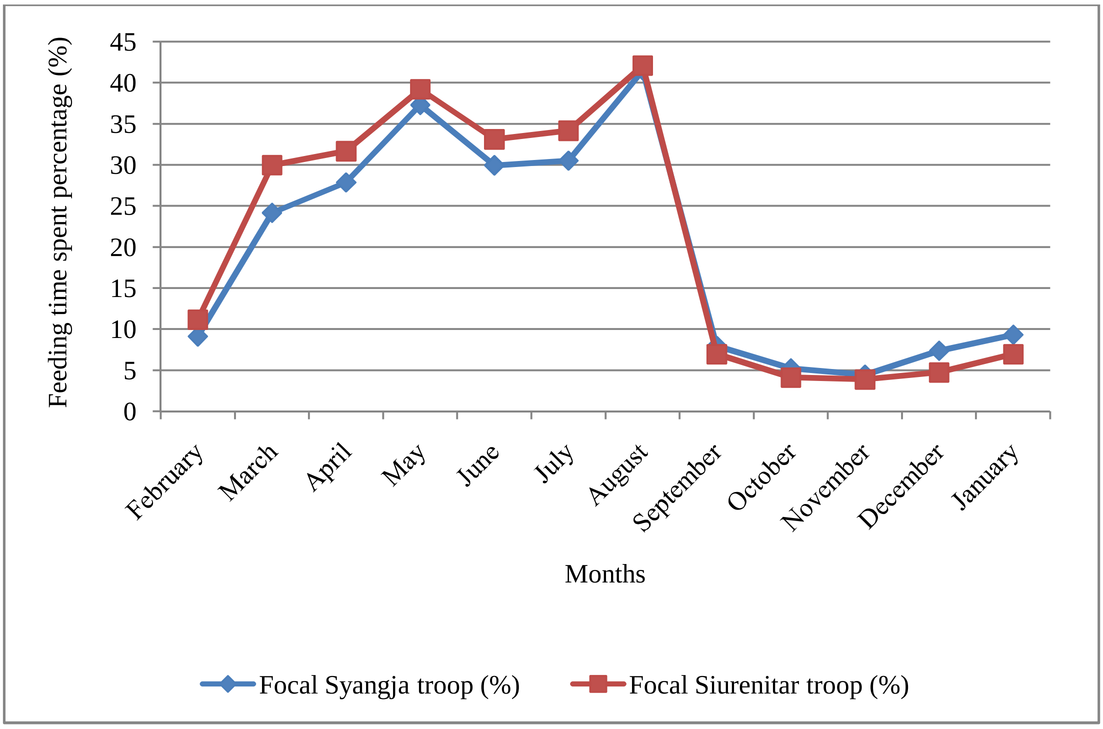

Figure 8: Monthly distribution of young leaf eating time in percentage for KFAST and BFAST

4.1.4.1.5.d Monthly variation of time spent in seed eating

The mean time spent for seed eating was 2.71% (S^2 = 5.8, CV = 88.5) per year by KFAST and 2.07% (S^2 = 3.6, CV = 92.2) per year by BFAST. In KRB forest, the time spent on seeds was highest in April 08.17% (Fig. 9, Table 20), and in March was 06.94% while the lowest time devoted for seeds in the month of December (00.15%). In BRB forest, the time spent on seeds was highest in April 06.96% (Fig. 9, Table 21) while the lowest time devoted for seeds in the month of December (00.10%).

The seeds are the concentrated energetic food. They are of high nutritive value. Assamese monkeys frequently fed seed of *Castanopsis indica* available during winter seasons and seed of *Arisaema tortuosum* available during summer seasons. Depending upon the productivity of the previous year, the old seeds were available throughout the year in the ground. The seed eating time was higher in March and April while lower in the months of November and December (Fig. 9). This shows the decline of seed eating time spent from rainy season towards the winter season.

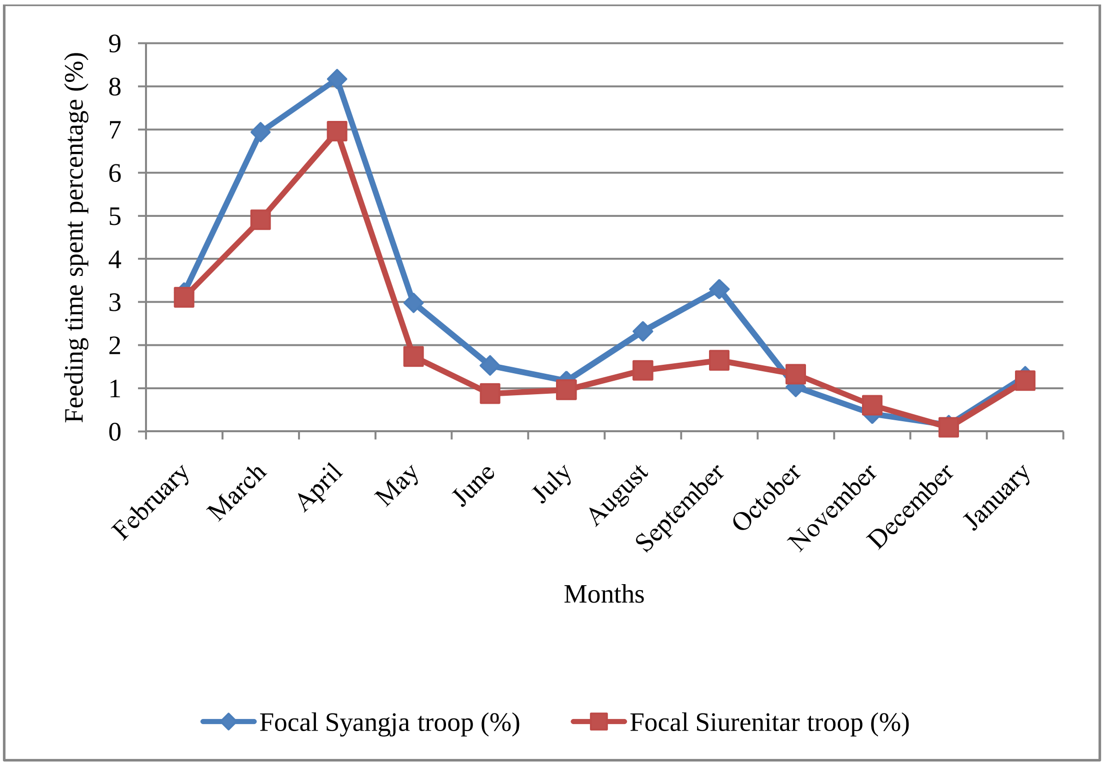

Figure 9: Monthly distribution of seed eating time in percentage for KFAST and BFAST

4.1.4.1.5.e Monthly variation of time spent in young shoot eating

The mean time spent for young shoot eating was 2.00% (S^2 = 4.4, CV = 105.3) per year by KFAST and 1.50% (S^2 = 1.1, CV = 69.2) per year by BFAST. The young shoot is the delicate part of the stem, generally the topmost portion of any tree, climber, plant or branch. It might have few small leaves, or sometime only cylindrical elongation of stem. So, it is a delicate young part with vascular bundles. The shoots probably consist of more moisture percentages. The delicate young shoot whole or inside part eating was common in Assamese monkeys. In KRB forest, the Assamese monkeys were spending more time in May (06.73%) and October (06.18%) for young shoot while in BRB forest the Assamese monkeys were spending more time only in May (04.11%) for young shoot. The data of time spent in May and October were significantly higher (Fig. 10, Table 20) to the feeding time of July-August and November to February for Kaligandaki while the data of time spent in May was significantly higher (Fig. 10, Table 21) to the feeding time of July-August and November to February for Budhigandaki.

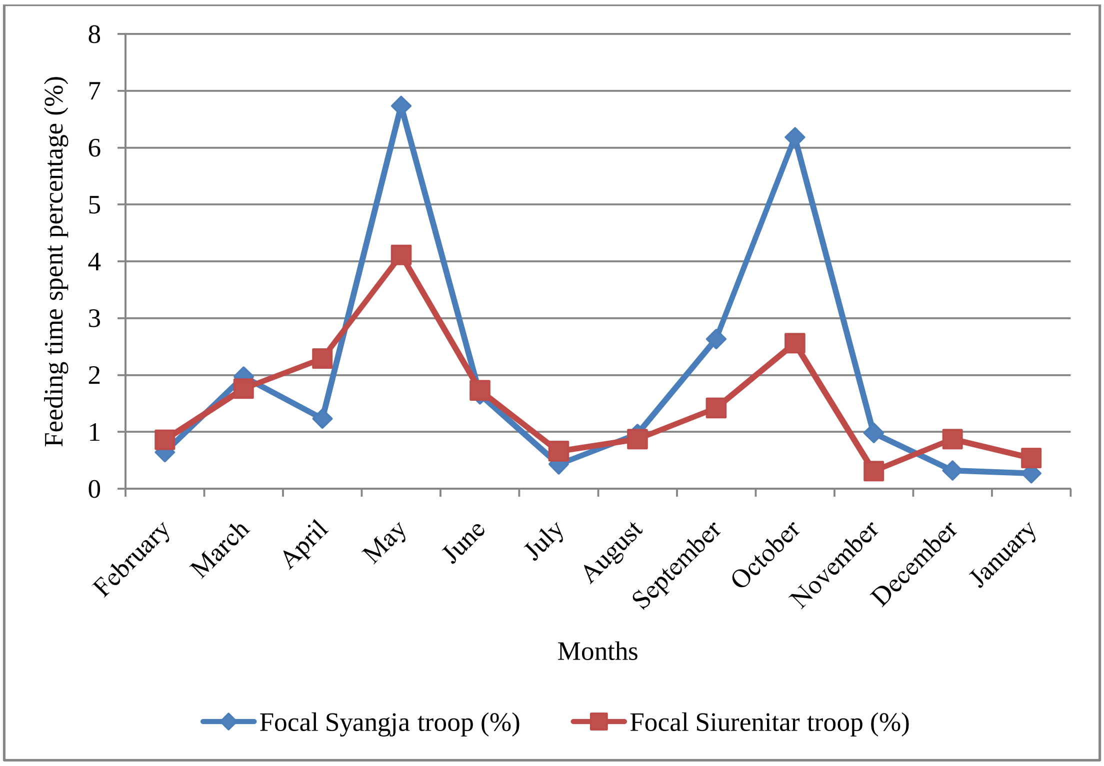

Figure 10: Monthly distribution of young shoot eating time in percentage for KFAST and BFAST

4.1.4.1.5.f Monthly variation of time spent in inflorescence eating

The average time spent on inflorescence eating over the year was 0.95% (S^2 = 1.1, CV = 112.8) for KFAST and it was 0.85% (S^2 = 0.6, CV = 92.8) for BFAST. The inflorescence is the floral parts arranged in the floral axis. The high peak of inflorescence abundance was in March and April. The time spent for inflorescence was highest in April (03.86% for KFAST and 02.81% for BFAST). Least time was observed during January 00.21% (Fig. 11, Table 20) for Kaligandaki while July 00.41% (Fig. 11, Table 21) for Budhigandaki. There was no found the inflorescence eating during the months of July, August and December by KFAST and during the months of February, November and January by BFAST.

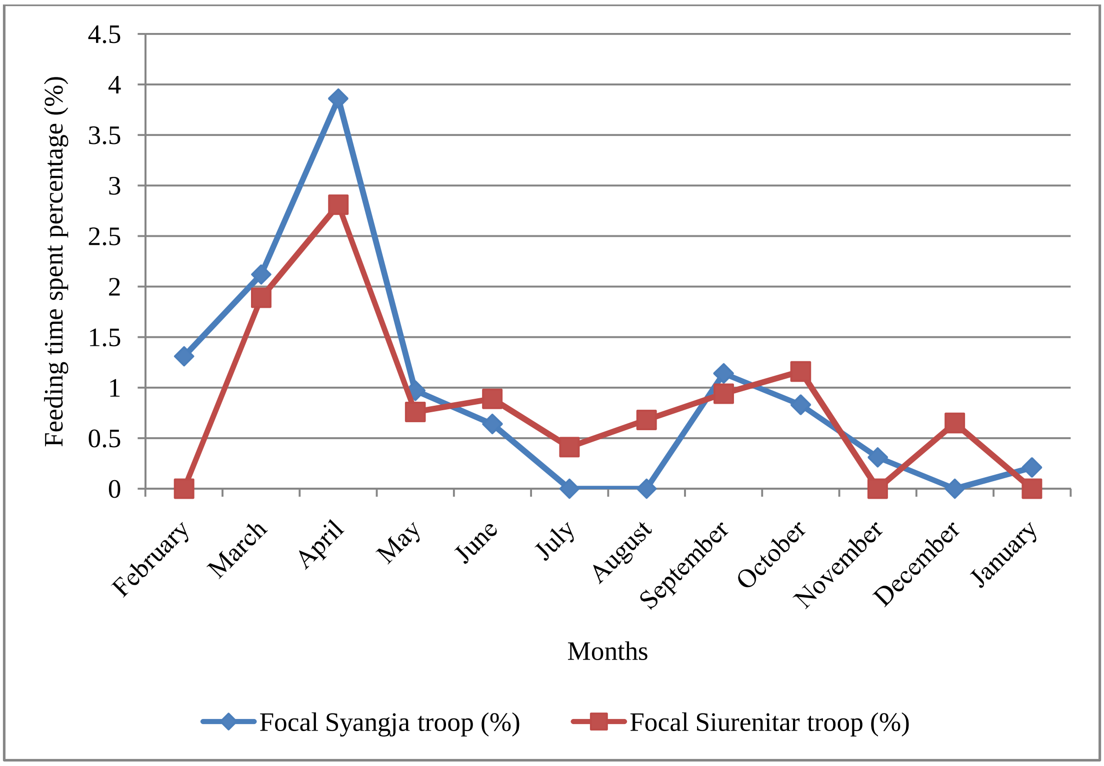

Figure 11: Monthly distribution of inflorescence eating time in percentage for KFAST and BFAST

4.1.4.1.5.g Monthly variation of time spent in bark eating

The bark is the fibrous semi-hard and sometime semi-dry covering of stems. The average time spent on bark eating over the year was 0.12% (S^2 = 0.0, CV = 88.4) for KFAST and it was 0.22% (S^2 = 0.1, CV = 104.6) for BFAST. The highest time spent on bark eating was recorded in December 00.26% (Fig. 12, Table 20) for Kaligandaki while in August 00.86% (Fig. 12, Table 21) for Budhigandaki. The lowest time spent was observed during January (00.03%) in Kaligandaki while during September (00.11%) in Budhigandaki. Assamese monkeys mostly preferred bark of *Ficus hispida* as food. The bark eaten by the Assamese monkeys was observed when there was less food item available in the forest. So, the bark eating was higher in August for Budhigandaki as compared to other months of the year when there was lower availability of other food items in this month. There was no found the bark eating during the months of March, April, August and October by KFAST and during the months of May, July and November by BFAST.

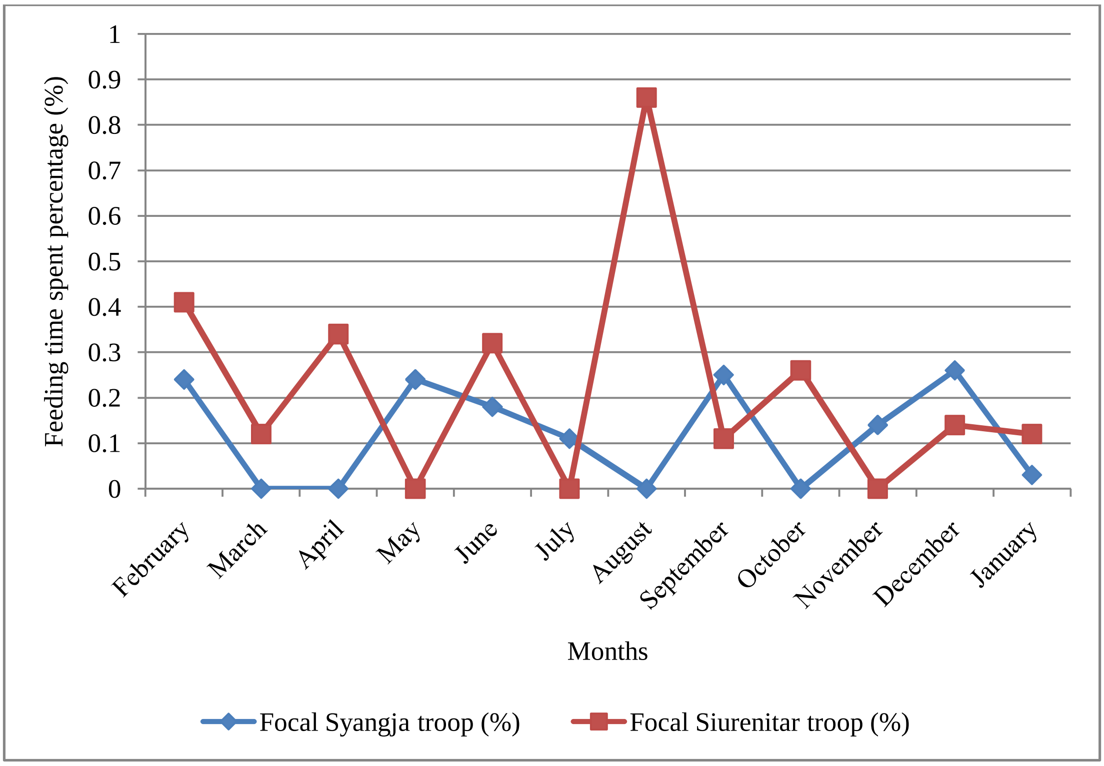

Figure 12: Monthly distribution of bark eating time in percentage for KFAST and BFAST

4.1.4.1.5.h Monthly variation of time spent in flower eating

The mean time spent for flower eating was 12.47% (S^2 = 194.5, CV = 111.8) per year by KFAST and 12.16% (S^2 = 157.4, CV = 103.2) per year by BFAST. Flowers are the clumped and highly seasonal due to its fix flowering seasons, so the seasonal distribution for flower eating was significant. The time spent for flowers had two peaks, in September 48.12% (Fig. 13, Table 20), and in April 33.51% for Kaligandaki and in September 44.17% (Fig. 13, Table 21), and in April 30.64% for Budhigandaki. In other months except March there were few flowers exploiting data. The seasonality of flowers shows that they were available only very few except August, October, February and May (Fig. 13). The high peak of floral parts abundance was in the months of March and April. However, the time spent for these months on flowers were second (April) and third (March) ranking, while the first being September. Thus, the data for September was significantly different to all other months except April.

The months of March, April and May were the main flowering months but after and end of the rainy season, there was flowering season again from August to the October. This autumn season might be the rare season for the flowers, so the Assamese monkeys liked to spend more time for this clumped food. The spring season is the common flowering season for all the flowering plants and the time for new young leaves too. The Assamese monkeys seem to prefer flowers whenever they are available. The pattern of time spent in florivory was fluctuating seasonally with all the months of the year (Fig. 13).

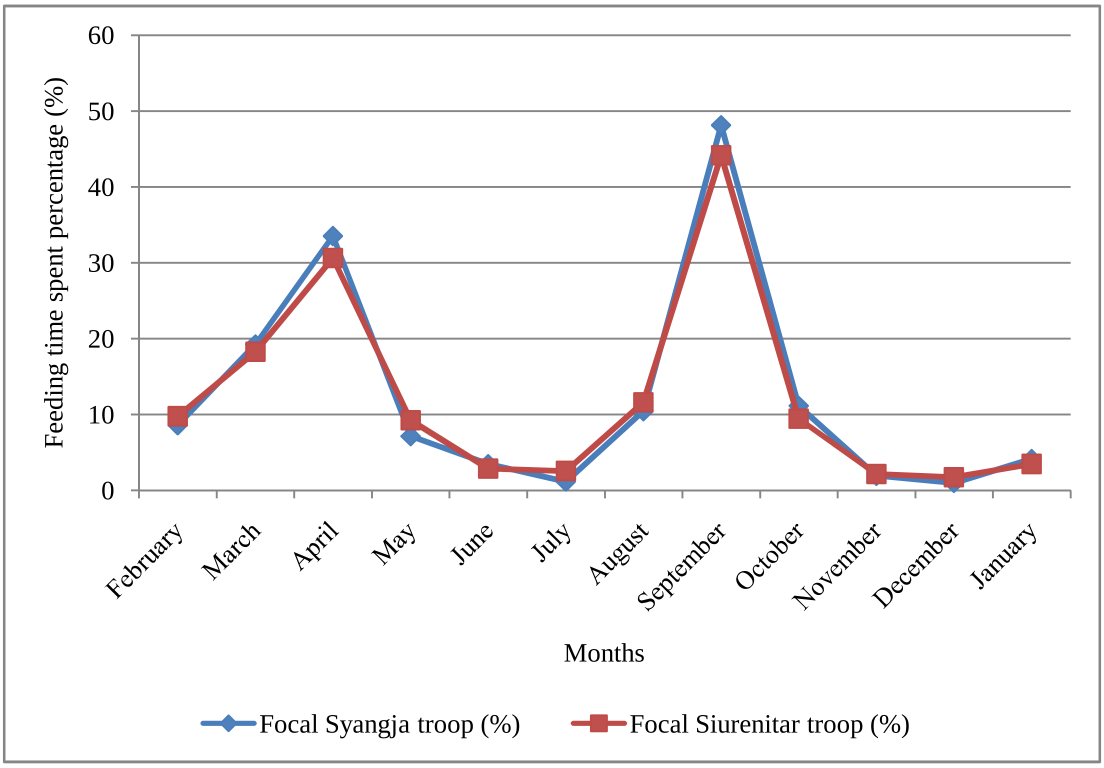

Figure 13: Monthly distribution of flower eating time in percentage for KFAST and BFAST

4.1.4.1.5.i Monthly variation of time spent in petiole eating

The mean time spent for petiole eating was 0.36% (S^2 = 0.1, CV = 93.5) per year by KFAST and 0.42% (S^2 = 0.1, CV = 67.7) per year by BFAST. The highest time spent on petiole eating was recorded in May 01.14% (Fig. 14, Table 20) for Kaligandaki while in May 00.84% (Fig. 14, Table 21) for Budhigandaki. The lowest time spent was observed during January (00.23%) in Kaligandaki while during December (00.12%) in Budhigandaki. There was no found the petiole eating during the months of February, July, September and October by KFAST and during the months of March and June by BFAST.

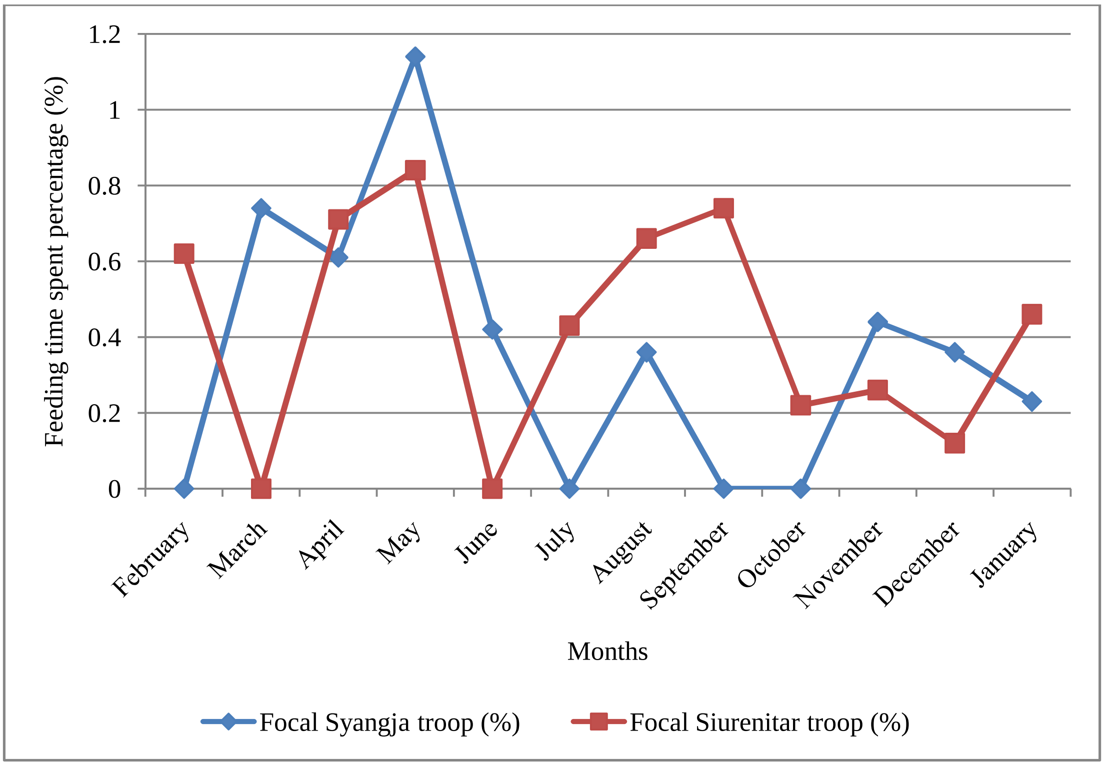

Figure 14: Monthly distribution of petiole eating time in percentage for KFAST and BFAST

4.1.4.1.5.j Monthly variation of time spent in leafbud eating

The mean time spent for leafbud eating was 0.59% (S^2 = 0.3, CV = 92.3) per year by KFAST and 0.87% (S^2 = 0.7, CV = 96.4) per year by BFAST. A leafbud is a swelling on a plant stem consisting of overlapping immature leaves or petals or it is a bud from which a leaf develops. Leafbuds were mainly available during March to June and the peak-month was April. In several plants, some leafbuds were abundant from May to August and the remaining months only few were seen. The highest time spent on leafbud eating was recorded in April 02.14% (Fig. 15, Table 20) for Kaligandaki while in April 03.53% (Fig. 15, Table 21) for Budhigandaki. The lowest time spent was observed during August (00.22%) in Kaligandaki while during October (00.12%) in Budhigandaki. There was no found the leafbud eating during the months of July and September by KFAST and during all months of the year the leafbuds were found eaten by BFAST (Fig. 15).

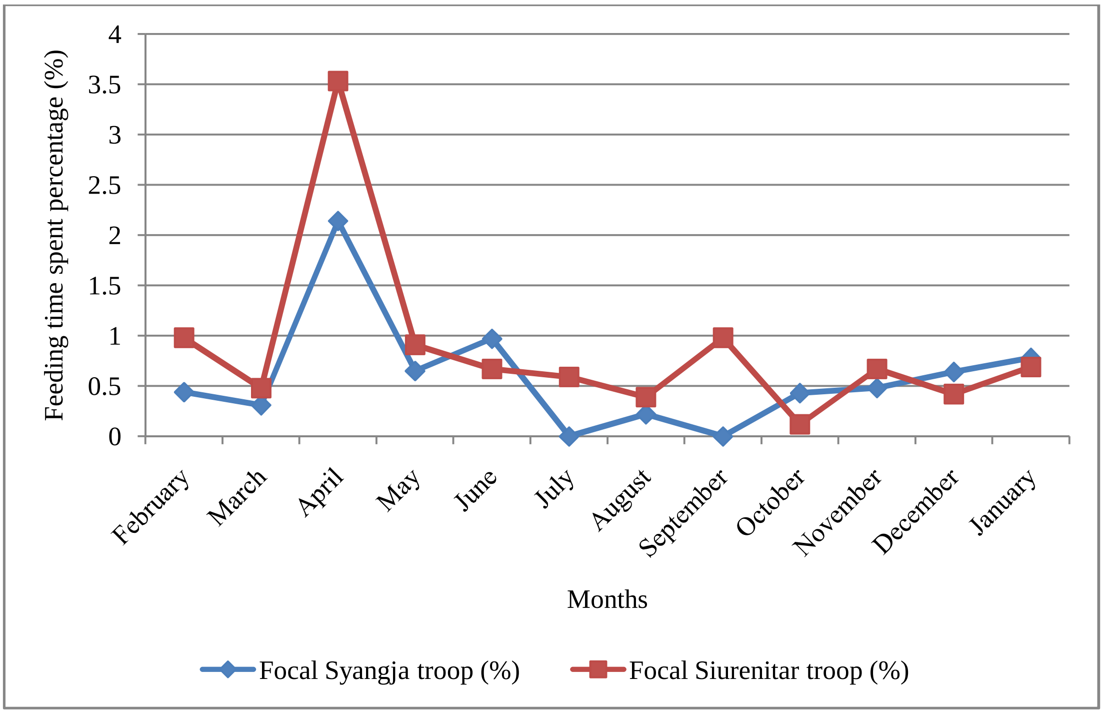

Figure 15: Monthly distribution of leafbud eating time in percentage for KFAST and BFAST

4.1.4.1.5.k Monthly variation of time spent in rhizome eating

The average time spent on rhizome eating over the year was 0.73% (S^2 = 0.5, CV = 100.5) for KFAST and it was 1.02% (S^2 = 0.8, CV = 87.1) for BFAST. The rhizome is a continuously growing horizontal underground stem which puts out lateral shoots and adventitious roots at intervals. It is also called creeping rootstalk. Rhizome of *Dioscorea bulbifera* was the most preferred food by Assamese monkeys. The highest time spent on rhizome eating was recorded in March 02.45% (Fig. 16, Table 20) for Kaligandaki while in March 02.97% (Fig. 16, Table 21) for Budhigandaki. The lowest time spent was observed during August (00.14%) in Kaligandaki while during September (00.34%) in Budhigandaki. There was no found the rhizome eating during the months of May and June by KFAST and during the months of May and August by BFAST (Fig. 16).

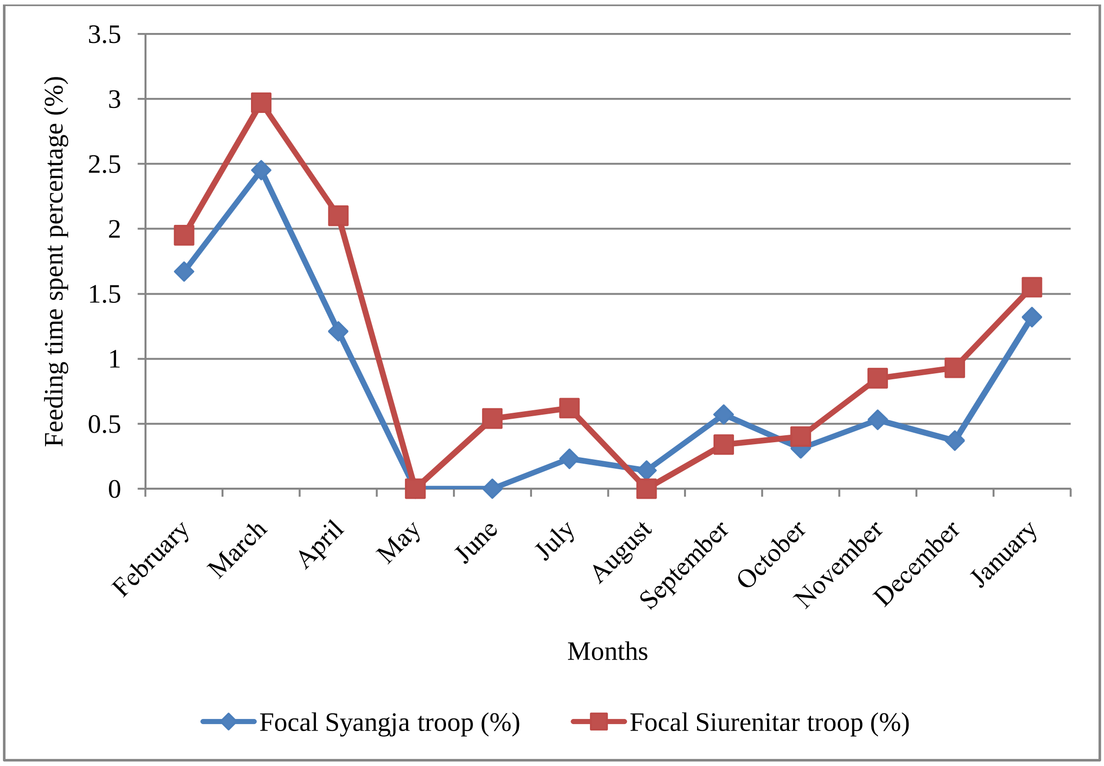

Figure 16: Monthly distribution of rhizome eating time in percentage for KFAST and BFAST

4.1.4.1.5.l Monthly variation of time spent in insect eating

The mean time spent for insect eating was 2.90% (S^2 = 20.4, CV = 155.8) per year by KFAST and 2.43% (S^2 = 11.6, CV = 139.9) per year by BFAST. Insects especially caterpillars were available in the forest throughout the year even though in small amounts. A peak time of insect eating was observed in the months of February and March. The highest time spent on insect eating was recorded in March 12.41% (Fig. 17, Table 20) for Kaligandaki while in March 10.11% (Fig. 17, Table 21) for Budhigandaki. The lowest time spent was observed during December (00.11%) in Kaligandaki while during January (00.23%) in Budhigandaki. There was no found the insect eating during the months of June, August, September and November by KFAST and during the months of April, October and December by BFAST (Fig. 17).

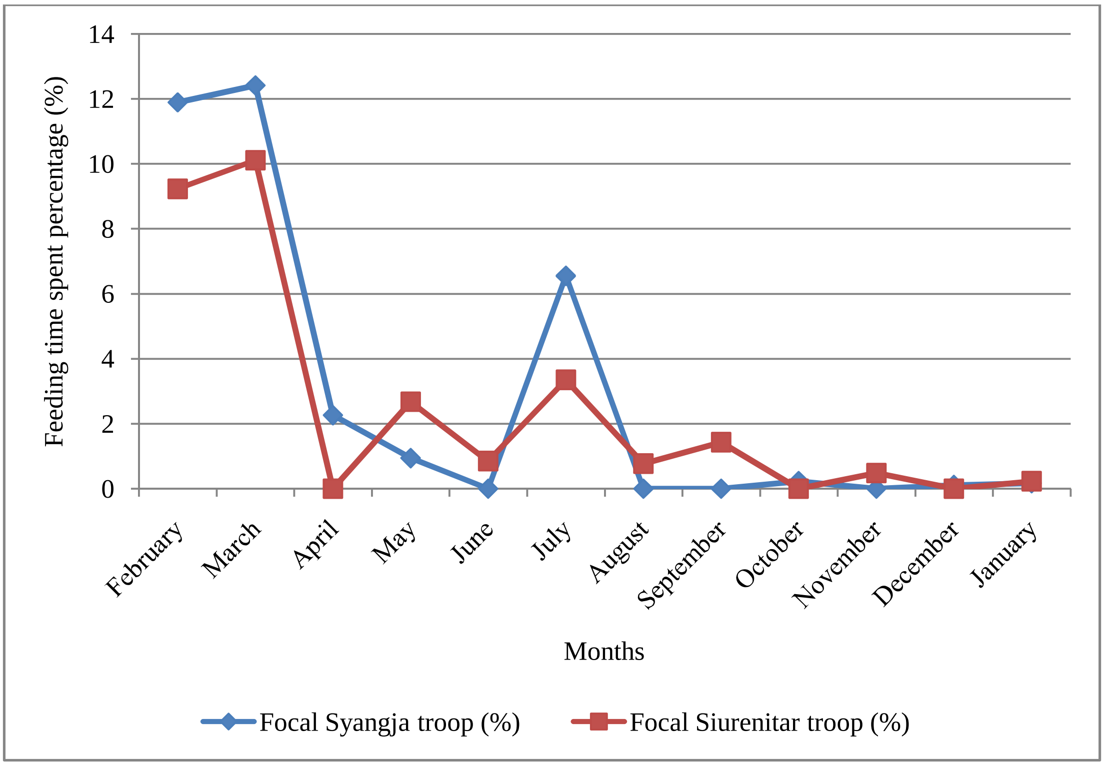

Figure 17: Monthly distribution of insect eating time in percentage for KFAST and BFAST

4.1.4.1.5.m Monthly variation of time spent in stone licking

Stone licking was one of the remarkable phenomenon observed in both the study area. Stone licking is one of the food among the inorganic food items of Assamese monkeys. Generally they lick the stones for digestion of other ingested food materials. They licked the stones in both river basins. The mean time spent for stone licking was 2.04% (S^2 = 5.5, CV = 115.3) per year by KFAST and 1.40% (S^2 = 3.9, CV = 141.3) per year by BFAST. Licking of stone was highest during March 07.67% (Fig. 18, Table 20) for Kaligandaki while during March 06.16% (Fig. 18, Table 21) for Budhigandaki. The least time devoted month for stone licking was during February (00.21%) in Kaligandaki while during February (00.32%) in Budhigandaki. There was no found the stone licking during the months of June and September by BFAST and during all months of the year the stones were found licked by KFAST (Fig. 18).

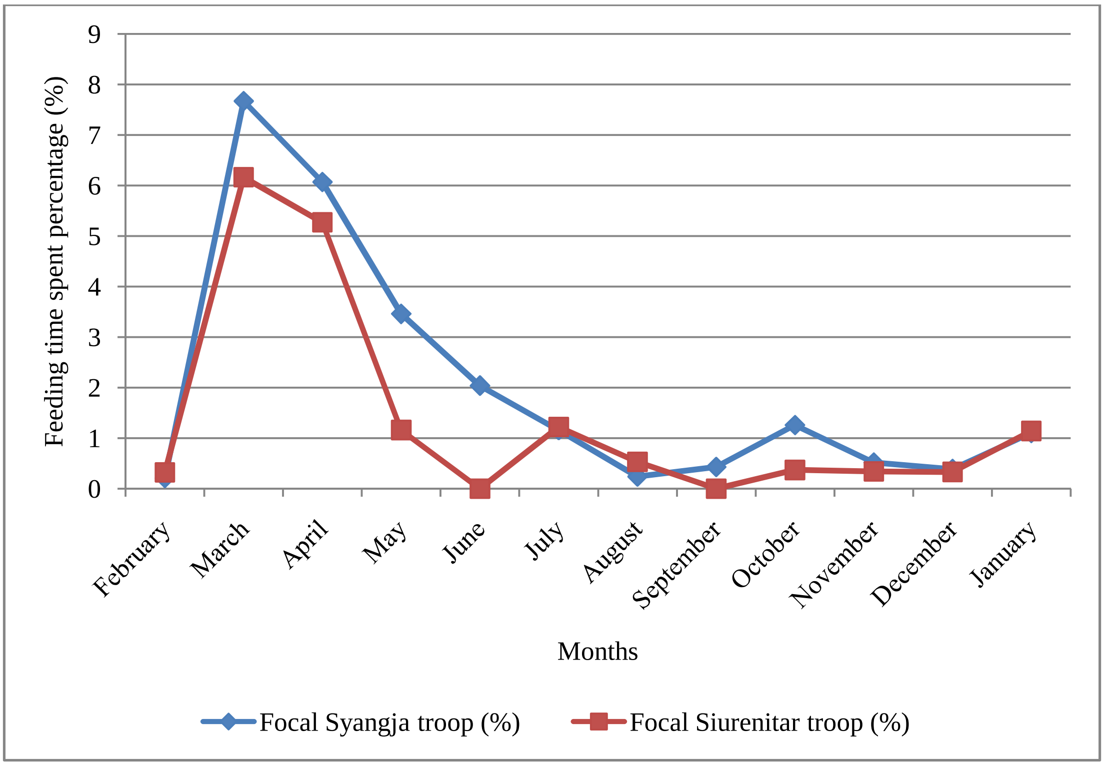

Figure 18: Monthly distribution of stone licking time in percentage for KFAST and BFAST

4.1.4.1.5.n Monthly variation of time spent in soil eating (geophagy)

The soil eating behavioral activity was investigated in both the study area. Soil eating is a common phenomenon observed in Assamese monkeys. They took regularly some amount of soil (Table 20) with some exceptions (Table 21). The red termite soil was available in the forest in two forms, one was in the form of termite moulds and the other was in the form of thin and long tunnels on tree trunks. The soil from both sites was eaten by Assamese monkeys. In addition the Assamese monkeys took the opportunity to eat the white and brown soil from the bank of rivers. The mean time spent for soil eating was 0.55% (S^2 = 0.3, CV = 92.5) per year by KFAST and 0.33% (S^2 = 0.1, CV = 83.9) per year by BFAST. Geophagy was highest during March 01.95% (Fig. 19, Table 20) for Kaligandaki while during September 00.95% (Fig. 19, Table 21) for Budhigandaki. The least time devoted month for soil eating was during October (00.12%) in Kaligandaki while during November (00.16%) in Budhigandaki. There was no found the soil eating during the months of April, July and October by BFAST and during all months of the year the soil was found eaten by KFAST (Fig. 19).

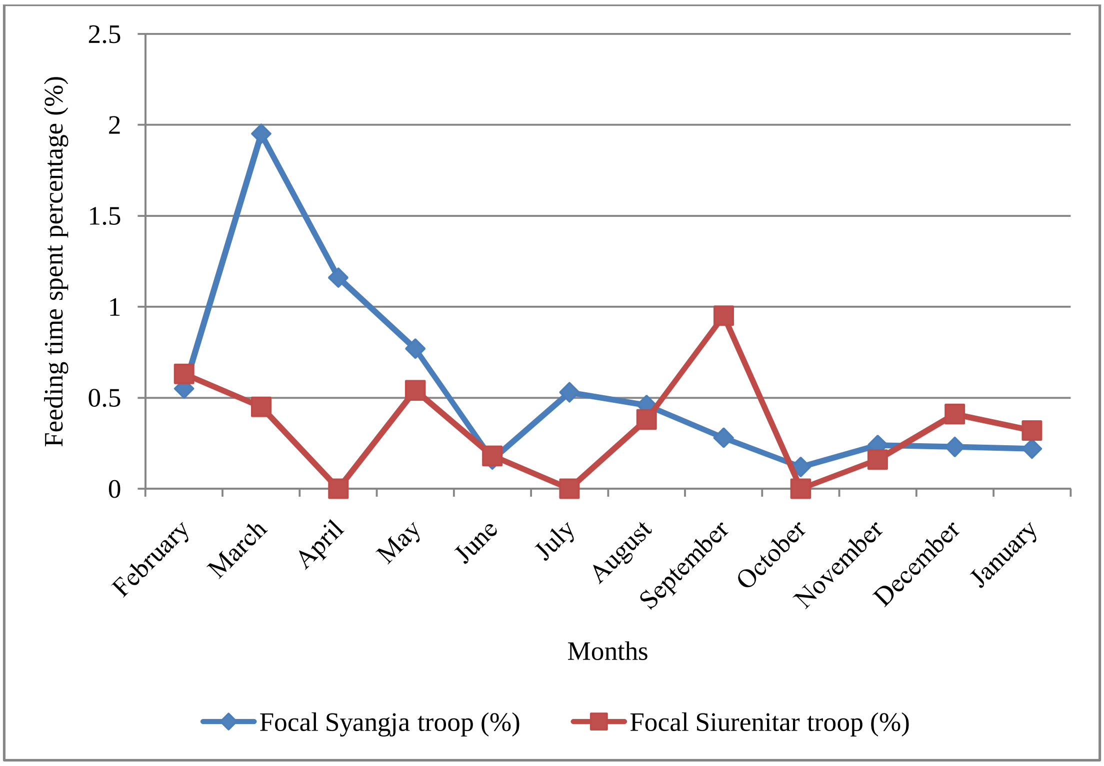

Figure 19: Monthly distribution of soil eating (geophagy) time in percentage for KFAST and BFAST

4.1.4.1.5.o Monthly variation of time spent in water drinking

The mean time spent for water drinking was 0.99% (S^2 = 0.8, CV = 90.1) per year by KFAST and 0.90% (S^2 = 0.7, CV = 90.5) per year by BFAST. Water is very essential liquid component that facilitates the chemical reactions within the body. It also helps to maintain the body fluids, and keeps the body tissues and organs moist. The water drinking is a short time consumption feeding item. The Assamese monkeys drank water regularly especially at the afternoon time from both the rivers (Kaligandaki and Budhigandaki) with a very few months exception (Table 20, 21). The highest time spent on water drinking was recorded in June 02.74% (Fig. 20, Table 20) for Kaligandaki while in June 02.65% (Fig. 20, Table 21) for Budhigandaki. The lowest time spent was observed during December (00.08%) in Kaligandaki while during February (00.17%) in Budhigandaki. There was no found the water drinking during the month of January by KFAST and during the months of December and January by BFAST (Fig. 20). The Assamese monkeys avoided water drinking due to too much cold during these months.

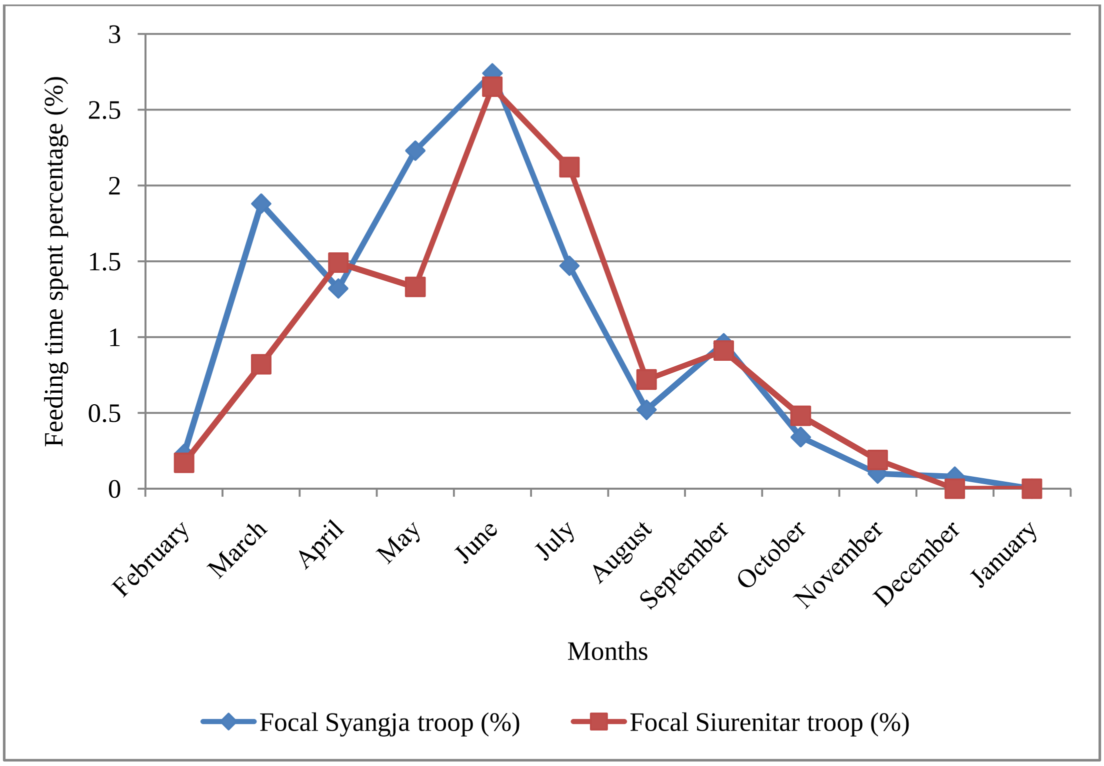

Figure 20: Monthly distribution of water drinking time in percentage for KFAST and BFAST

4.1.4.1.5.p Monthly variation of time spent in waste eating

Assamese monkeys were found eating and chewing the waste materials, thrown in the forest by the local people. They searched the cooked food items and vegetables thrown along with the waste materials and ate whenever they found. They were also found handling the cigarette papers and the remains of plastic bags either engulfing it after long chewing or throwing it. The average time spent for waste eating was 0.21% (S^2 = 0.1, CV = 129.5) per year by KFAST and 0.13% (S^2 = 0.0, CV = 85.9) per year by BFAST. The highest time spent on waste eating was recorded in March 00.82% (Fig. 21, Table 20) for Kaligandaki while in July 00.32% (Fig. 21, Table 21) for Budhigandaki. The lowest time spent was observed during December (00.02%) in Kaligandaki while during February (00.10%) in Budhigandaki. There was no found the waste eating during the months of May, July and November by KFAST and during the months of March, August, September and December by BFAST (Fig. 21).

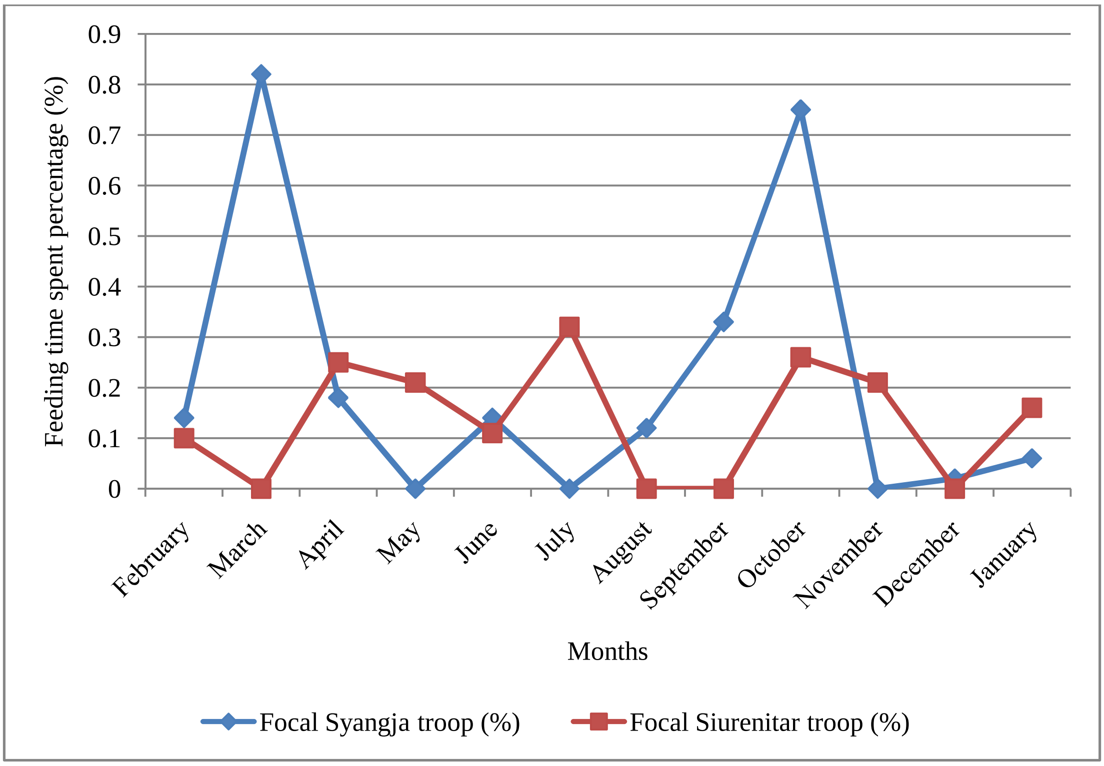

Figure 21: Monthly distribution of waste eating time in percentage for KFAST and BFAST

Table 20: Monthly distribution of food categories in % of feeding time for KFAST

Items	**2015**											**2016**	**Mean**	**Variance (S^2)**	**CV = Std-mean ratio**
	Feb.	**Mar.**	**Apr.**	**May**	**June**	**July**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	**Jan.**			
Fruits	12.14	04.62	03.98	24.42	43.37	49.14	11.16	14.32	26.02	36.15	42.55	17.72	23.80	226.5	63.2
Mature leaf	49.63	12.73	06.43	11.04	12.76	07.56	31.57	19.72	46.16	53.32	46.17	63.18	30.02	389.6	65.7
Young leaf	09.12	24.16	27.87	37.31	29.95	30.52	41.50	07.95	05.22	04.46	07.38	09.32	19.56	170.4	66.7
Seed	03.22	06.94	08.17	02.98	01.53	01.17	02.32	03.30	01.03	00.41	00.15	01.28	2.71	5.8	88.5
Young shoot	00.64	01.97	01.23	06.73	01.66	00.43	00.96	02.63	06.18	00.98	00.32	00.27	2.00	4.4	105.3
Inflorescence	01.31	02.12	03.86	00.97	00.64	-	-	01.14	00.83	00.31	-	00.21	0.95	1.1	112.8
Bark	00.24	-	-	00.24	00.18	00.11	-	00.25	-	00.14	00.26	00.03	0.12	0.0	88.4
Flower	08.57	19.22	33.51	07.12	03.43	01.12	10.43	48.12	11.12	01.91	00.96	04.11	12.47	194.5	111.8
Petiole	-	00.74	00.61	01.14	00.42	-	00.36	-	-	00.44	00.36	00.23	0.36	0.1	93.5
Leafbud	00.44	00.31	02.14	00.65	00.97	-	00.22	-	00.43	00.48	00.64	00.78	0.59	0.3	92.3
Rhizome	01.67	02.45	01.21	-	-	00.23	00.14	00.57	00.31	00.53	00.37	01.32	0.73	0.5	100.5
Insects	11.89	12.41	02.26	00.94	-	06.55	-	-	00.23	-	00.11	00.17	2.90	20.4	155.8
Stone licking	00.21	07.67	06.07	03.46	02.04	01.16	00.24	00.43	01.26	00.52	00.39	01.10	2.04	5.5	115.3
Soil eating	00.55	01.95	01.16	00.77	00.16	00.53	00.46	00.28	00.12	00.24	00.23	00.22	0.55	0.3	92.5
Water	00.23	01.88	01.32	02.23	02.74	01.47	00.52	00.96	00.34	00.10	00.08	-	0.99	0.8	90.1
Waste	00.14	00.82	00.18	-	00.14	-	00.12	00.33	00.75	-	00.02	00.06	0.21	0.1	129.5
Total	100	99.99	100	100	99.99	99.99	100	100	100	99.99	99.99	100	100.00	0.0	0.0

Table 21: Monthly distribution of food categories in % of feeding time for BFAST

Items	2015											2016	Mean	Variance (S^2)	CV = Std-mean ratio
	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.			
Fruits	13.56	10.15	06.17	27.19	45.23	47.12	12.84	16.26	31.17	39.12	41.43	21.25	25.96	195.3	53.8
Mature leaf	47.12	11.94	05.75	10.07	09.96	05.46	26.16	23.12	48.09	50.76	48.11	61.90	29.04	396.9	68.6
Young leaf	11.16	29.98	31.69	39.22	33.13	34.18	42.10	06.97	04.13	03.89	04.75	06.97	20.70	218.6	71.4
Seed	03.11	04.91	06.96	01.74	00.88	00.97	01.42	01.65	01.33	00.61	00.10	01.18	2.07	3.6	92.2
Young shoot	00.86	01.76	02.29	04.11	01.73	00.66	00.87	01.42	02.56	00.31	00.87	00.54	1.50	1.1	69.2
Inflorescence	-	01.89	02.81	00.76	00.89	00.41	00.68	00.94	01.16	-	00.65	-	0.85	0.6	92.8
Bark	00.41	00.12	00.34	-	00.32	-	00.86	00.11	00.26	-	00.14	00.12	0.22	0.1	104.6
Flower	09.77	18.26	30.64	09.23	02.86	02.55	11.61	44.17	09.45	02.15	01.74	03.48	12.16	157.4	103.2
Petiole	00.62	-	00.71	00.84	-	00.43	00.66	00.74	00.22	00.26	00.12	00.46	0.42	0.1	67.7
Leafbud	00.98	00.48	03.53	00.91	00.67	00.59	00.39	00.98	00.12	00.67	00.42	00.69	0.87	0.7	96.4
Rhizome	01.95	02.97	02.10	-	00.54	00.62	-	00.34	00.40	00.85	00.93	01.55	1.02	0.8	87.1
Insects	09.23	10.11	-	02.68	00.85	03.35	00.77	01.43	-	00.48	-	00.23	2.43	11.6	139.9
Stone licking	00.32	06.16	05.27	01.16	-	01.22	00.53	-	00.37	00.34	00.33	01.14	1.40	3.9	141.3
Soil eating	00.63	00.45	-	00.54	00.18	-	00.38	00.95	-	00.16	00.41	00.32	0.33	0.1	83.9
Water	00.17	00.82	01.49	01.33	02.65	02.12	00.72	00.91	00.48	00.19	-	-	0.90	0.7	90.5
Waste	00.10	-	00.25	00.21	00.11	00.32	-	-	00.26	00.21	-	00.16	0.13	0.0	85.9
Total	99.99	100	100	99.99	100	100	99.99	99.99	100	100	100	99.99	100.00	0.0	0.0

4.1.4.1.6 Food intake in grams

In the preceding chapter results 4.1.4.1.5, the time spent on feeding by Assamese monkeys was investigated. There were few significant results. Most differences were due to seasonable effects. However only time spent was compared which can give just an estimate of the real food intake. Thus it is for instance possible, that a monkey, that eats fast, gets actually more food in the same time span than a monkey eating slow.

Among the different food categories, stone licking, soil eating, water drinking and waste eating calculations in grams were not possible. Stone licking consists of nothing to count. The weight for water could not be estimated in the freely feeding condition of this study.

4.1.4.1.7 Monthly variation in food intake

The monthly mean food intake in grams for an adult individual of KFAST and BFAST was calculated. For an adult individual of KFAST, the mean food intake in March 971.56 grams (Table 22) was the highest and in June 862.17 grams, April

811.05 grams, May 779.43 grams and July 703.21 grams. The lowest intake was in February (314.03 grams). For an adult individual of BFAST, the mean food intake in March 898.73 grams (Table 22) was the highest and in June 885.51 grams, May 794.33 grams, April 737.68 grams and July 653.02 grams. The lowest intake was in February (281.62 grams). This shows that in nearly all dry and cold months they ate less weight. This might be related to the availability of a lower variety of food items (e.g. mature leaf) in this time of the year. It might be possible that the Assamese monkeys eat less in cold months because no heavy quality of food is available.

The monthly food intakes in grams were tested for each other among the months in both the study area (Kaligandaki and Budhigandaki). The intake in the months of March and June was significantly higher to the data of August to February (7 months). Similarly the intake in the months of April, May and July was significantly higher to August, October, November, January and February.

Table 22: Monthly mean food intake for an adult individual of KFAST and BFAST (in grams per statistical day)

Month	KFAST (per individual food in grams)	BFAST (per individual food in grams)
February, 2015	314.03	281.62
March	971.56	898.73
April	811.05	737.68
May	779.43	794.33
June	862.17	885.51
July	703.21	653.02
August	330.06	332.75
September	453.88	403.97
October	386.94	346.28
November	323.49	292.89
December	417.16	373.22
January, 2016	342.35	301.12
Mean per st. day	557.94	525.09

Paired t-test shows that average for KFAST and BFAST per individual food intake differ significantly.

4.1.4.1.7.a Monthly variation of fruit intake

The mean intake of fruits per year in grams was 27.19% (S^2 = 245.39, CV = 57.61) for KFAST and 29.54% (S^2 = 197.04, CV = 46.08) for BFAST. This food category recorded the highest rank (first position of intake) among all the categories of foods in both the study area. There were two peaks with high mean intake of fruits. One peak was in June and July (Fig. 22) and another peak was in November and December. The highest mean intake of fruits in grams was found in July 53.10% (Fig. 22, Table 23) and June 48.85% for KFAST and in July 53.65% (Fig. 22, Table 24) and June 51.62% for BFAST. The lowest mean intake of fruits in grams was found in April (06.19%) and March (07.83%) for KFAST and in April (11.10%) for BFAST. The fruit availability was highly seasonal in the forest, so the patterns of fruit intake data were fluctuated with the months.

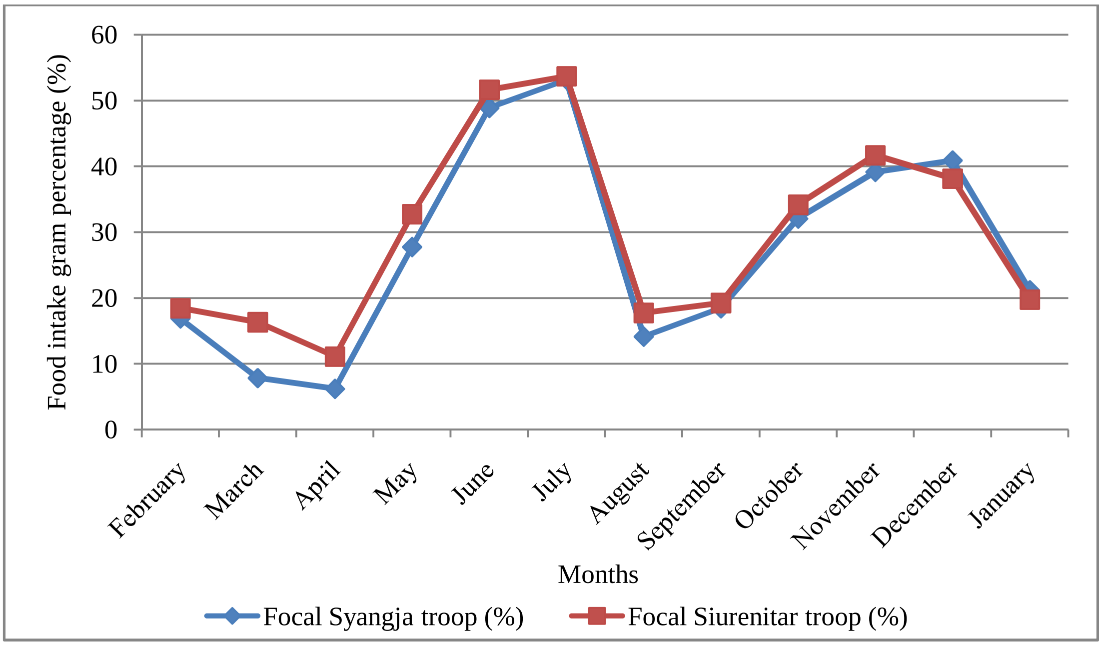

Figure 22: Monthly distribution of fruit intake for KFAST and BFAST (in gram % of mean intake)

4.1.4.1.7.b Monthly variation of mature leaf intake

The mean intake of mature leaves per year in grams was 26.67% (S^2 = 334.12, CV = 68.54) for KFAST and 26.34% (S^2 = 399.51, CV = 81.77) for BFAST. Mature leaves ranked the second position for intake of food in the major food categories.

For KRB forest, the intake was highest in January 57.17% (Fig. 23, Table 23) followed by February 51.23% and very close to this rank was December 49.22%. The lowest mature leaves intake was recorded in April (07.76%) followed by May

(08.31%) and very close to this rank were June (09.66%) and July (09.88%). For BRB forest, the intake was highest in January 62.63% (Fig. 23, Table 24) followed by February 49.16%, December 49.78% and very close to this rank were November 43.40% and October 39.10%. The lowest mature leaves intake was recorded in July (04.33%) followed by April (04.34%) and very close to this rank were June (05.65%) and May (06.08%). This shows the distribution fluctuated tremendously and significantly in the course of the year. The data shows the increasing trend of mature leaf intake by the Assamese monkeys from October to February in both the study area. This is due to the availability of mature leaves in these months rather than other food items in the forest.

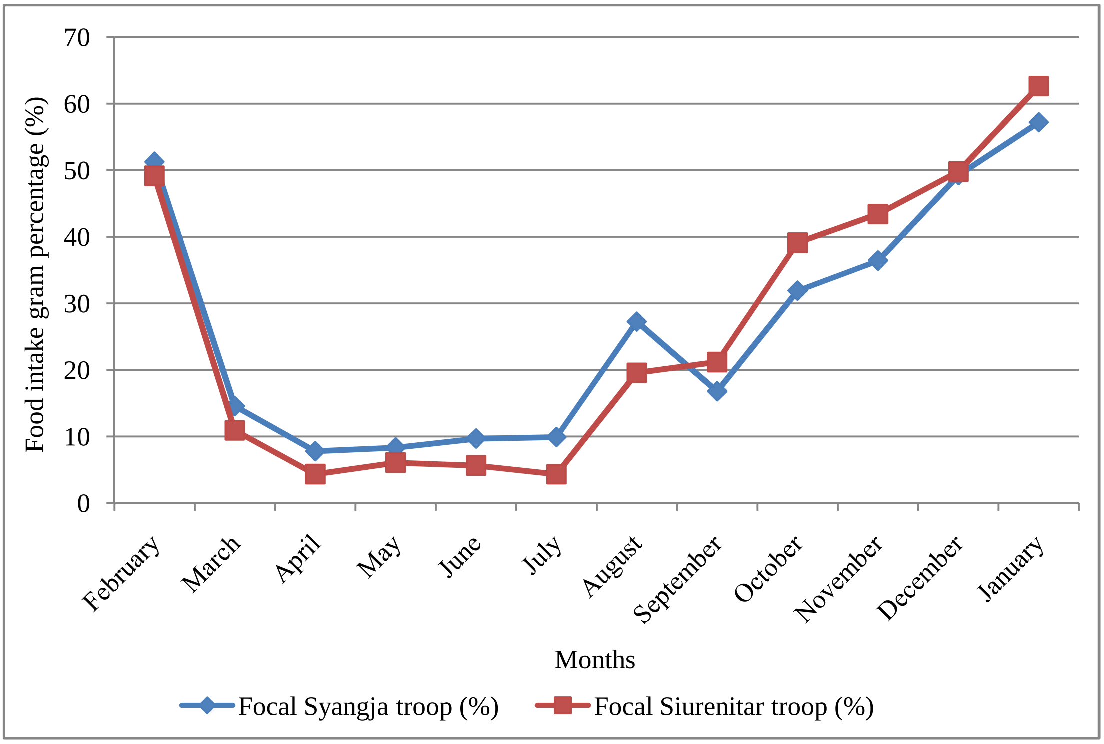

Figure 23: Monthly distribution of mature leaf intake for KFAST and BFAST (in gram % of mean intake)

4.1.4.1.7.c Monthly variation of young leaf intake

The mean intake of young leaves per year in grams was 20.40% (S^2 = 205.97, CV = 70.35) for KFAST and 21.96% (S^2 = 203.03, CV = 61.69) for BFAST. Young leaves ranked the third position for intake of food in the major food categories. For KRB forest, the intake was highest in August 46.06% (Fig. 24, Table 23) followed by May 39.10% and very close to this rank were June 31.12%, July 28.14%, March 27.11% and April 26.92%. The lowest young leaves intake was recorded in February (04.71%) followed by December (05.64%) and very close to this rank were January

(07.30%) and November (07.42%). For BRB forest, the intake was highest in August 44.65% (Fig. 24, Table 24) followed by May 37.26%, July 35.10% and very close to this rank were April 33.47%, March 32.42% and June 32.12%. The lowest young leaves intake was recorded in December (06.82%) followed by November (06.88%) and very close to this rank were October (07.16%), January (08.14%) and February (08.31%). This shows the distribution fluctuated tremendously and significantly in the course of the year. The data shows the increasing trend of young leaf intake by the Assamese monkeys from March to August in both the study area. This is due to the availability of young leaves in these months and these constitute the high nutritive value for Assamese monkeys.

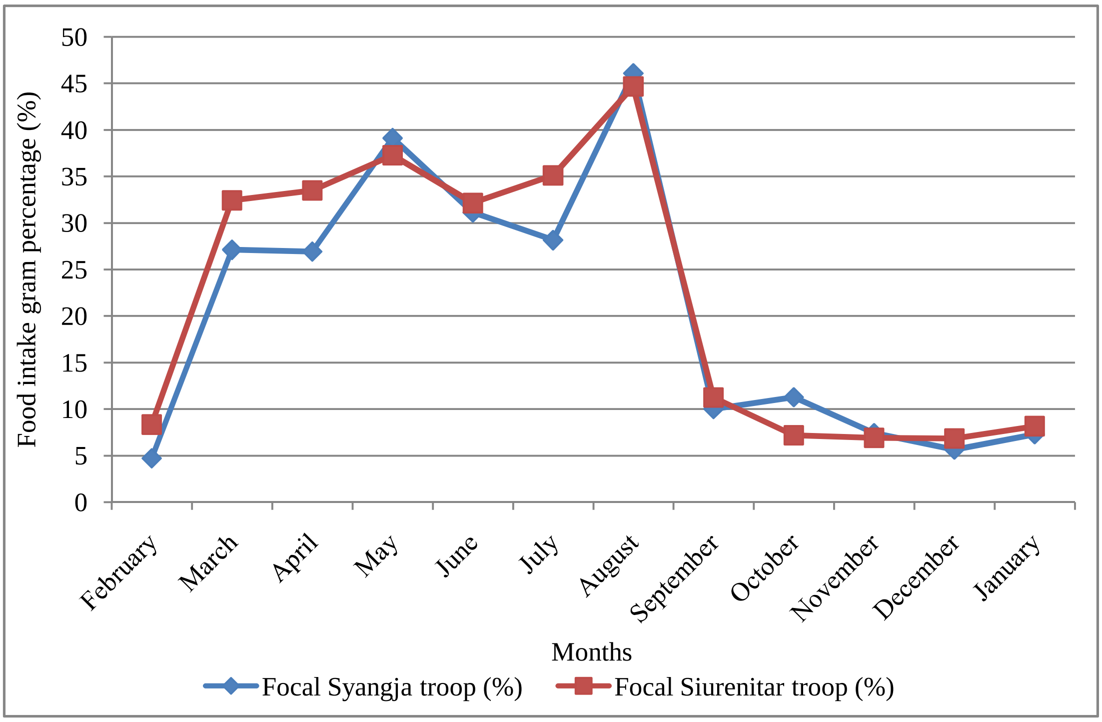

Figure 24: Monthly distribution of young leaf intake for KFAST and BFAST (in gram % of mean intake)

4.1.4.1.7.d Monthly variation of seed intake

The mean intake of seeds per year in grams was 2.94% (S^2 = 4.58, CV = 72.83) for KFAST and 2.71% (S^2 = 5.26, CV = 83.26) for BFAST. For KRB forest, the intake was highest in March 06.23% (Fig. 25, Table 23) followed by September 06.21% and very close to this rank was April 05.93%. The lowest seeds intake was recorded in December (00.18%). For BRB forest, the intake was highest in April 07.46% (Fig. 25, Table 24) and very close to this rank was March 06.69%. The lowest seeds intake was recorded in December (00.22%). Assamese monkeys frequently fed seed of

Castanopsis indica available during winter seasons and seed of *Arisaema tortuosum* available during summer seasons.

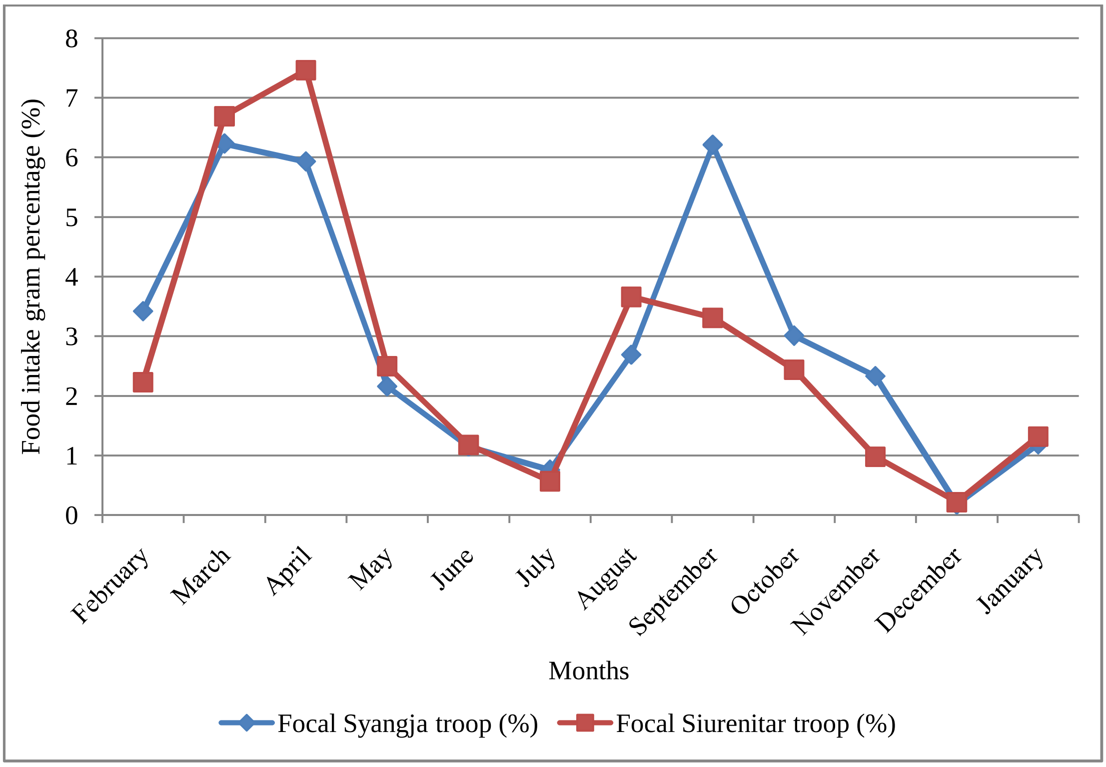

Figure 25: Monthly distribution of seed intake for KFAST and BFAST (in gram % of mean intake)

4.1.4.1.7.e Monthly variation of young shoot intake

The delicate young tip part of plants and branches were eaten by Assamese monkeys during all months of the year in both the study area. The mean intake of young shoot per year in grams was 2.88% (S^2 = 7.39, CV = 94.48) for KFAST and 1.91% (S^2 = 3.07, CV = 88.51) for BFAST. For KRB forest, the intake was highest in May 08.95% (Fig. 26, Table 23) and very close to this rank was April 06.57%. The lowest young shoot intake was recorded in December (00.53%) followed by August (00.54%) and very close to this rank was January (00.75%). For BRB forest, the intake was highest in May 06.29% (Fig. 26, Table 24) and very close to this rank was April 04.35%. The lowest young shoot intake was recorded in November (00.41%) and very close to this rank was July (00.46%). This shows that the monthly distributions were significant.

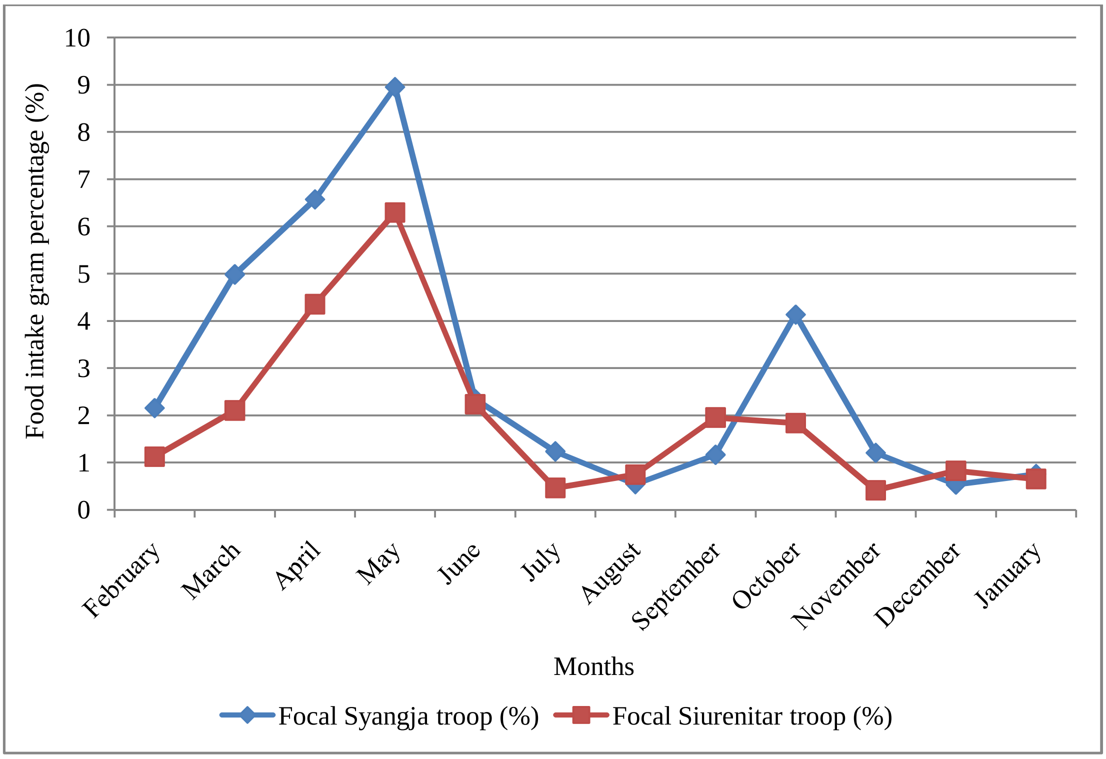

Figure 26: Monthly distribution of young shoot intake for KFAST and BFAST (in gram % of mean intake)

4.1.4.1.7.f Monthly variation of inflorescence intake

The mean intake of inflorescence per year in grams was 1.06% (S^2 = 1.17, CV = 76.59) for KFAST and 0.83% (S^2 = 0.53, CV = 66.98) for BFAST. For KRB forest, the intake was highest in April 03.66% (Fig. 27, Table 23) and very close to this rank was March 02.34%. The lowest inflorescence intake was recorded in January (00.26%) and very close to this rank were June (00.43%) and September (00.52%). There were no found the intake data of inflorescence during the months of July, August and December. For BRB forest, the intake was highest in April 02.92% (Fig. 27, Table 24). The lowest inflorescence intake was recorded in July (00.31%) and very close to this rank was December (00.43%). There were no found the intake data of inflorescence during the months of February, November and January.

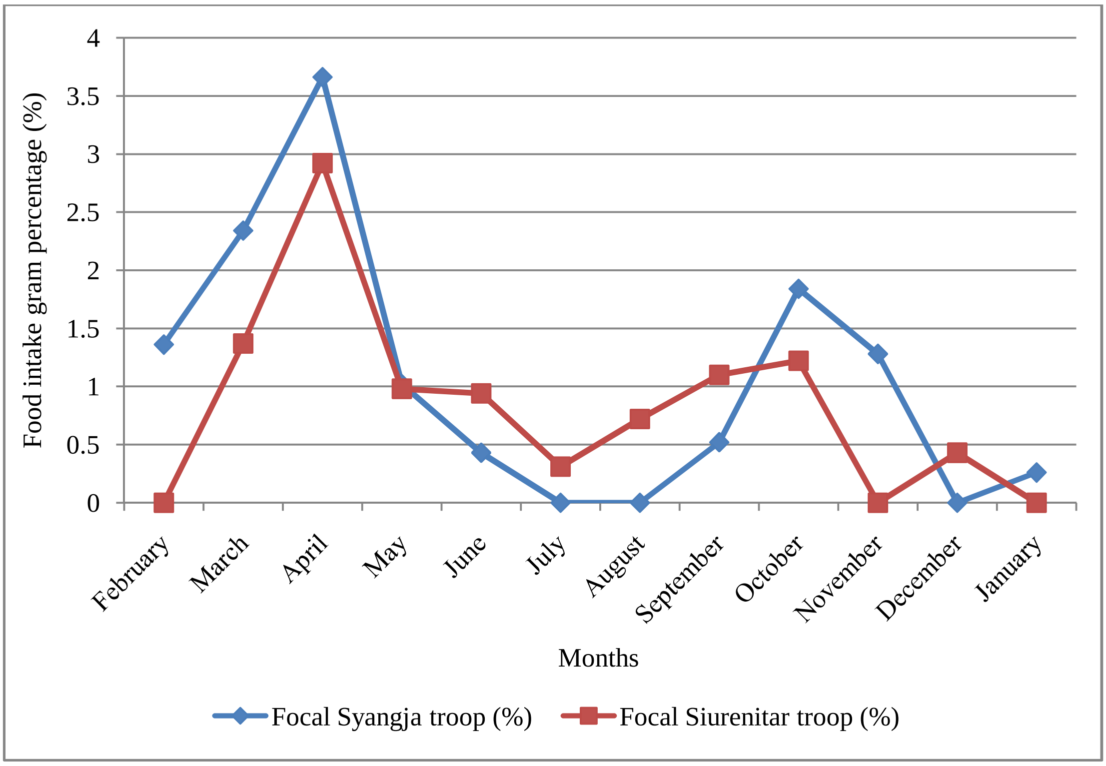

Figure 27: Monthly distribution of inflorescence intake for KFAST and BFAST (in gram % of mean intake)

4.1.4.1.7.g Monthly variation of bark intake

The mean intake of bark per year in grams was 0.28% (S^2 = 0.12, CV = 81.96) for KFAST and 0.30% (S^2 = 0.03, CV = 48.35) for BFAST. For KRB forest, the intake was highest in February 01.21% (Fig. 28, Table 23). The lowest bark intake was recorded in January (00.11%) and during most of the months the intake data were below 1%. There were no found the intake data of bark during the months of March, April, August and October. For BRB forest, the intake was highest in February 00.76% (Fig. 28, Table 24). The lowest bark intake was recorded in December (00.10%) and during all the months of the year the intake data were below 1%. There were no found the intake data of bark during the months of May, July and November. Assamese monkeys mostly preferred bark of *Ficus hispida* as food.

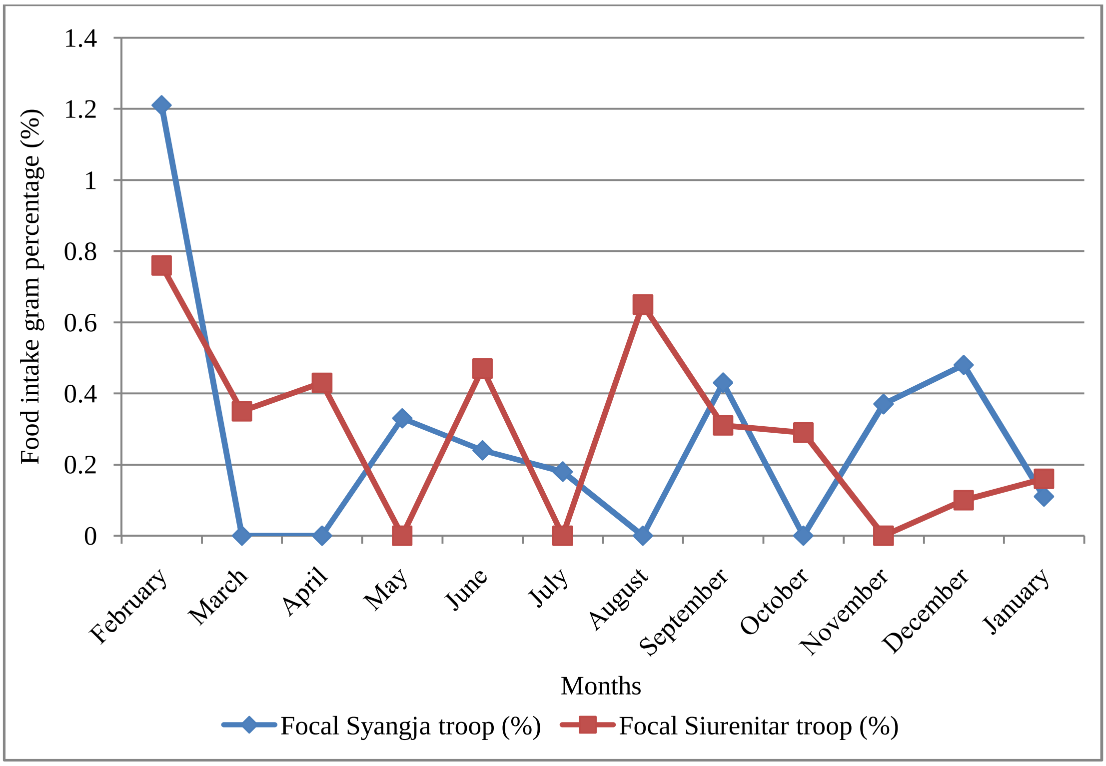

Figure 28: Monthly distribution of bark intake for KFAST and BFAST (in gram % of mean intake)

4.1.4.1.7.h Monthly variation of flower intake

The mean intake of flower per year in grams was 14.07% (S^2 = 184.65, CV = 96.59) for KFAST and 12.90% (S^2 = 150.12, CV = 93.86) for BFAST. Flowers ranked the fourth position for intake of food in the major food categories. The flowers are the highly seasonal. There were two peaks of exploitation of flowers in this study. One peak was in April and another peak was in September. For KRB forest, the intake was highest in September 45.81% (Fig. 29, Table 23) and very close to this rank was April 34.38%. The lowest flower intake was recorded in December (01.23%). For BRB forest, the intake was highest in September 39.12% (Fig. 29, Table 24) and very close to this rank was April 32.76%. The lowest flower intake was recorded in July (01.47%).

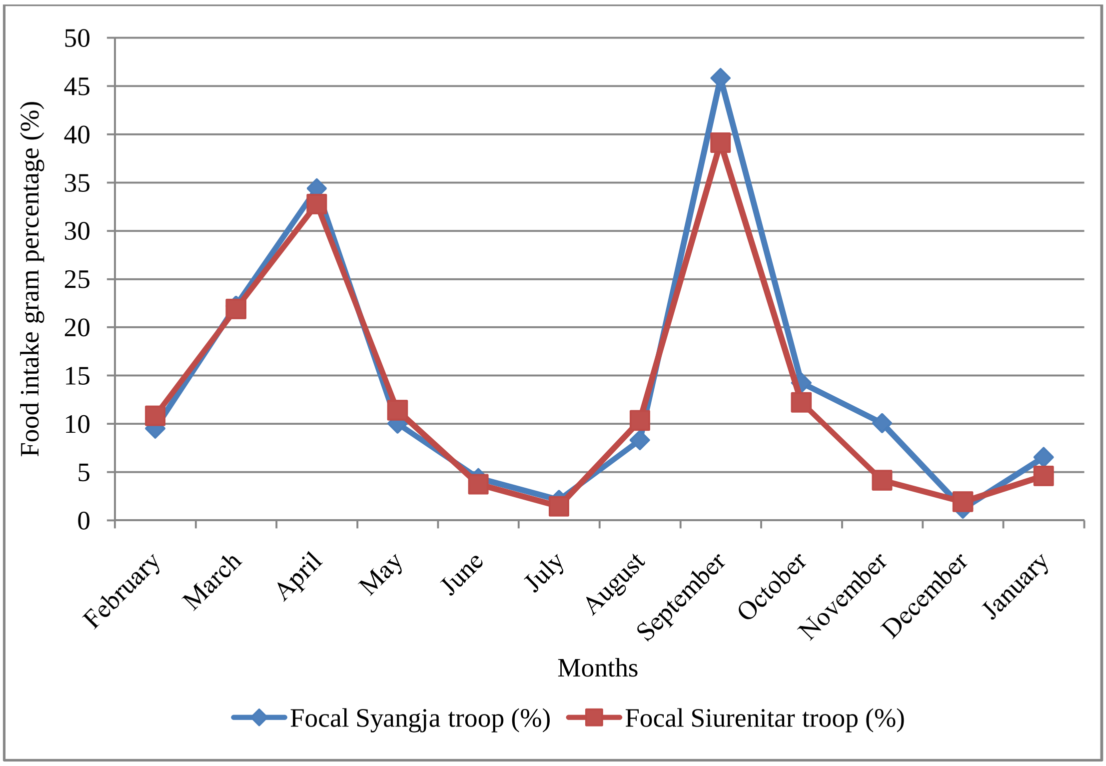

Figure 29: Monthly distribution of flower intake for KFAST and BFAST (in gram % of mean intake)

4.1.4.1.7.i Monthly variation of petiole intake

The mean intake of petiole per year in grams was 0.44% (S^2 = 0.08, CV = 41.88) for KFAST and 0.44% (S^2 = 0.04, CV = 39.01) for BFAST. This is only one of the result that shows the same gram percentage of petiole intake in both the study area. For KRB forest, the intake was highest in May 01.17% (Fig. 30, Table 23). The lowest petiole intake was recorded in November (00.32%) and during almost all the months except May the intake data were below 1%. There were no found the intake data of petiole during the months of February, July, September and October. For BRB forest, the intake was highest in February 00.93% (Fig. 30, Table 24). The lowest petiole intake was recorded in December (00.17%) and during all the months of the year the intake data were below 1%. There were no found the intake data of petiole during the months of March and June.

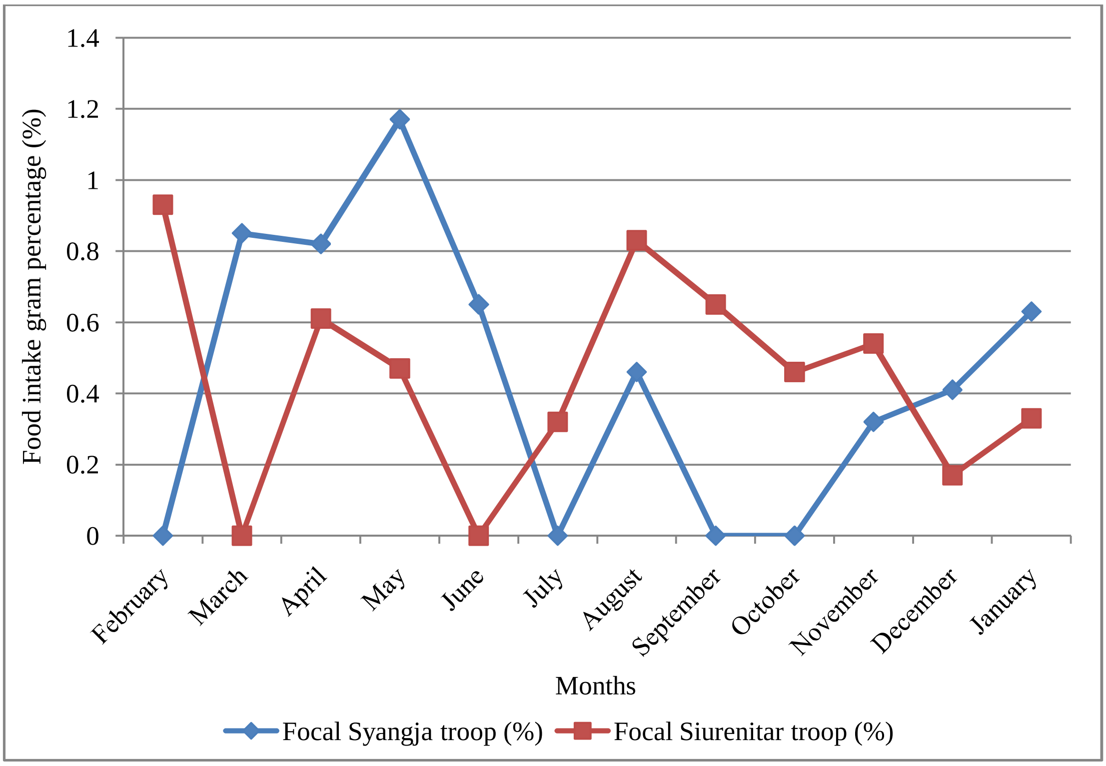

Figure 30: Monthly distribution of petiole intake for KFAST and BFAST (in gram % of mean intake)

4.1.4.1.7.j Monthly variation of leafbud intake

The mean intake of leafbud per year in grams was 0.78% (S^2 = 0.23, CV = 51.41) for KFAST and 0.70% (S^2 = 0.05, CV = 33.44) for BFAST. This result shows nearly the same gram percentage of leafbud intake in both the study area. For KRB forest, the intake was highest in April 02.01% (Fig. 31, Table 23). The lowest leafbud intake was recorded in August (00.38%) and during most of the months the intake data were below 1%. There were no found the intake data of leafbud during the months of July and September. For BRB forest, the intake was highest in April 01.23% (Fig. 31, Table 24). The lowest leafbud intake was recorded in October (00.37%) and during all the months of the year except April the intake data were below 1%.

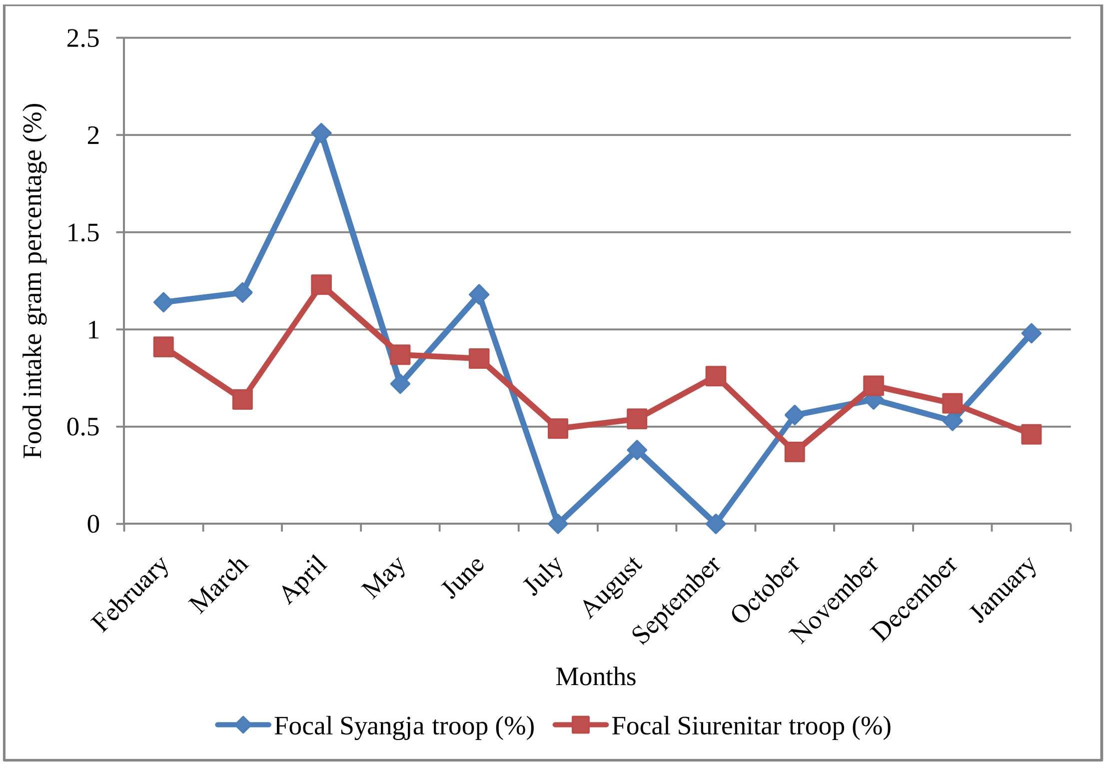

Figure 31: Monthly distribution of leafbud intake for KFAST and BFAST (in gram % of mean intake)

4.1.4.1.7.k Monthly variation of rhizome intake

The mean intake of rhizome per year in grams was 1.22% (S^2 = 1.42, CV = 81.12) for KFAST and 1.02% (S^2 = 0.29, CV = 49.98) for BFAST. For KRB forest, the intake was highest in January 03.38% (Fig. 32, Table 23) followed by March 03.12% and very close to this rank were February 02.33% and April 02.32%. The lowest rhizome intake was recorded in August (00.21%) and during most of the months the intake data were below 1%. There were no found the intake data of rhizome during the months of May and June. For BRB forest, the intake was highest in February 02.52% (Fig. 32, Table 24) followed by March 02.12% and very close to this rank were January 01.82% and April 01.33%. The lowest rhizome intake was recorded in September (00.44%) and during most of the months the intake data were below 1%. There were no found the intake data of rhizome during the months of May and August. Rhizome of *Dioscorea bulbifera* was the most preferred food by Assamese monkeys.

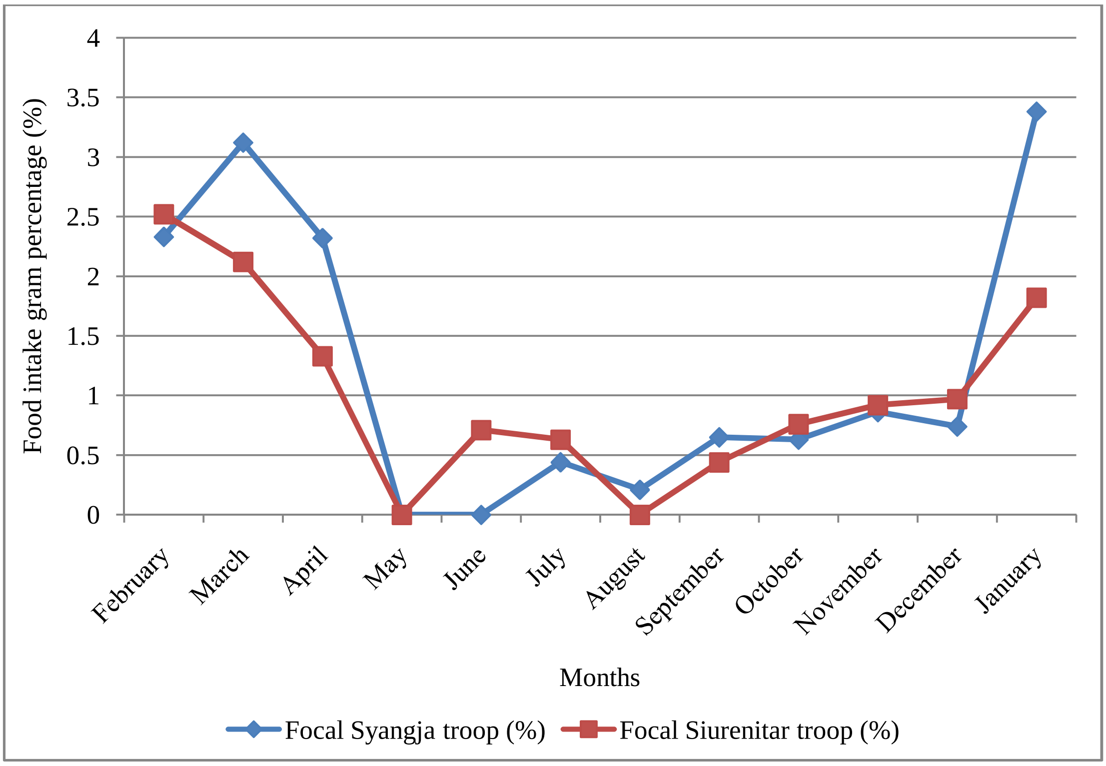

Figure 32: Monthly distribution of rhizome intake for KFAST and BFAST (in gram % of mean intake)

4.1.4.1.7.l Monthly variation of insect intake

The mean intake of insect per year in grams was 2.07% (S^2 = 11.69, CV = 109.99) for KFAST and 1.35% (S^2 = 2.58, CV = 112.82) for BFAST. For KRB forest, the intake was highest in March 09.62% (Fig. 33, Table 23). Most available insects were caterpillars. Assamese monkeys frequently fed these caterpillars as food when other food items were less available in the forest. The lowest insect intake was recorded in December (00.18%) and during most of the months the intake data were below 1%. There were no found the intake data of insect during the months of June, August, September and November. For BRB forest, the intake was highest in March 05.17% (Fig. 33, Table 24) and very close to this rank was February 04.79%. The lowest insect intake was recorded in January (00.12%) and during most of the months the intake data were below 1%. There were no found the intake data of insect during the months of April, October and December.

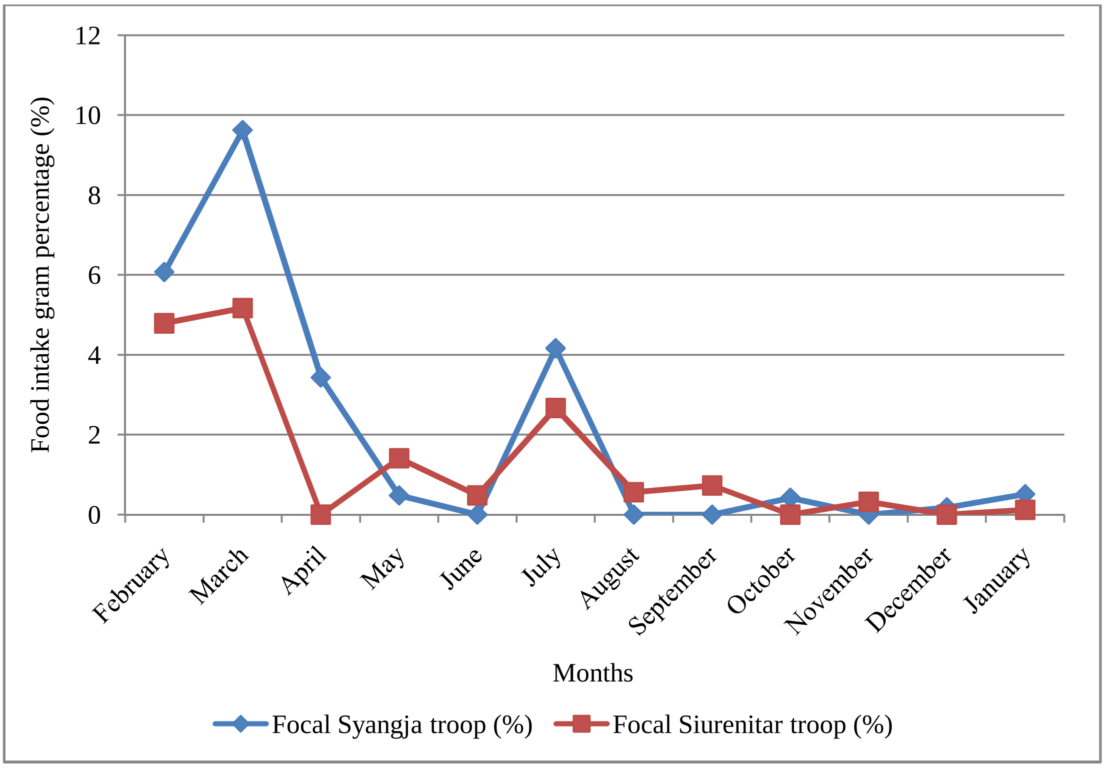

Figure 33: Monthly distribution of insect intake for KFAST and BFAST (in gram % of mean intake)

Table 23: Monthly distribution of food categories for KFAST (in gram % of mean intake)

Items						**2015**						**2016**	**Mean**	**Variance (S^2)**	**CV=Std-mean ratio**
	Feb.	**Mar.**	**Apr.**	**May**	**June**	**July**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	**Jan.**			
Fruits	16.86	07.83	06.19	27.73	48.85	53.10	14.12	18.42	32.03	39.11	40.85	21.18	27.19	245.39	57.61
Mature leaf	51.23	14.52	07.76	08.31	09.66	09.88	27.23	16.77	31.87	36.39	49.22	57.17	26.67	334.12	68.54
Young leaf	04.71	27.11	26.92	39.10	31.12	28.14	46.06	10.02	11.27	07.42	05.64	07.30	20.40	205.97	70.35
Seed	03.42	06.23	05.93	02.16	01.15	00.76	02.69	06.21	03.01	02.33	00.18	01.19	2.94	4.58	72.83
Young shoot	02.15	04.98	06.57	08.95	02.34	01.23	00.54	01.16	04.13	01.20	00.53	00.75	2.88	7.39	94.48
Inflorescence	01.36	02.34	03.66	01.02	00.43	-	-	00.52	01.84	01.28	-	00.26	1.06	1.17	76.59
Bark	01.21	-	-	00.33	00.24	00.18	-	00.43	-	00.37	00.48	00.11	0.28	0.12	81.96
Flower	09.52	22.21	34.38	10.03	04.37	02.11	08.31	45.81	14.24	10.07	01.23	06.54	14.07	184.65	96.59
Petiole	-	00.85	00.82	01.17	00.65	-	00.46	-	-	00.32	00.41	00.63	0.44	0.08	41.88
Leafbud	01.14	01.19	02.01	00.72	01.18	-	00.38	-	00.56	00.64	00.53	00.98	0.78	0.23	51.41
Rhizome	02.33	03.12	02.32	-	-	00.44	00.21	00.65	00.63	00.86	00.74	03.38	1.22	1.42	81.12
Insects	06.07	09.62	03.43	00.48	-	04.16	-	-	00.42	-	00.18	00.51	2.07	11.69	109.99
Total	100	100	99.99	100	99.99	100	100	99.99	100	99.99	99.99	100	100.00	0.0	0.0

Table 24: Monthly distribution of food categories for BFAST (in gram % of mean intake)

Items	2015											2016	Mean	Variance (S^2)	CV = Std-mean ratio
	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.			
Fruits	18.43	16.32	11.10	32.71	51.62	53.65	17.72	19.23	34.14	41.67	38.12	19.74	29.54	197.04	46.08
Mature leaf	49.16	10.91	04.34	06.08	05.65	04.33	19.57	21.18	39.10	43.40	49.78	62.63	26.34	399.51	81.77
Young leaf	08.31	32.42	33.47	37.26	32.12	35.10	44.65	11.21	07.16	06.88	06.82	08.14	21.96	203.03	61.69
Seed	02.23	06.69	07.46	02.50	01.18	00.57	03.66	03.31	02.44	00.98	00.22	01.32	2.71	5.26	83.26
Young shoot	01.12	02.10	04.35	06.29	02.23	00.46	00.74	01.95	01.83	00.41	00.82	00.65	1.91	3.07	88.51
Inflorescence	-	01.37	02.92	00.98	00.94	00.31	00.72	01.10	01.22	-	00.43	-	0.83	0.53	66.98
Bark	00.76	00.35	00.43	-	00.47	-	00.65	00.31	00.29	-	00.10	00.16	0.30	0.03	48.35
Flower	10.84	21.91	32.76	11.42	03.74	01.47	10.36	39.12	12.23	04.16	01.95	04.62	12.90	150.12	93.86
Petiole	00.93	-	00.61	00.47	-	00.32	00.83	00.65	00.46	00.54	00.17	00.33	0.44	0.04	39.01
Leafbud	00.91	00.64	01.23	00.87	00.85	00.49	00.54	00.76	00.37	00.71	00.62	00.46	0.70	0.05	33.44
Rhizome	02.52	02.12	01.33	-	00.71	00.63	-	00.44	00.76	00.92	00.97	01.82	1.02	0.29	49.98
Insects	04.79	05.17	-	01.41	00.48	02.67	00.56	00.73	-	00.32	-	00.12	1.35	2.58	112.82
Total	100	100	100	99.99	99.99	100	100	99.99	100	99.99	100	99.99	100.00	0.0	0.0

4.1.4.2 Other major behaviors

The behavior of Assamese monkeys was recorded by the activities that they performed during the observation period and data were collected using focal animal sampling method. All of their activities were grouped into four major categories. They were foraging, resting, moving and grooming. The pattern of activity was influenced by various factors like the seasons, food, habitat, etc. There was no particular time for agonistic behavior. They showed agonistic behavior at any time during foraging, resting, moving and grooming.

4.1.4.2.1 Resting behavior

Resting is the state when the position of Assamese monkeys are either sitting or lying with or without eye close and not active in other activities.

During the winter season, the Assamese monkeys of both the river system (Kaligandaki and Budhigandaki) were seen in resting position in the morning and late afternoon. At the time of summer months, they were seen in resting position in mid afternoon. Among the total observation time in KRB, the total resting time spent by KFAST was 197.8 hours and the percentage resting time was calculated as 27.63% (Table 25). Among the total observation time in the BRB, the total resting time spent by BFAST was 171.2 hours and the percentage resting time was calculated as 24.78% (Table 26). The mean resting time spent by two troops was 184.5 hours and in percentage it was 26.20%.

4.1.4.2.2 Moving behavior

The behavioral phenomenon in which the Assamese monkeys displace from one place to another is called moving. Walking, playing and swinging are also categorized under moving activities in my study.

During the observation period, it was found that they were moving maximum during the winter months for feeding than the summer and rainy season. They were seen moving at the time of late morning and afternoon in winter months and they were seen moving at the time of early morning and evening during summer and rainy season. Among the total observation time in KRB, the total moving time spent by KFAST was 126.9 hours and the percentage moving time was calculated as 17.72% (Table 25). Among the total observation time in the BRB, the total moving time spent by BFAST was 114.6 hours and the percentage moving time was calculated as 16.58% (Table 26). The mean moving time spent by two troops was 120.75 hours and in percentage it was 17.15%.

4.1.4.2.3 Grooming behavior

This is a behavioral phenomenon where Assamese monkeys search their own fur/hair or fur/hair of others for lice or bugs or dirts.

During the observation period, the monkeys were grooming at the time of morning and pre-afternoon when they were on rest. In winter, there were three peaks of grooming i.e., morning, afternoon and evening. During summer, maximum grooming occurred in morning and afternoon. In rainy season, grooming was at its peak in the afternoon. There was also auto-grooming in which a monkey searched its own body. The female mothers were the most active groomers than the males.

The grooming was significantly higher during the mating season. Before and after the copulation, the female started grooming and vice versa.

During the total observation period in KRB, the total grooming time spent by KFAST was 96.6 hours and the percentage grooming time was calculated as 13.49% (Table 25). During the total observation period in the BRB, the total grooming time spent by

BFAST was 98.7 hours and the percentage grooming time was calculated as 14.28% (Table 26). The mean grooming time spent by two troops was 97.65 hours and in percentage it was 13.88%.

Table 25: Total time spent in feeding behavior and other major activities of KFAST

SN	Behaviors		Total time spent	
			Time in hours	**Percentage**
1.	Feeding		294.7	41.16
2.	Resting		197.8	27.63
3.	Moving		126.9	17.72
4.	Grooming		96.6	13.49
		Total	716	100

Table 26: Total time spent in feeding behavior and other major activities of BFAST

SN	Behaviors		Total time spent	
			Time in hours	**Percentage**
1.	Feeding		306.5	44.36
2.	Resting		171.2	24.78
3.	Moving		114.6	16.58
4.	Grooming		98.7	14.28
		Total	691	100

The behavioral data shows that BFAST spent more time in feeding (44.36%) as compared to the feeding time spent (41.16%) of KFAST. However, the resting time (27.63%) of KFAST was higher than BFAST resting time (24.78%). The moving time (17.72%) and grooming time (13.49%) of KFAST were more or less similar with the moving time (16.58%) and grooming time (14.28%) of BFAST.

4.1.5 Crop raiding

Crop raiding was found to be the major problem caused by the Assamese monkeys in both KRB villages and the BRB villages.

4.1.5.1 Crop raiding in Kaligandaki river basin villages

All the wards of Darlamdanda VDC and Khanichhap VDC of Palpa and Malunga Tunibot VDC of Syangja became affected by Assamese monkeys. Among these wards, Khanichhap-2, Khanichhap-9, Darlamdanda-2 and Darlamdanda-6 of Palpa and Malunga Tunibot-6 of Syangja were found the most affected areas by the monkeys. According to 33 respondents of Darlamdanda-2, the total crop loss was 18.98 quintals. Loss of crop at Darlamdanda-6 with 25 respondents was 31.15 quintals. In Khanichhap-2, it was 1.97 quintals responded by 8 people. Damage of crop at Khanichhap-2 was 2.3 quintals and it was 2.2 quintals at Khanichhap-9.

In Malunga Tunibot-6, the total crop loss was recorded 42.04 quintals responded by 29 people. Raj Kumar Shrestha, a local farmer, was the most suffering farmer with 11.4 quintals crop loss by the monkeys in which loss of maize, wheat, millet, fruits, lentil, broad beans and mustard were 5.4, 1.8, 1.8, 0.6, 0.3, 0.3 and 1.2 quintals respectively. This may be due to the proximity of crop field to nearest forest is less than 100 m.

Table 27: Villagewise crop damage in quintal by Assamese monkeys in KRB

SN	Name of village	Quintals
1.	Darlamdanda-Ramdi village	18.98
2.	Sunadi village	31.15
3.	Khanichhap-Ramdi village	1.97
4.	Bardanda village	2.3
5.	Padhari village	2.2
6.	Syangja Ramdi village	42.04

Among the crops, *Zea mays* (47.14%) was recorded the highest crop loss followed by fruits (16.43%), *Triticum aestivum* (11.13%), *Pennisetum glaucum* (5.72%), *Oryza sativa* (4.58%), *Solanum tuberosum* (4.27%), *Lens culinaris* (4.07%), *Brassica nigra* (1.26%), *Cucurbita pepo* (1.14%), brown lentil (0.81%), *Vicia faba* (0.8%), sesham (0.6%), *Vigna mungo* (0.35%), cauliflower (0.14%) and *Solanum lycopersicum* (0.1%) (Fig. 34).

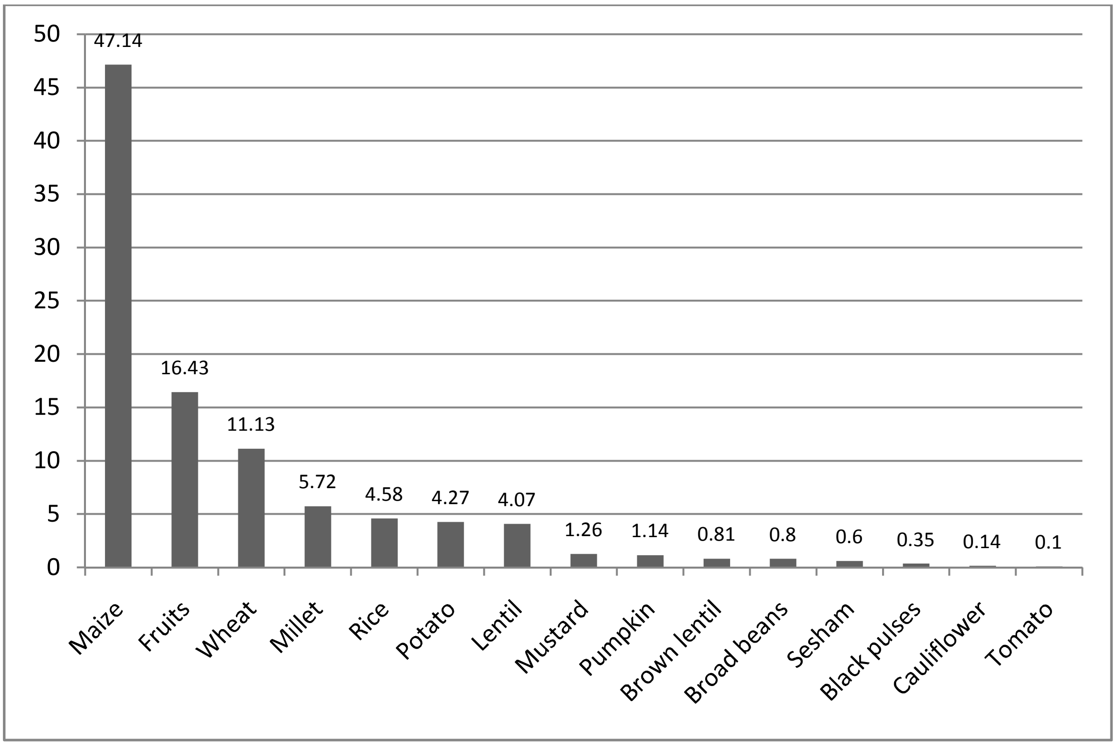

Figure 34: Percentage of crop raid by Assamese monkeys in KRB villages

In KRB villages, 13.8 hectares area was recorded affected by the monkeys. Total crop yield was expected to be 327.75 quintals but only 229.23 quintals yield was observed. This shows 98.52 quintals loss of crops by the monkeys. Loss of crops in quintal is mentioned below (Table 28).

Table 28: Individual crop loss in quintal by Assamese monkeys in KRB

SN	Crops	Quintals	SN	Crops	Quintals
1	Maize	46.45	9	Pumpkin	1.13
2	Fruits	16.19	10	Brown lentil	0.8
3	Wheat	10.97	11	Broad beans	0.79
4	Millet	5.64	12	Sesham	0.6
5	Rice	4.52	13	Black pulses	0.35
6	Potato	4.21	14	Cauliflower	0.14
7	Lentil	4.01	15	Tomato	0.1
8	Mustard	1.25			

4.1.5.2 Crop raiding in Budhigandaki river basin villages

The villages (Kalleri, Ratmate, Tarebhir, Chalise, Basanta, Kostar and Jharlanditar) of Salang VDC of Dhading and Baseri and Majhitar villages of Ghyalchok VDC of Gorkha were recorded affected by Assamese monkeys. Among these, Baseri, Majhitar and Kalleri were found the most affected villages. According to 23 respondents of Kalleri, 54.6 quintals of crop loss was recorded. Kashi Ram Darlami, a local farmer, was suffered by highest crop loss (6 quintals) by the monkeys. The proximity between crop field and nearest forest was about 200 m. In Ratmate, it was 4.5 quintals loss responded by 2 people. 9.6 quintals damage was at Tarebhir by 3 respondents. 2 people responded 1.5 quintals damage at Chalise village. Basanta, Kostar and Jharlanditar villages were recorded 4.8, 5.7 and 0.9 quintals crop damage respectively.

Baseri village was recorded 70.5 quintals crop loss according to 25 respondents. Sabitri Gurung's crop field was highest loss with 7.5 quintals. This may be due to the proximity of crop land to the nearest forest was about 100 m. Crop loss in Majhitar village was recorded 82.04 quintals responded by 42 people. Two local farmers namely Resham Lal Shrestha and Bir Bahadur Gurung experienced highest crop loss (5.4 quintals each) in Majhitar village. The reason may be the proximity of crop land to the nearest forest was less than 100 m.

Table 29: Villagewise crop damage in quintal by Assamese monkeys in BRB

SN	Name of village	Quintals
1	Kalleri village	54.6
2	Ratmate village	4.5
3	Tarebhir village	9.6
4	Chalise village	1.5
5	Basanta village	4.8
6	Kostar village	5.7
7	Jharlanditar village	0.9
8	Baseri village	70.5
9	Majhitar village	82.04

Among the crops, *Zea mays* (58.43%) was recorded the highest crop damage followed by *Oryza sativa* (11.34%), *Lens culinaris* (8.74%), *Arachis hypogaea* (4.35%), *Glycine max* (4.18%), *Triticum aestivum* (3.22%), fruits (2.97%), *Vigna mungo* (1.87%), *Solanum tuberosum* (1.67%), sesham (0.92%), *Solanum lycopersicum* (0.79%), *Pennisetum glaucum* (0.67%), *Brassica nigra* (0.36%), *Vicia faba* (0.25%), brown lentil (0.18%) and *Cucurbita pepo* (0.06%) (Fig. 35).

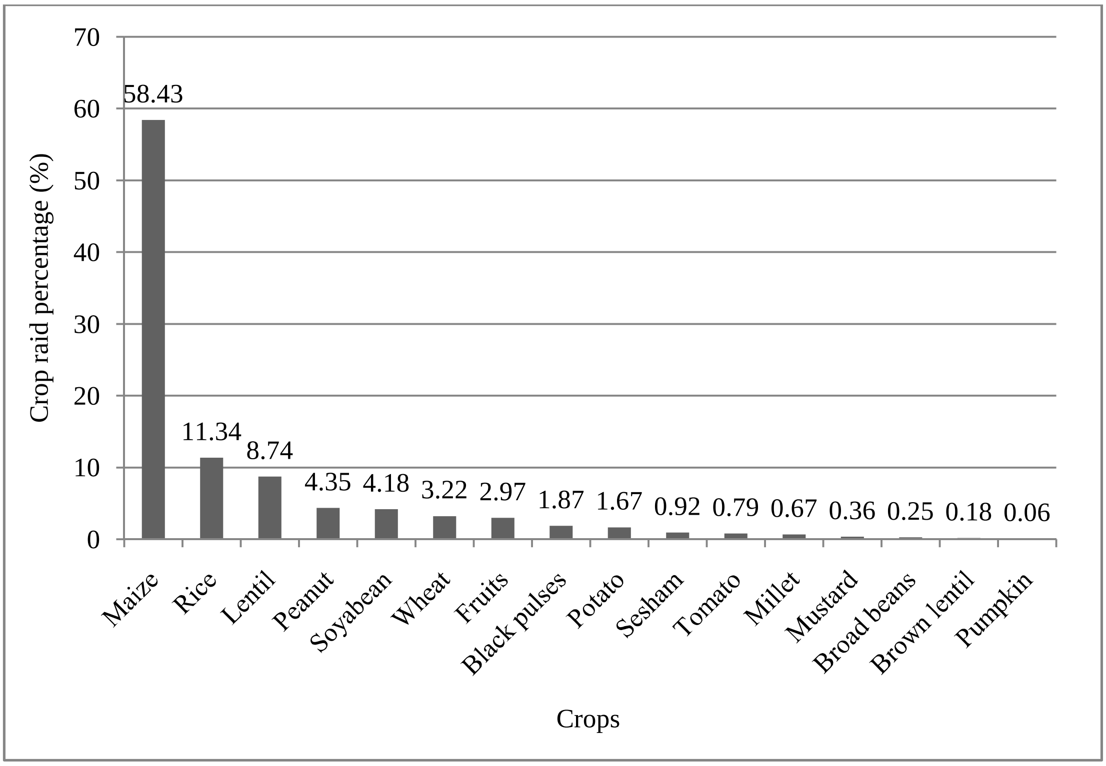

Figure 35: Percentage of crop raid by Assamese monkeys in BRB villages

In BRB villages, 32.21 hectares area was recorded affected by monkeys. The expected total crop yield was 951.15 quintals but 717.01 quintals was recorded yield. This shows 234.14 quintals crop damaged. Damage of crops in quintal is mentioned below (Table 30).

Table 30: Individual crop loss in quintal by Assamese monkeys in BRB

SN	Crops	Quintals	SN	Crops	Quintals
1	Maize	136.81	9	Potato	3.91
2	Rice	26.55	10	Sesham	2.15
3	Lentil	20.46	11	Tomato	1.85
4	Peanut	10.19	12	Millet	1.56
5	Soyabean	9.80	13	Mustard	0.84
6	Wheat	7.54	14	Broad beans	0.58
7	Fruits	6.95	15	Brown lentil	0.42
8	Black pulses	4.38	16	Pumpkin	0.15

4.2 Discussion

4.2.1 Population status and distribution

In this study, Assamese monkeys in KRB (Ramdi to Ranimahal) and BRB (Benighat to Arughat) was found to be distributed in five different blocks (two blocks for

Kaligandaki and three blocks for Budhigandaki). A total of 85 individuals in five different troops were recorded in which 24, 18, 16, 13 and 14 from Palpa (Palpa troop), Syangja (Syangja troop), Dhading (Rigdikhola troop), Gorkha (Rockybhir troop) and also Gorkha (Siurenitar troop) respectively. However, Chalise *et al*. (2013) had recorded 166 individuals of Assamese monkeys with 7 troops in SNNP; troop size recorded was 15 from Rholche/Cha-gaun, 12 from Mahabhir, 27 from Alchhe/Sikrekhola, 29 from Sinche, 35 from Fulbari gate, 31 from Raniban and 17 from Sanagaun-Mudkhu. This shows higher in number and population due to being this SNNP as protected area whereas KRB and BRB are situated outside the protected areas. Paudel and Chalise (2018) had recorded the population of Assamese monkeys in Baglung and Parbat of KRB with four troops in 4 different blocks having 47 individuals in which 16, 15, 13 and 3 from Aduwari, Pang, Dhairing and Balewa respectively. This is similar to present study because of similar type of geology in these areas. Adhikari *et al*. (2018) had recorded the population of Assamese monkeys at Ramdi of KRB having total 48 individuals with two different troops; 27 (Palpa troop-A) and 21 (Syangja troop-B). This is similar to present study of KRB.

Ross and Reeve (2003) reported that wild primate population typically involves a considerable investment of time and resource. These investing resources may not be enough for primate survey in mountainous topography. Chalise (2000) recorded 7 troops of Assamese monkeys in MBCA in 1997 with 7-50 group size and 1:2.03 was of adult male to female ratio. In 1998 in same area, he recorded 1:1.9 adult male to female ratio with 13-27 group size in 4 different troops. Southwick *et al*. (1964) recorded two Rhesus troops in Bengal with 10-25 group size and 1:1.7 was of adult male to female ratio. Regmi and Kandel (2008) reported 9 troops of Assamese monkeys in LNP with 13-23 troop size and 1:1.92 was of adult male to female ratio. Adhikari (2013) recorded 3 Assamese troops in Lamjung with 13-25 group size and 1:2.14 was of adult male to female ratio. Paudel and Chalise (2018) reported 4 troops of Assamese monkeys with 3-16 troop size in Baglung and Parbat, KRB VDCs and 1:0.81 was of adult male to female ratio. Whereas the present study recorded five Assamese monkey troops (two in KRB and three in BRB) and observed troop size varies from 13-24 individuals similar to Chalise (1998), Southwick *et al*. (1964), Regmi and Kandel (2008) and Adhikari (2013).

The adult male to female sex ratio of Assamese monkey troops observed in this study was 1:1.83 (6 males and 11 females) for KRB and it was 1:1.5 (8 males and 12 females) for BRB. This shows the adult sex ratio of present study Kaligandaki (1:1.83) is similar to Southwick *et al*. (1964), Chalise (1998) and Regmi and Kandel (2008) while the adult sex ratio of present study Budhigandaki (1:1.5) is slightly variable to that of the above stated ratios. Both the adult sex ratios (Kaligandaki 1:1.83 and Budhigandaki 1:1.5) of present study are apparently not similar to that of Chalise (1997), Adhikari (2013), and Paudel and Chalise (2018). The reason is macaques live in multi-male, female-kin bonded groups and male to female ratio ranges from 1:2.2 *Macaca radiate* to 1:9 *Macaca nemestriana* (Feeroz, 1996), so *Macaca assamensis* also prefer same like as other macaques. Hanya *et al*. (2003) recorded 1.43 group/km^2 and 0.737 group/km^2 group densities of Japanese macaques in disturbed and undisturbed area in Yakusima, Japan. Regmi and Kandel (2008) recorded 0.0790 group/km^2 group density of Assamese macaques in LNP. Paudel and Chalise (2018) recorded Assamese macaque group density 0.016 group/km^2 in Baglung and Parbat while in this study the group density of Assamese macaques was 0.025 group/km^2 for KRB and 0.015 group/km^2 for BRB. Hanya *et al*. (2003) calculated population density 22.9 and 11.8 individuals/km^2 in disturbed and undisturbed area respectively in Yakusima, Japan with 16 mean group size. Regmi and Kandel (2008) calculated Assamese macaque population density 1.8691 individuals/km^2 with 23.66 mean group size. Adhikari (2013) recorded 0.28 individuals/km^2 population density of Assamese macaques with 17.66 mean group size in Lamjung. Paudel and Chalise (2018) recorded 0.44 individuals/km^2 population density of Assamese macaques with 11.75 mean group size in Parbat and Baglung while in this study, Assamese monkey population density was 0.52 individuals/km^2 with 21 mean group size for KRB and 0.22 individuals/km^2 with 14.33 mean group size for BRB. The variation in density of macaques may be due to the lack of proper rules, regulation and effective implemention by government to protect the population of macaques.

Ale (2010), using line transect method, recorded 4.65 langurs/km^2 population density of Highland langurs in LNP. Wangchuk (1995) reported 2.1 langurs/km^2 population density of golden langurs. Paudel and Chalise (2018) recorded the population density of Assamese macaques in Parbat and Baglung site with 0.44 individuals/km^2, but in this study, the population density of Assamese macaques was 0.52 individuals/km^2 in

KRB and 0.22 individuals/km^2 in BRB. Several studies show that human interference and environmental constrains may affect composition of group and group size of the macaques (Machairas *et al*., 2003). Newly constructed Kaligandaki corridor and road constructed along the BRB as well as Budhigandaki hydroelectric project disturbed the Assamese macaque population. Furthermore, human interference and low food resources may affect group size of macaques.

4.2.2 Habitat analysis

Habitat is an essential component for the animals where they live, eat food, and perform their behavioral activities. Different quadrate plots and vegetation analysis revealed that the Assamese monkeys of KRB and BRB inhabited in sub-tropical deciduous riverine forest with rocky cliffs habitat. In this study, the botanical quadrate sampling (20 m × 20 m) taken in different altitudinal areas of KRB forest revealed that *Trichilia connaroides* was the dominant tree species in the forest. This species was followed by *Schima wallichii*, *Aegle marmelos, Ficus hispida* and others. But in BRB forest, *Shorea robusta* was found the dominant tree species in the forest. This species was followed by *Adina cardifolia*, *Lagerstroemia parviflora*, *Spondias pinnata*, *Terminalia alata, Phyllanthus emblica*, *Mallotus philippensis* and others. 37 tree species with 748 numbers were in KRB forest and 34 tree species with 756 numbers were in BRB forest. This study revealed that *Trichilia connaroides* as the dominant tree species with 35.68% relative density and 8.38% relative frequency in KRB forest while *Shorea robusta* as the dominant tree species with 29.75% relative density and 8.87% relative frequency in BRB forest. Similar to this present study result was found in Paudel and Chalise (2017) that the quadrate size of 20 m × 20 m in which 58 plant species with 716 number were recorded at Baglung and Parbat KRB and the dominant plant species was *Shorea robusta* with 31.42% relative density and 8.37% relative frequency followed by *Diospyros malabarica* with 10.93% relative density and 8.37% relative frequency. Aryal and Chalise (2013) recorded from Arkhale and Nayagaun Gulmi through 8 quadrates of size 25 m × 25 m quadrate sampling, 23 plant species with 191 number were recorded and the dominant plant species was *Pinus ruxberghii* with 30.89% relative density and 13.04% relative frequency followed by *Schima wallichi* with 8.34% relative density and 10.87% relative frequency. Rijal (2014) also laid down 8 quadrates of size 25 m × 25 m at

Nagarjun forest of SNNP by quadrate sampling, 27 plant species with 196 number were recorded and the dominant plant species was *Schima wallichi* with 30.89% relative density followed by *Machilus duthiei* with 8.98% relative density and *Castanopsis tribuloides* with 10.87% relative frequency. This indicates that the different topographical and altitudinal variations cause the change in vegetation pattern.

Assamese monkeys' sleeping sites in Nepal are typically rocky cliffs along hill evergreen forest (Chalise, 2003). Mitra (2002) reported that the species preferred the rocky terrain and hill slopes in West Bengal, India. Raman *et al*. (1995) recorded seven of eight sightings in Mizoram, India, were along cliffs with primary vegetation and other was also close to the cliff face. Choudhury (2008) reported the rocky cliffs with sparse vegetation as an apparently minor habitat in Bhutan. In western Thailand, field contacts with the species were in forest by or on rocky mountains (Eudey, 1991). Fooden (1986) traced no information on such sites and speculated that the species would be found to sleep in trees. They slept in protruding crags or the large trees in Huay Kha Khaeng Wildlife Sanctuary (Eudey, 1991). However, the subsequent information from different countries shows the use of cliffs by the macaques as their sleeping sites. In present study, in both the KRB and BRB, sleeping sites of the Assamese monkeys during night time were found on rocky cliffs and rocky outcrops in steep as well as slope areas of the river basin rocks. The colour of the rocks in both the river system resembled with the Assamese monkeys' body colour. This might be the adaptation of the Assamese monkeys with the habitat environment. Cliffs might serve as sleeping sites for the monkeys. Assamese macaques may require steep cliffs at lower altitudes (KRB and BRB rocks), but they do not require at higher altitudes as in Nagarjun troops of SNNP, Nepal where they sleep on the trees.

4.2.3 Behavior

Behavior is the response of both the physical as well as habitat condition of animals (Sarkar, 2000). It may vary from habitat to habitat depending upon the resource distribution. Food, drink, mates and roosting trees are the most important resources for primates which control their activities. Among these resources, food seems to be the most crucial primary factor which regulates day-to-day activity profiles (Sarkar *et al*., 2012). During this study period, five troops of Assamese macaques were recorded in pre-designed four blocks of KRB and BRB VDCs. Four major behaviors were recorded in both the study field during the study period in which feeding was 41.16%, resting 27.63%, moving 17.72% and grooming 13.49% in KRB and feeding was 44.36%, resting 24.78%, moving 16.58% and grooming 14.28% in BRB whereas Bhattarai (2002) recorded eating 29.20%, sitting 33%, walking 28.20%, grooming 6.40%, mating 1.1%, aggresion 0.71% and playing 0.40% in LNP; Chalise (2003) had recorded 44% in foraging, 25% in moving, 18% in resting and 13% in grooming in MBCA; Chalise *et al*. (2005) recorded foraging 43.4%, moving 31.7%, sitting 18.5%, grooming 3.4% and stone licking 1.7% in LNP; Chalise *et al*. (2013) studied a habituated Assamese monkey troop in SNNP and found 46% of the diurnal time invested in foraging/eating, 19% in resting, 16% in locomotion, 12% in sleeping, 6% in grooming and 1% in playing; Adhikari and Chalise (2014) recorded foraging 45%, locomotion 25%, resting 20% and grooming 10% in Lamjung; Pandey and Chalise (2015) recorded 39.53% time in foraging/eating, 21.46% time in locomotion, 16.51% time in grooming while 14.95% time inactive, 6.11% time in sleeping and 1.43% time in playing in SNNP; Paudel and Chalise (2017) recorded foraging 47.25%, moving 27.25%, resting 14% and grooming 11.50% in Baglung and Parbat of KRB and Adhikari *et al*. (2018) recorded foraging/feeding 41.10%, resting 30.24%, moving 4.65% and grooming 23.99% in Palpa side of Ramdi. These all results are more or less similar to the present study but in constrast to this, Zhou *et al*. (2007) reported an average of 39.6% of time spent in resting, 33.2% in moving, 18.3% in feeding, 7.5% in social behavior and 1.4% in other behaviors. They further reported the significant seasonal variations in time investment with the increase in time investment on feeding during dry season than in rainy season. It is obvious that in natural habitat they should invest much more time to acquire food than to spend in other social activities (Chalise *et al*., 2005). The differences in behavioral activities may be due to different season, food resources availability and day length as well.

Food plant availability and its distribution primarily determines the time spend on locomotion of macaques (Sarkar, 2000). Assamese macaques spent 17.72% (Kaligandaki) and 16.58% (Budhigandaki) time for locomotion which seems near with Sarkar *et al*. (2012) in forest group of Assamese macaque in Jokai Reserved Forest of Assam as 25% time (range 23-26) for locomotion. Similarly, Chalise (2000a) recorded four major behaviors in MBNP taking geophagy into separate account and found 3 to 4% difference in case of feeding in his study (1997/98) invested 29/25%. This study shows 41.16% (Kaligandaki) and 44.36% (Budhigandaki) time spent on feeding while Sarkar *et al*. (2012) reported 40% time (range 38-45) on feeding. Chalise (2000) recorded 47/44% which is 3 to 4% difference in case of feeding in his study (1997 to 1998) in MBNP. Adhikari and Chalise (2014) recorded in four different seasons as 47%, 45%, 44% and 43% time spent on feeding in winter, pre-monsoon, monsoon and post monsoon respectively with 4% difference.

Animals have to maintain their time spent on locomotion and resting in order to make a balance of energy demand and supply. Hence the Assamese macaques spent 27.63% (Kaligandaki) and 24.78% (Budhigandaki) time in resting whereas different time spent was reported by Sarkar *et al*. (2012) for resting 13% (range 7-20). Similarly, Adhikari and Chalise (2014) reported 20% time for resting in Lamjung while Pandey and Chalise (2015) recorded 14.95% time for resting in SNNP.

Grooming behavior reduces social tension in long term (Schino *et al*., 1988) and establishes a social bonding among individuals within the group (Kurland, 1977). Assamese macaques in this study spent 13.49% (Kaligandaki) and 14.28% (Budhigandaki) time on grooming. Chopra (1992) reported 14% in grooming by Rhesus macaque which is similar to present study, but in constrast to this, Bhattarai (2002) recorded grooming 6.40%, Chalise (2003) recorded grooming 13% similar to present study, Chalise *et al*. (2005) recorded grooming 3.4%, Chalise (2013) reported grooming 6%, Adhikari and Chalise (2014) recorded 10% grooming, Pandey and Chalise (2015) reported 16.51% grooming, Paudel and Chalise (2017) recorded grooming 11.50%, Adhikari *et al*. (2018) reported grooming 23.99% which shows higher than present study while Zhou *et al*. (2007) reported grooming 7.5% that shows lower than present study. Hence, lacks of extra social tension in the Assamese macaques due to its less size reduce the time spend on grooming and vice versa.

The higher percentage of feeding time spent during the study period in both the research sites (KRB and BRB) was may be due to lack of sufficient food on the habitats. Due to newly born Kaligandaki corridor and road constructed alongside the Budhigandaki river as well as Budhigandaki hydroelectric project, the habitats of Assamese macaques are divided into several fragments so the macaques also spent more time for searching their own food in the forest.

4.2.3.1 Feeding behavior

Several studies have revealed that there is dietary variation among primates (Campbell *et al*., 2007; Yeager & Kool, 2000). Macaque species have been described as primarily frugivorous (Caldecott, 1986; Yeager, 1996; O'brien & Kinnaird, 1997; Andrews, 2003; Riley, 2007). O'brien and Kinnaird (1997) recorded that crested black macaques (*Macaca nigra*) spent 66% of feeding time on fruits. A study of tonkean macaques (*Macaca tonkeana*) in Sulawesi, Indonesia, showed that fruits accounted for 76.7%-84.4% of their diets (Riley, 2007). These results are higher than the present study of Assamese macaques (*Macaca assamensis*) feeding time spent on fruits (Kaligandaki 23.80% and Budhigandaki 25.96%). The time investment on fruits of present study is similar with report from the diet of Assamese macaques consuming fruit 23% in Bangladesh (Ahsan, 1994) and close to fruit accounted for 17.4% of the diet of Assamese macaque in limestone habitats of Nonggang, China (Zhou *et al*., 2011). However, evidence is steadily accumulating that leaves contribute a large proportion of diet in some species (Zhao, 1996; Hanya, 2004). For example, Japanese macaques (*Macaca fuscata*) in the coniferous forest of Yakushima spent 45% of feeding time on leaves, and feeding time on fruits was only 13% (Hanya, 2004) similar to the present study on leaves (mature and young) eating time spent 49.58% in KRB forest and 49.74% in BRB forest but different on fruit eating time. The present study result also supports 46% time spent on leaves by Assamese macaques in Bangladesh (Ahsan, 1994) as compared to the higher time spent on leaves accounted for 77.4% of total feeding records by Assamese macaques at Nonggang Nature Reserve of China (Zhou *et al*., 2011). Even within a species and population, considerable dietary variation in terms of plant species and parts eaten may occur (Hanya *et al*., 2003; Harris & Chapman, 2007). For example, Hanya *et al*. (2003) found variation in diet amongst Japanese macaques inhabiting different altitudinal zones. Much of these differences can largely be explained as differences in the temporal availability and spatial distribution of fruit resources (Hanya *et al*., 2003; Hanya, 2004).

Assamese macaques in Kaligandaki and Budhigandaki invested majority (>40% in average) of their diurnal time on feeding (Ghimire *et al*., 2021). They spent more than half of the diurnal time on feeding and foraging during the winter months (December-February) when resources were limited in cold and dry periods. There appears to have a strong seasonality in food resources availability in the area and macaques show plasticity in food items selection according to their availability. Similar to these findings, Assamese macaques of Nonggang Nature Reserve, China devoted more time on feeding and less time on resting and grooming in the dry season (Zhou *et al*., 2007). Monkeys use low quality of foods such as mature leaves for feeding, when high-quality of foods like fruits and young leaves are scarce (Zhou *et al*., 2006).

Kaligandaki and Budhigandaki Assamese macaques depicted food specialist nature showing their higher dependence to the less dominant food plants of the habitat. The dominant plants of the habitat were not always the first choice of food for Assamese macaques. The habitat of the Kaligandaki Assamese macaques was dominated by the plant species such as *Trichilia connaroides*, *Schima wallichii*, *Aegle marmelos*, etc., however, the most consumed plant parts were from relatively less abundant *Albizzia chinensis*. The Budhigandaki Assamese macaques inhabit the area of higher abundance of *Shorea robusta*, *Adina cordifolia*, *Lagerstroemia parviflora,* etc. and the species third in the rank was the most preferred food-plant. Leaves appeared major bulk in the diet of Assamese macaques among different plant parts. Assamese macaques are primarily dependent upon leaves, fruits and seeds though described as omnivorous (Boonaratana *et al*., 2020).

Assamese macaques are more folivorous in dry season and more frugivorous in wet season. This indicates that they are able to modify their diet seasonally. They shift their preference for major food items seasonally. Availability of food is not even over the year in highly seasonal habitats, so species cannot rely entirely on preferred foods. They use less preferred fallback foods in their diet during a certain period of the year (Marshall & Wrangham, 2007). This shows omnivorous species tune their feeding patterns according to the availability of seasonal resources. Furthermore, climate change is predicted to have significant effects on plant phenology and vegetation structure (Chapman *et al*., 2005). Fruit production pattern seasonally becomes sometimes more important in determining the diet of primates (Dunn *et al*., 2010). Seasonal variation in diet of Assamese macaques was clearly linked to the seasonal fluctuation in availability of food. For example, the consumption of mature leaves was dropped during the spring season when they relied heavily on young leaves. This type of relationship is widely demonstrated in primates (Overdorff, 1993; Atsalis, 1999;

Simmen *et al*., 2003; Norsica *et al*., 2006). Animals that live in seasonally changing environments concentrate on specific food sources that are available all year round or vary their diet in relation to seasonal changes in availability (Guo *et al*., 2007).

Among primates, the extreme dietary specialization is rare and most species utilize a range of food resources as they become available (Hill, 1997). The composition of diet and feeding behavior are critical factors affecting monkey activity budgets, because of the tradeoffs between acquisition of energy and the metabolic cost of different activities (Altmann, 1974; Milton, 1980; Post, 1981; Oates, 1987; Peres, 1993; Passamani, 1998). In general, animals are thought to diversify food sources when consuming leaves to obtain the best supplement of nutrients (Westoby, 1978) and avoid an overload of particular toxins or digestibility reducing compounds (Freeland & Janzen, 1974). The Assamese macaques were observed to visited more food species when feeding from more leaves during the dry season and are believed to exhibit higher feeding effort. The results of the present study are also consistent with the predictions of optimal foraging theory (MacArthur & Pianka, 1966), as when fruit was reported to be limited, Assamese macaques made adjustment to their diet, consuming more leaves and a greater number of species. Some primates even show pronounced plasticity in feeding pattern. Also, the habitat characteristics are likely to influence the foraging behavior of primates. In the eastern rain forests and littoral forests *Microcebus spp*. are highly frugivorous (Atsalis, 1999; Lahann, 2007), whereas in dry deciduous forests they feed mainly on gum, insect secretions, and arthropods (Hladik *et al*., 1980; Radespiel *et al*., 2006). The plasticity eventually allowed *Microcebus spp*. to co-exist with several other cheirogaleid species in productive site without clear feeding niche separation (Lahann, 2007).

Several plant species still bore flowers even during the wet season although most of the tree species flowered during the dry season. Thus, there were flowers available year-round. The study focal troops of Assamese macaques in both the research sites consumed flowers throughout the study period. Unripe fruit available mainly from January that got ripen at the beginning of the wet season after the first heavy rain in May. Thus, ripe fruits were maximally available during the rainy season. Despite non-significant variation on time spending on fruits between dry and wet seasons, time devoted in feeding fruit was highest in July (Kaligandaki 49.14% and Budhigandaki

47.12%). Though fruits were available year-round, they were suitable food source for Assamese macaques. Fruits, particularly mature fruits, are richer in sugar and more rapidly converted into energy than leaves (Richard, 1985). Some fruits that were available during the day season have hard outer layers and are fibrous with no or only very little flesh and are thus either not accessible or might not provide enough usable energy for Assamese macaques. The consumption of ripe fruit is seasonally dependent, eaten more in the wet season, although the composition of unripe fruit remains relatively similar across the year. Though young leaves are consumed throughout the study period, the proportion of young leaves increases throughout the dry season and the mature leaves being eaten only during the dry season may compensate nutritionally for the lack of available ripe fruits in the dry season. Howler monkeys were also reported to maximize fruit intake when it is available and that when fruit is scarce they switch to a diet consisting almost entirely of leaves (Milton, 1980; Glander, 1981; Estrada, 1984; Silver *et al*., 1998).

Food abundance and climatic factors can significantly affect the behavior of animals and constrain their activity budgets. The population of western black crested gibbons (*Nomascus concolor*) in Mt. Wuliang lives in montane forest and is close to the northern extreme of the distribution for gibbons (Hylobatidae). Their habitats show remarkable seasonal variation in terms of food availability, temperature, and rainfall (Ning *et al*., 2019). To understand behavioral adaptations of western black crested gibbons to different sets of ecological conditions, Ning *et al*. (2019) examined relationships among food availability, mean temperature, rainfall, and behavior patterns by observing two groups for one year each. Their results revealed that activity budget was affected by food availability and mean temperature. The gibbons spent more time eating flowers when that resource was more available and spent less time moving when fruit was more available. The gibbons spent less time feeding and more time resting, and spent less feeding time on fruit and leaves when the mean temperature was lower. These results suggest that the gibbons displayed a pronounced preference for flowers as a food resource and adopted a time minimizer strategy when high-nutrient food items (i.e., fruit) were more available. In addition, the gibbons adopted an energy-conserving strategy during periods of low temperature. The flexibility of behavioral patterns in responding to food availability and temperature may potentially improve the gibbons' prospects of surviving and reproducing in a northern montane forest (Ning *et al*., 2019).

Although my study sites are located in sub-tropical broad-leaf riverine forest area, fruit consumption of Assamese macaques at KRB and BRB is much lower than tropical macaques such as *Macaca fascicularis*: 66.7% (Yeager, 1996), *M. nigra*: 66% (O'brien & Kinnaird, 1997), *M. brunnescens*: 90.4% (Andrews, 2003), and *M. tonkeana*: 76.7-84.4% (Riley, 2007), and more similar to sub-tropical species *M. assamensis*: 17.4% (Zhou *et al*., 2011) and temperate species such as *M. fuscata yakui*: 13% (Hanya, 2004) and *M. mulatta*: 9% (Goldstein & Richard, 1989). The difference is, at least partly, explained by the seasonal scarcity of fruit in Kaligandaki and Budhigandaki habitats. Many studies have shown a strong correlation between rainfall and fruit production, and that little fruit is available in the dry season (Li & Rogers, 2006; Zhou *et al*., 2006). Thus, it seems that the lean period when fruit is uncommon is longer in this region than in the tropics where fruit is more or less available year round (Yeager, 1996; Riley, 2007). Furthermore, Assamese macaques at Kaligandaki and Budhigandaki spent most maintenance activities on the steep slopes and rocky areas with patchy forest. They frequently forage in open bushy and shrubby lands with low fruit availability (Chalise *et al*., 2013). This further decreases fruit availability for Assamese macaques.

Assamese macaques have an enlarged caecum and colon as the primary fermentation chamber, which enhances their digestive abilities to digest large amounts of fiber-rich foods (Lambert, 1998; Hanya, 2004). This physiological fact suggests that Assamese macaques may have an ability to digest large amounts of fiber-rich food such as mature leaves, young leaves, bark, petiole, leafbud, etc. Compared with mature leaves, young leaves are preferred foods for primates because they have higher nutritional quality such as for protein and are lower in fiber and secondary compounds (Richard, 1985). Although the availability of young leaves decreased markedly from October to January, a high level of young leaves was maintained in the diet of Assamese macaques almost year-round.

Forest fragmentation and isolation can reduce the size of available habitat and lead to lower food availability for some primate species. The persistence of nonhuman primates in fragments depends largely on their ability to adjust their diet in response environmental change. The western black crested gibbon (*Nomascus concolor*) is distributed in northern Vietnam, northwestern Laos, and southwestern China, but little is known about its diet except from studies in the well-protected forests of Mt.

Wuliang and Mt. Ailao, central Yunnan (Ni *et al*., 2014). Ni *et al*. (2014) studied food abundance and diet over two years in a small group surviving in an isolated and disturbed forest at Bajiaohe, southern Yunnan, and drew a comparison with the population at Dazhaizi in Mt. Wuliang and found that gibbons at Bajiaohe consumed mostly fruit, but did not eat figs, unlike most other gibbon populations. Liana fruits and mature leaves were used as alternative foods during periods of tree fruit scarcity. Their results indicate that gibbons in Bajiaohe respond to habitat fragmentation and isolation by consuming a variety of plant species, depending on those that are locally available, and increasing time spent feeding on fruits of trees and lianas rather than increasing time spent consuming leaves.

A great flexibility in dietary foods may permit primates to live in a variety of habitats. When high-quality food such as fruit is scarce, primates can use fiber-rich foods as fallback foods (Marshall & Wrangham, 2007). Accumulated evidence shows the folivory of *Macaca* species (e.g. Zhao, 1996; Hanya, 2004) is originally frugivorous. This dietary flexibility according to habitat may be one of reasons why the genus *Macaca* is more widely distributed than any other nonhuman primate genus. For example, Japanese macaques can use a large amount of mature leaves in response to long-term seasonal reduction in fruit in temperate regions (Hanya, 2004). Similarly, there is a long lean period when fruit is uncommon in KRB and BRB habitats. Monkeys may also need to develop the ability to cope with fiber-rich food so as to survive in such environments. Although physiological investigation is needed, the fact that Assamese macaques rely heavily on leaves as fallback foods suggests an adaptation that has allowed Assamese macaques to survive in KRB and BRB habitats.

In KRB, 41.16% of the observation time was devoted to feeding (maximum 56.34% in January and minimum 24.45% in August) and it was 44.36% of the observation time on feeding (maximum 58.18% in January and minimum 25.92% in August) in BRB by the Assamese monkeys. In contrast to this result, Chalise (1995) found in Ramnagar, 32.27% of the observation time devoted to feeding (maximum 46% in January and February, minimum 16.55% in August) by the adult langurs and Podzuweit (1994) studied the same troop of langurs in the same area during 1991-92 and she recorded 32.90% of feeding time for adult female langurs annually. This difference with the present study is that in hilly regions there are low amount of food availability as compared to Terai region and Assamese monkeys also spend more time for searching the food in hilly regions. However, the time spent for each food category was determined for Kaligandaki and Budhigandaki Assamese monkeys. They spent different amount of time for different food according to their preference. The major food categories revealed that most of the time is spent on leaves, 49.58% (30.02% mature leaves and 19.56% young leaves) in KRB forest and 49.74% (29.04% mature leaves and 20.70% young leaves) in BRB forest. This is similar to Podzuweit (1994) data of time spent on leaves (49.02%) and Chalise (1995) data of time spent on leaves (50.11%) by Ramnagar langurs. In present study, the descending orders of time spent on feeding by Assamese monkeys in KRB forest are mature leaves (30.02%), fruits (23.80%), young leaves (19.56%), flowers (12.47%), insects (2.90%), seeds (2.71%), stone licking (2.04%), young shoots (2.0%), water (0.99%), inflorescence (0.95%), rhizome (0.73%), leafbud (0.59%), soil eating (0.55%), petiole (0.36%), waste (0.21%) and bark (0.12%) while in BRB forest are mature leaves (29.04%), fruits (25.96%), young leaves (20.70%), flowers (12.16%), insects (2.43%), seeds (2.07%), young shoots (1.50%), stone licking (1.40%), rhizome (1.02%), water (0.90%), leafbud (0.87%), inflorescence (0.85%), petiole (0.42%), soil eating (0.33%), bark (0.22%) and waste (0.13%). Podzuweit (1994) recorded the time spent on feeding of food categories in descending order as mature leaves (40.57%), fruits (15.10%), petiole and pulvinus (14.92%), young leaves (8.45%), flowers (6.30%), pith (3.80%), stone licking (3.20%), insects (3.10%), honey licking (2.40%), bark (0.60%), wood (0.60%), soil eating (0.50%), algae (0.22%), water (0.20%) and gum (0.04%). On the other hand, Chalise (1995) recorded the time spent on feeding of food categories in descending order as young leaves (21.65%), fruits (17.88%), mature leaves (16.33%), flowers (12.82%), pulvinus (10.52%), seeds (4.03%), insects (3.78%), stone licking (2.74%), honey licking (2.39%), pith (2.27%), shoots (1.74%), petiole (1.62%), soil eating (0.86%), algae (0.84%), water (0.19%), gum (0.13%), bark (0.11%), unknown (0.11%) and waste (0.02%). These results indicate that due to seasonal availability of food plants and different species of monkeys play vital role for the contribution of feeding time spend for each food category.

Ripley (1976) studied grey langurs in SriLanka and the area occupy the lowland mixed deciduous and evergreen forest which experiences a climate that can be characterized roughly as winter-wet, summer-dry. There langurs were spending 77.8% (71.9-83.7) on leaves, 10.4% (7.9-12.5) on fruits and 7.4% on flowers. In this case, only flower eating seems similar whereas for leaves and fruits it was totally different. Hladik (1977) recorded 48% of feeding time on leaves (21% mature leaves and 27% young leaves) for grey langurs of SriLanka. This is similar to the leaf diet at KRB and BRB, and the time spent on flowers in SriLanka (7%) is also similar to Podzuweit, but the time spent on fruits (45% in SriLanka) was astonishingly higher than the present study. The amount of fruit availability in the study sites might have influences to the monkeys feeding time.

Newton (1992) reported 25.7% of the total feeding time for the langurs in Kanha Tiger Reserve, in Central India. The study area consisted of 67.8% moist deciduous forest (dominated by sal), 27.5% meadow and 4.7% dry deciduous forest on the rocky outcrops or 'chattans'. The total time spent on feeding was dissimilar (i.e. shorter) to the present study but on the broad categories of foods: leaf (49.1%), fruit (24.4%), flower (9.50%) and insects (3.0%) it was similar to KRB and BRB. Kar-Gupta and Kumar (1994) from Rajaji National Park, Uttar Pradesh, India, during their five months study, recorded 56.6% of the time for leaf-eating (22.5 mature and 34.1 young) by common langurs which is similar to the result of Podzuweit and the fruit eating (24.9%) is similar to the results of Newton and the present study. Flower eating (17.9%) is near to this study but they were studying during winter i.e. the flowering season only. Thus flower eating might be over represented.

Curtin (1982) did a 16 months study on foraging and ranging among gray langurs (*Presbytis entellus*) in the Nepal Himalaya, a forest type occurred according to Stainton's (1972): *Rhododendron arboreum*, *Abier spectabilis*, *Tsuga dumosa*, upper temperate mixed broad leaf, *Quercus semecarpifolia* and *Pinus excelsa*. Meadow and cultivation comprised additional habitat types. The time spent on leaves (45%; 31% mature and 14% young) was near to the results of this study and the amount of time for fruits (47%) was extremely higher than the present study.

The dietary variation of food categories might be possible. The most variable intake of the Assamese monkeys corresponds to a seasonally variable availability. The more contrasted annual food cycle of this more active species requires an important, investment in energy which in turn, is provided by the more scattered and rich food resources. "Variation in food supply may have an important effect on different physiological mechanism, as was clearly observed for prosimians and simian primates living in dry tropical climates. In the rain forest, there are also variations in composition and abundance of food availability" (Hladik, 1988).

Daily activity patterns and micro-variations in specific behaviors are important and essential for understanding how primates meet their energetic or nutritional requirements while dealing with environmental change. However, such data regarding the Assamese macaques living in limestone forests has yet to be obtained. The study focused on the daily activity patterns and temporal distribution of feeding behaviors of Assamese macaques at the Nonggang National Nature Reserve in southwest Guangxi, China (Li *et al*., 2019). Animals generally need compensation for the energy deficiency caused by previous night's resting (Chapman & Chapman, 1991). Due to the fact that they are folivorous while still preferred to fruits (Huang *et al*., 2015; Zhou *et al*., 2018), the Assamese macaques in the KRB and BRB forests consumed more fruits during the morning than in the afternoon.

Assamese macaques are mostly folivores, and the time spent on leaf-eating (mature and young) was nearly half (49.58% in Kaligandaki and 49.74% in Budhigandaki) of their total feeding time (Ghimire *et al*., 2021). Similar to these findings, young leaves were staple food items of Assamese macaques in Nonggang, China (Zhou *et al*., 2011; Huang *et al*., 2015). Assamese macaques between Kaligandaki and Budhigandaki did not contribute significant difference in time investment on different food items. However, Koirala *et al*. (2017) reported significant difference of two troops of Assamese macaques in SNNP. Adhikari *et al*. (2018) also reported significant alteration in behavior of Assamese macaques in Ramdi of Palpa. Both the troops of this study are in a similar ecological set up of deciduous rainforest and also have highly similar food plant preferences, that might have caused almost similar investment of time on feeding and food selection.

Besides leaves, the invested time on fruits, flowers and seeds were also high. This shows that Assamese macaques prefer to avoid leaves (especially mature) when other more nutritive foods are available. Schulke *et al*. (2011) reported larger time investment on fruits (42.4%) in Thailand. Assamese macaques in Nonggang, China, invested less than 20% time on feeding fruits, suggesting their folivorous habits (Zhou *et al*., 2011; Huang *et al*., 2015). During dry season, some primates eat barks when the least amount of food is available (Sugiyama, 1964). Bark is considered as the leading importance in diet of Bornean orangutans when major fruits were not available (Nishida, 1976). Bark eating in this study was recorded in Assamese macaques when availability of fruits and young leaves was less. It shows that Assamese macaques use bark for feeding when the other food items are less available.

The carbohydrates, vitamins and trace elements needed are supplied by young leaves, fruits and flowers. Extra nutrients they can derive from other food categories. “The common langurs eat bark during the dry season when least amount of food is available through the year. Bark also provides food with water in this season (Sugiyama, 1964). Japanese monkeys (*Macaca fuscata*) utilized bark for food in winter and early spring when few fruit is available (Iwano, 1973). Among great apes, gorillas and orangutans are known to chew bark through the year. Bark assumed a leading importance in the diet of Bornean orangutans during some time in a year when major fruits did not ripen” (Nishida, 1976). Bark eating in Kaligandaki Assamese monkeys was recorded in the months of February, May, June, July, September, November, December and January and in Budhigandaki Assamese monkeys it was recorded in the months of February, March, April, June, August, September, October, December and January. It seems that Assamese monkeys like to utilize bark as food in any season whenever other foods are less abundant.

Availability of food in Kaligandaki and Budhigandaki deciduous forests is highly seasonal. The effect of such seasonality on availability of food is reflected in the feeding behavior of Assamese macaques. Distribution of food determines the search strategies and movement patterns of animal which in turn affect the time investment on feeding (Reyna-Hurtado *et al*., 2018). Species that experience large and unpredictable seasonal variation in availability of food tend to grow and reproduce at slower rates than species with more predictable environments (Wright *et al*., 2015). Animals travel less and shorter distances during scarcity of high energy foods but use their home range more broadly (Nagy-Reis & Setz, 2017). Similar to these findings, Assamese macaques in Kaligandaki and Budhigandaki switched between the young leaves and mature leaves according to their availability, but the young leaves were higher preference food.

Availability of food in the forest can vary tremendously from year to year. Especially the fruits and flowers were not available in similar amounts in each year. Furthermore, reduced precipitation or a very hot and dry year the production of reproductive parts is reduced even in a forest like KRB and BRB, and Assamese monkeys depend more on leaves. In dry areas like Jodhpur, India, langurs depend mainly on leaves (43.9%) near to present study. They utilize a large number of plant species which suggest that langurs are not very selective in their diet and consume whatever plant material is available (Srivastava, 1989). Usually in arid areas, plants bear a smaller amount of vegetative and reproductive parts. Therefore, to fulfill their needs they should exploit many plants. “It is also possible that this arid environment has different productivity levels in different months, so that some plant species are available in one month and some in others” (Srivastava, 1989) which would have been reflected in plant numbers.

In Bangladesh, at Madhupur, the capped langurs (*Presbytis pileata*) spent 35% of time per year in feeding (Stanford, 1991a) in which 57.8% of the feeding time was spent on leaves and leafy parts, 24.4% fruits similar to present study, 9.3% seeds, 7.0% flowers, and 1.6% others. The capped langurs at Madhupur live in a moist deciduous forest. The forest vegetation is composed of predominantly sal and other typical east Asian forest genera such as *Adina*, *Dillenia* and *Terminalia*. The food plants of langurs recorded are very similar to present results from Kaligandaki and Budhigandaki. The similarity arises due to the fact that both areas are situated in the same region and within the same climatic zone. In both areas six seasons (major 3) are distinguished and very similar in duration. Both areas have the hot season from March to June, followed by monsoon rains mostly from June to October. November through February are cool and dry. Stanford (1991) stated “Madhupur follows a typical Indian subcontinent monsoon forest phonological pattern (Puri, 1960). Leaf production peaks in the pre-monsoon and early-monsoon (April-May); fruit production peaks bimodally, in mid-monsoon (June-July) and again in mid-winter (November-December). Flowers are most abundant just before (March-April) and just after (October) the rains. From December to March a major leaf fall occurs, producing a predominantly bare forest aspect”.

In East Malaysia, Davies *et al*. (1988) studied *Presbytis rubicunda* at Sepilok Virgin Jungle Reserve, Sabah for 17 months. The study area has a low-lying western part which is flooded by streams in the wettest months, and the eastern area was dominated by steep-sided sand stone ridges that are dry for 6 months of the year. There were however two periods of young leaf production: during the wettest months and during the fruiting season. Flowering showed a small peak in March (5% of the trees), and fruiting was also only 5%. The leaf monkeys were highly selective in their diet, and their food was generally less abundant in the forest. Eventhough in total they spent 36.5% of their feeding time on young leaves, 30.1% on seeds higher than present study, 19.2% on fruits, 11.1% on floral parts, and 1.1% on leafy parts. This monkey species is poorly adapted to a folivorous diet due to its dental structure and a relatively low stomach volume for fermentation digestion of folivorous material. Therefore, they depend mainly on highly digestable food as fruits. Nevertheless, they feed a reasonable amount of leaves per year. This type of different feeding behavior in the monkey species suggests that “environmental factors such as plant chemistry will also influence colobine food selection” (McKey, 1978; Waterman *et al*., 1988). Oates *et al*. (1980) recorded the feeding time for *Presbytis johnii* as 27% on mature leaves, 31% young leaves, 9% flowers, 25% fruits in a primary tropical evergreen high forest of the southern Western Ghat mountains, India. The young leaves were frequently available in this site but the total time spent on leaves was very similar to the results of others. It can be concluded that monkeys mainly depend on the major food categories (leaves, fruits and flowers) for their survival and the amount of time spent for each category is in accordance to the availability.

The study of feeding behavior is essential to the understanding of a species' ecological adaptation to the environment, and it is also an important factor to be considered when examining the relationship between ecology and sociobiological problems. Closely related species often have very different diets, whereas many unrelated species have convergent dietary patterns. Therefore, these patterns are not dependent upon taxonomic relationships (Sussman, 1987). These and other type of complexity of problems on feeding ecology lead the primatologist to study on the basis of activity budget.

In this study, the intake of food was calculated. On average, an adult Assamese monkey of KRB ate 557.94 grams fresh weight and that of BRB ate 525.09 grams fresh weight per statistical day. Therefore, it can be estimated that more than 1 kg (1115.88 gram per day; 365 days = 407.29 kg) biomass is taken from the forest each day by an individual adult Assamese monkey in KRB and in BRB it is also more than 1 kg (1050.18 gram per day; 365 days = 383.31 kg) biomass is taken from the forest each day by an individual adult Assamese monkey. These results are similar to Chalise (1995) Ramnagar adult langur that ate 542.84 grams fresh weight per statistical day (1085.68 gram per day; 365 days = 396.27 kg biomass). In KRB forest, mean intake leaves contribute 47.07% gram (mature leaves 26.67% gram and young leaves 20.40% gram), fruits 27.19% gram, flowers 14.07% gram, seeds 2.94% gram, young shoots 2.88% gram, insects 2.07% gram, rhizome 1.22% gram, inflorescence 1.06% gram, leafbud 0.78% gram, petiole 0.44% gram and bark 0.28% gram, and time spent for leaves was 49.58% (mature leaves 30.02% and young leaves 19.56%), fruits 23.80%, flowers 12.47%, insects 2.90%, seeds 2.71%, stone licking 2.04%, young shoots 2.0%, water 0.99%, inflorescence 0.95%, rhizome 0.73%, leafbud 0.59%, soil eating 0.55%, petiole 0.36%, waste 0.21% and bark 0.12% whereas in BRB forest, mean intake leaves contribute 48.30% gram (mature leaves 26.34% gram and young leaves 21.96% gram), fruits 29.54% gram, flowers 12.90% gram, seeds 2.71% gram, young shoots 1.91% gram, insects 1.35% gram, rhizome 1.02% gram, inflorescence 0.83% gram, leafbud 0.70% gram, petiole 0.44% gram and bark 0.30% gram, and time spent for leaves was 49.74% (mature leaves 29.04% and young leaves 20.70%), fruits 25.96%, flowers 12.16%, insects 2.43%, seeds 2.07%, stone licking 1.40%, young shoots 1.50%, water 0.90%, inflorescence 0.85%, rhizome 1.02%, leafbud 0.87%, soil eating 0.33%, petiole 0.42%, waste 0.13% and bark 0.22%. Chalise (1995) in Ramnagar langurs recorded mean intake leaves 49.8% gram, fruits 26.4% gram, flowers 15.8% gram, insects 5.0% gram, shoots 1.3% gram, algae 1.1% gram, honey 0.5% gram, bark and termite soil each 0.1% gram (time spent for them was respectively, 52.4%, 21.9%, 12.8%, 3.8%, 1.7%, 0.8%, 2.4%, 0.1% and 0.9% geophagy whole). This shows results of present study are similar to Chalise (1995) leaves, fruits, flowers and shoots, however insect intake is different but time spent for insect eating is more or less similar and other food categories seem to be different.

Table 31: Monthly distribution of food categories in relation to time spent feeding and mean intake in gram (time and intake are in %) for KFAST

Food items		**2015**											**2016**	**Mean**
		Feb.	**Mar.**	**Apr.**	**May**	**June**	**July**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	**Jan.**	
Fruits	Time	12.14	04.62	03.98	24.42	43.37	49.14	11.16	14.32	26.02	36.15	42.55	17.72	23.80
	Intake	16.86	07.83	06.19	27.73	48.85	53.10	14.12	18.42	32.03	39.11	40.85	21.18	27.19
Mature leaf	Time	49.63	12.73	06.43	11.04	12.76	07.56	31.57	19.72	46.16	53.32	46.17	63.18	30.02
	Intake	51.23	14.52	07.76	08.31	09.66	09.88	27.23	16.77	31.87	36.39	49.22	57.17	26.67
Young leaf	Time	09.12	24.16	27.87	37.31	29.95	30.52	41.50	07.95	05.22	04.46	07.38	09.32	19.56
	Intake	04.71	27.11	26.92	39.10	31.12	28.14	46.06	10.02	11.27	07.42	05.64	07.30	20.40
Seed	Time	03.22	06.94	08.17	02.98	01.53	01.17	02.32	03.30	01.03	00.41	00.15	01.28	2.71
	Intake	03.42	06.23	05.93	02.16	01.15	00.76	02.69	06.21	03.01	02.33	00.18	01.19	2.94

Young shoot	Time	00.64	01.97	01.23	06.73	01.66	00.43	00.96	02.63	06.18	00.98	00.32	00.27	2.0
	Intake	02.15	04.98	06.57	08.95	02.34	01.23	00.54	01.16	04.13	01.20	00.53	00.75	2.88
Inflorescence	Time	01.31	02.12	03.86	00.97	00.64	-	-	01.14	00.83	00.31	-	00.21	0.95
	Intake	01.36	02.34	03.66	01.02	00.43	-	-	00.52	01.84	01.28	-	00.26	1.06
Bark	Time	00.24	-	-	00.24	00.18	00.11	-	00.25	-	00.14	00.26	00.03	0.12
	Intake	01.21	-	-	00.33	00.24	00.18	-	00.43	-	00.37	00.48	00.11	0.28
Flower	Time	08.57	19.22	33.51	07.12	03.43	01.12	10.43	48.12	11.12	01.91	00.96	04.11	12.47
	Intake	09.52	22.21	34.38	10.03	04.37	02.11	08.31	45.81	14.24	10.07	01.23	06.54	14.07
Petiole	Time	-	00.74	00.61	01.14	00.42	-	00.36	-	-	00.44	00.36	00.23	0.36
	Intake	-	00.85	00.82	01.17	00.65	-	00.46	-	-	00.32	00.41	00.63	0.44
Leafbud	Time	00.44	00.31	02.14	00.65	00.97	-	00.22	-	00.43	00.48	00.64	00.78	0.59
	Intake	01.14	01.19	02.01	00.72	01.18	-	00.38	-	00.56	00.64	00.53	00.98	0.78
Rhizome	Time	01.67	02.45	01.21	-	-	00.23	00.14	00.57	00.31	00.53	00.37	01.32	0.73
	Intake	02.33	03.12	02.32	-	-	00.44	00.21	00.65	00.63	00.86	00.74	03.38	1.22
Insects	Time	11.89	12.41	02.26	00.94	-	06.55	-	-	00.23	-	00.11	00.17	2.90
	Intake	06.07	09.62	03.43	00.48	-	04.16	-	-	00.42	-	00.18	00.51	2.07
Stone licking	Time	00.21	07.67	06.07	03.46	02.04	01.16	00.24	00.43	01.26	00.52	00.39	01.10	2.04
	Intake													
Soil eating	Time	00.55	01.95	01.16	00.77	00.16	00.53	00.46	00.28	00.12	00.24	00.23	00.22	0.55
	Intake													
Water	Time	00.23	01.88	01.32	02.23	02.74	01.47	00.52	00.96	00.34	00.10	00.08	-	0.99
	Intake													
Waste	Time	00.14	00.82	00.18	-	00.14	-	00.12	00.33	00.75	-	00.02	00.06	0.21
	Intake													

Table 32: Monthly distribution of food categories in relation to time spent feeding and mean intake in gram (time and intake are in %) for BFAST

Food items						**2015**							**2016**	**Mean**
		Feb.	**Mar.**	**Apr.**	**May**	**June**	**July**	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**	**Jan.**	
Fruits	Time	13.56	10.15	06.17	27.19	45.23	47.12	12.84	16.26	31.17	39.12	41.43	21.25	25.96
	Intake	18.43	16.32	11.10	32.71	51.62	53.65	17.72	19.23	34.14	41.67	38.12	19.74	29.54
Mature leaf	Time	47.12	11.94	05.75	10.07	09.96	05.46	26.16	23.12	48.09	50.76	48.11	61.90	29.04
	Intake	49.16	10.91	04.34	06.08	05.65	04.33	19.57	21.18	39.10	43.40	49.78	62.63	26.34
Young leaf	Time	11.16	29.98	31.69	39.22	33.13	34.18	42.10	06.97	04.13	03.89	04.75	06.97	20.70
	Intake	08.31	32.42	33.47	37.26	32.12	35.10	44.65	11.21	07.16	06.88	06.82	08.14	21.96
Seed	Time	03.11	04.91	06.96	01.74	00.88	00.97	01.42	01.65	01.33	00.61	00.10	01.18	2.07
	Intake	02.23	06.69	07.46	02.50	01.18	00.57	03.66	03.31	02.44	00.98	00.22	01.32	2.71

Young shoot	Time	00.86	01.76	02.29	04.11	01.73	00.66	00.87	01.42	02.56	00.31	00.87	00.54	1.50
	Intake	01.12	02.10	04.35	06.29	02.23	00.46	00.74	01.95	01.83	00.41	00.82	00.65	1.91
Inflorescence	Time	-	01.89	02.81	00.76	00.89	00.41	00.68	00.94	01.16	-	00.65	-	0.85
	Intake	-	01.37	02.92	00.98	00.94	00.31	00.72	01.10	01.22	-	00.43	-	0.83
Bark	Time	00.41	00.12	00.34	-	00.32	-	00.86	00.11	00.26	-	00.14	00.12	0.22
	Intake	00.76	00.35	00.43	-	00.47	-	00.65	00.31	00.29	-	00.10	00.16	0.30
Flower	Time	09.77	18.26	30.64	09.23	02.86	02.55	11.61	44.17	09.45	02.15	01.74	03.48	12.16
	Intake	10.84	21.91	32.76	11.42	03.74	01.47	10.36	39.12	12.23	04.16	01.95	04.62	12.90
Petiole	Time	00.62	-	00.71	00.84	-	00.43	00.66	00.74	00.22	00.26	00.12	00.46	0.42
	Intake	00.93	-	00.61	00.47	-	00.32	00.83	00.65	00.46	00.54	00.17	00.33	0.44
Leafbud	Time	00.98	00.48	03.53	00.91	00.67	00.59	00.39	00.98	00.12	00.67	00.42	00.69	0.87
	Intake	00.91	00.64	01.23	00.87	00.85	00.49	00.54	00.76	00.37	00.71	00.62	00.46	0.70
Rhizome	Time	01.95	02.97	02.10	-	00.54	00.62	-	00.34	00.40	00.85	00.93	01.55	1.02
	Intake	02.52	02.12	01.33	-	00.71	00.63	-	00.44	00.76	00.92	00.97	01.82	1.02
Insects	Time	09.23	10.11	-	02.68	00.85	03.35	00.77	01.43	-	00.48	-	00.23	2.43
	Intake	04.79	05.17	-	01.41	00.48	02.67	00.56	00.73	-	00.32	-	00.12	1.35
Stone licking	Time	00.32	06.16	05.27	01.16	-	01.22	00.53	-	00.37	00.34	00.33	01.14	1.40
	Intake													
Soil eating	Time	00.63	00.45	-	00.54	00.18	-	00.38	00.95	-	00.16	00.41	00.32	0.33
	Intake													
Water	Time	00.17	00.82	01.49	01.33	02.65	02.12	00.72	00.91	00.48	00.19	-	-	0.90
	Intake													
Waste	Time	00.10	-	00.25	00.21	00.11	00.32	-	-	00.26	00.21	-	00.16	0.13
	Intake													

The weight of food eaten should be related to the time spent eating at least if the food is uniform. However, Hladik (1977) states, “Unfortunately, the time spent feeding cannot be accepted as an estimate of the food intake, since feeding rate may differ considerably between food items.” Eventhough, time spent on feeding is always considered as a parameter to explain the feeding ecology and behavior of primates, at least for Assamese monkey species. The results of Kaligandaki and Budhigandaki showed exactly the situation what Hladik stated. The seasonal distribution of different food categories of KFAST is given in reference to time spent versus the mean intake (Table 31) and that of BFAST is given in Table 32. This will focus more information about seasonal feeding and intake of Assamese monkeys.

Hladik (1977) investigated the time spent feeding and food intake of mature leaves, young leaves and green fruits of some plant species. For the purple-faced langur he recorded (in April) the time spent for mature leaves was 51.1% corresponding to 57.3% gram of the fresh weight ingested, for young leaves and shoots 46.3% of the total feeding time spent and 39.1% gram intake and for green fruits they spent 2.6% time and get back 3.6% gram of intake. Similarly, to the gray langurs (in August) it was recorded 34.4% of time spent on young leaves and shoots which pay back 37.7% gram of intake, 30.0% time for green fruits to get 36.3% gram, 27.4% of time to intake 19.1% gram of flowers and from other leaves 6.8% gram obtained spending 8.0% of time. It might be due to different habitat and insect eating, that there is little different in amount of intake of plant parts by the purple-faced langurs of SriLanka, gray langurs of Ramnagar and Assamese monkeys of KRB as well as BRB forests.

There are some species that had been studied with two different dietary sampling methods in the same habitat. For each species the diet has been defined both in terms of the percent of feeding time devoted to various dietary categories and in terms of the total weight eaten from each dietary category. For simplicity and for comparability, all foods were allocated to one of the three dietary categories: plant structural parts, plant reproductive parts, and animal matter (Sailer *et al*., 1985). Gaulin and Gaulin (1982) for *Alouatta seniculus* (body wt. 7.65 kg) feeding time: 47.8% plant reproductive parts, 52.2% plant structural parts correspond to 75.4% gram and 24.6% gram of intake. Similarly, Iwamoto (1982) for *Macaca fuscata* (body wt. 10.10 kg) feeding time: 36.0% for plant reproductive parts, 31.0% plant structural parts and 33.0% animal matter correspond to 52.0% gram, 41.0% gram and 7.0% gram. The food intake of *M. fuscata* is very similar to the intake of Kaligandaki and Budhigandaki Assamese monkeys. The results from different sites for different monkey species suggest that if the animal's size and feeding habits are similar or close to each other, the amount of food ingestion is also similar.

4.2.4 Crop raiding

In this study, the closeness of the forest to the agricultural land of KRB and BRB villages was about 100 m, so the level of disturbances and human-monkey conflict was high. Anthropogenic activities have forced non-human primates into conflict interactions with local people especially through crop raiding (Priston *et al*., 2012).

The cause of human primate conflicts in local areas is due to damage of crop by primates in those areas where local people are mainly subsistence farmers (Hill, 1998). When supply of natural food is insufficient, easily digested and high quality human food is a good alternative form of nutrition for primates, that could be the most important cause of crop raiding (Khatun *et al*., 2013).

Raiding of crop by monkeys in Nepal is very common. Upreti (1985) recorded that barley and buckwheat raided by wild animals in Rara and Langtang National Parks. Similarly, Jackson (1990) also recorded damage of crop by monkeys in Makalu Barun Conservation Area.

During a study in Bandipokhara, Palpa, Nepal, Ghimire (2001) reported the highest damage of crop by monkeys was maize (34.12%), followed by potato (23.05%), rice (12.01%), fruits (11.68%), wheat (9.57%), millet (5.13%), buckwheat (2.38%) and pulses (2.06%). Chalise (1997, 1999) recorded that crop depredation proportions in different crops. In his study in MBCA, the highest crop loss was maize (32%), followed by potato (24%), rice (14%), fruits (12%), millet (11%), wheat (4%), buckwheat (2%) and pulses (1%). Chalise (2001) reported the damage in Lakuwa village as 7.76% maize and 4.14% pulses. During investigation in Shiva village, Chalise (2001) recorded maize 13.88%, fruits 41.86%, rice 19.16% and wheat 8.97%. Adhikari *et al*. (2018) reported maize 35%, vegetables 20%, pulses 13%, fruits 13%, potato 6% and rice 2% in Ramdi area. In this study in KRB villages, the highest crop damage by Assamese monkeys was recorded maize (47.14%), followed by fruits (16.43%), wheat (11.13%), millet (5.72%), rice (4.58%), potato (4.27%), lentil (4.07%), mustard (1.26%), pumpkin (1.14%), brown lentil (0.81%), broad beans (0.8%), sesham (0.6%), black pulses (0.35%), cauliflower (0.14%) and tomato (0.1%) (Ghimire & Chalise, 2019). In BRB villages, the highest crop damage was also recorded maize (58.43%), followed by rice (11.34%), lentil (8.74%), peanut (4.35%), soyabean (4.18%), wheat (3.22%), fruits (2.97%), black pulses (1.87%), potato (1.67%), sesham (0.92%), tomato (0.79%), millet (0.67%), mustard (0.36%), broad beans (0.25%), brown lentil (0.18%) and pumpkin (0.06%) (Ghimire & Chalise, 2018). This study shows the highest damage of crop as maize (47.14% in KRB and 58.43% in BRB) as compared to Ghimire (2001), Chalise (1997, 1999, 2001) and Adhikari *et al*. (2018), those reported low crop damage in Bandipokhara, Palpa, MBCA and Ramdi respectively. The main reasons for these differences are due to low food availability for the monkeys in the forests and destruction of their natural habitats (constructing Kaligandaki corridor and Budhigandaki hydropower development) which tends to move the monkeys towards human settlements and crop fields.

Frequency of crop raid is affected by the natural food availability and individual numbers of monkeys in an area. Raiding crop is an essential component of ecology of primates inhabiting human settlements (Naughton-Treves *et al*., 1998) but it is likely to minimize the tolerance of subsistence farmers towards conservation of such crop-raider threatened primate species (Khatun *et al*., 2013). This fact may be useful in predicting the vulnerability of the Assamese monkey survival in KRB and BRB area. Artificial provisioning causes changes in the diet, home range and habitat and even the behavior of the monkey (Southwick *et al*., 1976). Monkeys are more habituated to local people in Ramdi area because of provisioning of foods. Due to this, their diet, habitat, home range and behavioral patterns are also changed. Most of the local villagers believe that natural food scarcity, habitat destruction and changes in behavior of the monkeys due to artificial provisioning by Hindu Pilgrims are the major causes of monkeys shifting into crop-raiders. Monkeys living in the habitat with low wild food resources are more likely to shift towards human settlement areas with dependence on crop foods (Yamada & Muroyama, 2010). The food provided by the Hindu Pilgrims in temple areas of Ramdi might have caused behavioral changes and increased their dependence to provisioned food rather than foraging from the wild. The supplied provisioning food is not sufficient for the monkeys and in order to fulfill nutrients requirement monkeys enter to the crop fields that ultimately increase the conflicts between the monkeys and the local villagers.

Damage of crop by monkey species is one of the serious problems in many villages of Nepal (Chalise, 1997; Ghimire & Chalise, 2018, 2019). Despite of raiding crops, monkeys also help in seed dispersal in the forest (Chalise, 1999). The scarcity of wild foods and destruction of natural habitats tend the monkeys to enter the crop fields and raid the crops. Such situation forces them to survive on human crop field and settlements. The detail assessment of the habitat quality and its management would minimize the human-monkey conflicts and it will be helpful for conservation of the nationally endangered and protected Assamese macaque species in Kaligandaki and Budhigandaki river basins of Nepal.

CHAPTER 5

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Total population of Assamese monkeys was recorded 85 from five troops (two troops from KRB and three troops from BRB). The adult male to female sex ratio was 1:1.83 in Kaligandaki and 1:1.5 in Budhigandaki. Average group size was 21 in KRB and 14.33 in BRB. By distribution pattern, monkeys belonging to Block D were found most variant and Block A least variant. This indicates that analysis for the highly variant Blocks such as Block D, Block E and Block B need high caution than the less variant Blocks such as Block A and Block C.

Different quadrate plots and vegetation analysis revealed that the Assamese monkeys of KRB and BRB were found inhabited in sub-tropical deciduous riverine forest with rocky cliffs habitat. The frequently used food plant of Kaligandaki Assamese monkeys was leaf of *Albizzia chinensis* and that of Budhigandaki was leaf of *Lagerstroemia parviflora* throughout the year though they ate other plant species and their parts available seasonally in both the research sites. Most of the botanical quadrate plots also included *Albizzia chinensis* species in KRB and that of *Lagerstroemia parviflora* species in BRB although dominated by *Trichilia connaroides* in Kaligandaki and *Shorea robusta* in Budhigandaki. Further, the sleeping sites of the Assamese monkeys during night time were found on rocky cliffs and rocky outcrops in steeply as well as slope areas of both the KRB and BRB rocks. These rocky cliffs and rocky outcrops were very close with specific food plants of the monkeys in both the sites that might help them to prefer this type of habitat.

The feeding behavior has been found the major activity profile followed by resting, moving and grooming. Feeding activity was mainly in early morning and late afternoon. Obtaining food and eating are the major concerns of the Assamese monkeys for their all activities. The moving activity was increased during the scarcity of food. The resting and grooming activities were increased during the sufficient available of food from the forests. Maximum time was spent for feeding activity followed by resting, moving and grooming.

Assamese monkeys of KRB and BRB contributed higher time investment for consuming leaf, followed by fruits, flowers and others. KRB monkeys frequently consumed leaves of *Albizzia chinensis* and BRB monkeys utilized leaves of *Lagerstroemia parviflora* as their major food plant throughout the year, which shows both KRB and BRB monkeys are mostly folivorous. Choice of food and feeding time investment of different plant parts may differ depending on the availability of food in the area. Monkeys living in the wild at comparable ecological setup with similar nutrient concentrations of staple foods have analogous food choices and time investments.

Raiding the crops by Assamese monkeys is one of the serious problems in both Kaligandaki and Budhigandaki river basin villages. Maize crop was highly preferred by the Assamese monkeys as a major crop raid in both the study areas. The scarcity of wild foods and destruction of natural habitats tend the monkeys to enter the crop fields and raid the crops.

5.2 Recommendations

On the basis of the findings of this study, the following recommendations are offered for consideration by concerned authorities for the protection of surviving population of Assamese monkeys at different topographical habitat of Nepal:

1. Assamese monkeys raid the different varieties of crops in the Kaligandaki and Budhigandaki river basin villages, so the related government organization should suggest the local people of such areas for alteration of farming in the crop fields.

2. Natural food plants of the monkeys should be grown up throughout the bare areas. The forestation of flowering and fruiting plants should be carried out that help to minimize their crop raid in the crop fields.

3. Rocky cliffs and rocky outcrops habitat of the Assamese monkeys along the Kaligandaki and Budhigandaki river basins should be protected by the concerned authorities of Government of Nepal.

4. Further researches on ecology and behavior of Assamese monkeys should be carried out that will help for the policy makers of the nation to ensure long term conservation and management of this nationally protected Assamese monkeys in Nepal.

CHAPTER 6

6. SUMMARY

The summarized forms of research works are:

- General objective of research was to study on general ecology and feeding behavior of Assamese monkeys *(Macaca assamensis)* in mid-hills of Nepal especially in KRB and BRB.
- Specific objectives were to explore population status and distribution pattern, habitat preference, behaviors specially feeding behavior and crop raiding status of Assamese monkeys in KRB and BRB.
- Field work was carried out from February 2015 to January 2016. Total work time was 1804 hours of which 911 hours was spent in KRB and 893 hours in BRB. Monkey contact time was 1407 hours of which 716 hours was spent for the behavioral data collection in KRB and 691 hours in BRB. Monthly schedule for data collection in the field was made 9 to 10 days per month for each research site.
- Population surveys of Assamese monkeys were carried out from all the possible trails in KRB and BRB as described in Altmann (1974) and practiced by Chalise (2003).
- Botanical quadrates of 20 m × 20 m sized were used to analyze vegetation pattern and habitat of the monkeys.
- Behavioral data were taken by scan sampling method and focal animal sampling method (Altmann, 1974). Four major behaviors (feeding, resting, moving and grooming) were observed.
- Feeding behavior was recorded by direct observation in the field area of KRB and BRB. Feeding items, feeding time and quantity of food of Assamese monkeys from different habitat were collected by direct observation in the field following the methods as in Chalise *et al*. (2013).
- Crop raiding data were obtained from local household villagers as per the pre-set questions format. Questionnaire survey was designed and stratified random sampling method was performed to select the respondent.

- A total of 42 individuals of Assamese monkeys were recorded in two different troops in KRB of which Palpa troop 24 and Syangja troop 18 were recorded. In BRB, a total of 43 individuals were counted in three different troops of which Rigdikhola troop 16, Rockybhir troop 13 and Siurenitar troop 14 were recorded.
- Botanical quadrate sampling (20 m × 20 m) plotted in different altitudinal areas of KRB forest revealed that *Trichilia connaroides* as dominant plant species with 35.68% relative density and 8.38% relative frequency. But in BRB forest, *Shorea robusta* was dominant plant species with 29.75% relative density and 8.87% relative frequency.
- Different quadrate plots and vegetation analysis revealed that the Assamese monkeys of KRB and BRB were found inhabited in sub-tropical deciduous riverine forest with rocky cliffs habitat. The frequently used food plant of Kaligandaki Assamese monkeys was leaf of *Albizzia chinensis* and that of the Budhigandaki was leaf of *Lagerstroemia parviflora* throughout the year. Further, the sleeping sites of the Assamese monkeys during night time were found on rocky cliffs and rocky outcrops in steeply as well as slope areas of both KRB and BRB rocks.
- Total time spent in feeding was 294.7 hours (41.16%) followed by resting 197.8 hours (27.63%), moving 126.9 hours (17.72%) and grooming 96.6 hours (13.49%) by KFAST and feeding 306.5 hours (44.36%), resting 171.2 hours (24.78%), moving 114.6 hours (16.58%) and grooming 98.7 hours (14.28%) by BFAST.
- KFAST contributed mean intake leaves 47.07% gram (mature leaves 26.67% gram and young leaves 20.40% gram) and time spent for leaves was 49.58% (mature leaves 30.02% and young leaves 19.56%) followed by fruits, flowers, and others.
- BFAST contributed mean intake leaves 48.30% gram (mature leaves 26.34% gram and young leaves 21.96% gram) and time spent for leaves was 49.74% (mature leaves 29.04% and young leaves 20.70%) followed by fruits, flowers and others.
- Assamese monkeys of both KRB and BRB preferred maize (47.14% in KRB villages and 58.43% in BRB villages) as the major crop raid followed by fruits, wheat, millet and others in KRB villages and rice, lentil, peanut and others in BRB villages.

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PHOTO PLATES

Kaligandaki river basin

Plate 1: Habitat of Assamese monkeys

Plate 2: Researcher at the research field

Plate 3: An adult male Assamese monkey searching for food

Plate 4: Assamese monkeys grooming on *Ficus religiosa* tree

Plate 5: An adult male Assamese monkey resting on *Ficus religiosa* tree

Plate 6: A subadult male Assamese monkey in resting position

Plate 7: A juvenile Assamese monkey climbing on *Ficus religiosa* tree

Plate 8: My supervisor guiding me the data collection methods in the research field

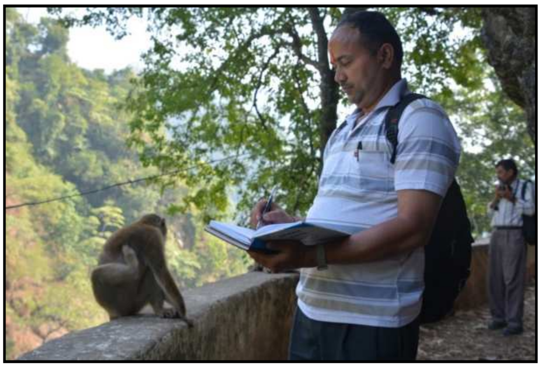

Plate 9: Researcher collecting the behavioral data of Assamese monkeys in the field

Plate 10: An adult female Assamese monkey searching for food

Plate 11: An adult female Assamese monkey eating leaf of *Dioscorea bulbifera*

Plate 12: A juvenile Assamese monkey in resting state

Plate 13: A juvenile Assamese monkey eating leaf of *Dioscorea bulbifera*

Plate 14: An adult male Assamese monkey in resting state

Plate 15: An adult female Assamese monkey in resting state

Plate 16: Breast feeding mother-infant Assamese monkeys

Plate 17: Crop (rice grains) eating Assamese monkeys

Plate 18: Questionnaires with villagers about crop loss due to Assamese monkeys

Plate 19: Fallow land fields due to Assamese monkeys

Budhigandaki river basin

Plate 20: Habitat of Assamese monkeys

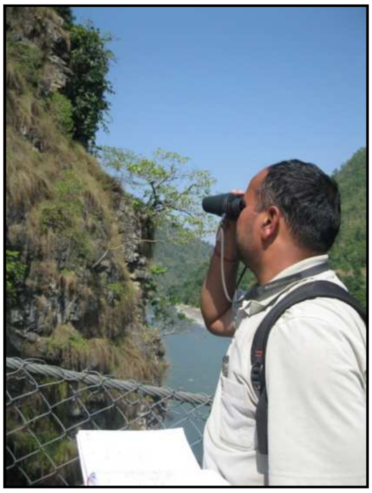

Plate 21: Researcher observing Siurenitar troop of Assamese monkeys

Plate 22: Siurenitar troop of Assamese monkeys in their rocky outcrops habitat

Plate 23: An adult male Assamese monkey searching for food

Plate 24: Researcher collecting the data in the research field

Plate 25: Constructing the tunnels of Budhigandaki hydro-electric project in and around the Assamese monkeys' habitats

Plate 26: Researcher sharing ideas scientifically with Chief District Officer (CDO) of Gorkha District, Local Development Officer (LDO) of Dhading District, President of Budhigandaki Hydro-electric Project, Securities and others about the impact of Budhigandaki hydropower development to the natural habitats of Assamese monkeys

Plate 27: Mother with infant of Assamese monkeys resting on *Magnifera indica* tree

Plate 28: An adult female Assamese monkey resting on ground

Plate 29: An adult male Assamese monkey resting on tree

Plate 30: An adult female Assamese monkey climbing on the tree

Plate 31: Questionnaires with villagers about crop loss due to Assamese monkeys

Plate 32: Fallow land fields due to Assamese monkeys

APPENDICES

Appendix I: Data sheet - Scan sampling

Observer's name :______________________________ Date :____________ Start time:___________

Target animal/Group name:____

Location: _________________________________ Weather: _________________________________

Interval: ______________ sec./min.

SN	Behavior			
	Feeding	**Resting**	**Moving**	**Grooming**
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
Percent (%)				

Comments: ____

____

____

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Appendix II: Data sheet - Focal animal sampling

Observer's name :______________________________ Date :____________ Start time:___________

Focal animal/Group name:____

Location: _________________________________ Weather: _________________________________

Behavior/Interaction ("who does what to whom")

Start ____

____

____

____

____

____

____

____

____

____

____

____

____

____ Stop

Comments: ____

____

____

____

____

____

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____

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Appendix III: Data sheet - Feeding behavior

Observer's name :______________________________ Date :____________ Start time:___________

Target animal/Group name:____

Location: _________________________________ Weather: _________________________________

Interval: ______________ sec./min.

Feeding Items	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**%**
Fruits											
Mature leaf											
Young leaf											
Seed											
Young shoot											
Inflorescence											
Bark											
Flower											
Petiole											
Leafbud											
Rhizome											
Insects											
Stone licking											
Soil eating											
Water											
Waste											

Comments: ____

Appendix IV: Data sheet - Questionnaire for crop raiding by monkey species

Q.N. :____ Date :___________

Name: ____ Age:_________ Sex: M/F/Y/C

District: _______________ VDC: _______________ Village: _______________ Ward No.: _____

Name of households / relation to observer: ______________________ / ______________________

Have you lost crops due to monkeys? Yes No

If so when? Or others? ____

Crop: Maize/Rice/Wheat/Millets/Potato/Fruits/Others _____________________________________

Which year: Every year Last year This year Never Worst year

Monkey species involved: Assamese Rhesus Langur App.

Number_________ Season______________ Month(s) loss occurred: ______________________

Time of raid: Early morning Late morning Noon Afternoon Evening

Crop affected part: Eaten Destroyed

How much lost: _________ muri or kg.

Affected crop field area ______________ ropani

Expected yield of that crop field ______________ muri or kg.

Gross yield per year ______________ muri or kg.

Proximity of damage field to the jungle: 100m /200m-500m /1000m /2000m

Jungle vegetation type: _________________________ Topography__________________________

Nearest house/hut from damage field: <100m /100m-200m /200m-500m /500m-1km

Action taken against the damage: Guarded by Man / Woman / Young / Children / Dog / Scarecrows / Tin-box / Poison / Firecrackers / Shotguns / Others

What will be the solution? ____

____

____

What do you expect from the authority? ____

____

____

Appendix V: Table showing the plant species and their forms found around the home range of Assamese monkeys in Kaligandaki and Budhigandaki river basin forests

SN	Local Name	Life Form	Scientific Name	Family
1	Aankha taruwa	T	*Trichilia connaroides* (Wight & arn.) Bent.	Meliaceae
2	Amala	T	*Phyllanthus emblica* L.	Euphorbiaceae
3	Amaru	T	*Spondias pinnata* (L.f.) Kurz.	Anarcardiaceae
4	Amp	T	*Magnifera indica* L.	Anarcardiaceae
5	Archal sano	T	*Antidesma acidum* Retz.	Euphorbiaceae
6	Archal thulo	T	*Antidesma ghaesembilla* Gaertn.	Euphorbiaceae
7	Bahunkath	T	*Hymenodictyon excelsum* (Roxb.) Wall.	Rubiaceae
8	Bakaino	T	*Melia azedarach* L.	Meliaceae
9	Ban paiyun	T	*Prunus cerasoides* Buch.-Ham. ex D. Don.	Rosaceae
10	Bankainyo	T	*Wendlandia c.f. coriacea* (Wall.)	Rubiaceae
11	Bansuntala	T	*Carallia brachiata* (Lour.) Merr.	Rhizophoraceae
12	Bar	T	*Ficus benghalensis* L.	Moraceae
13	Barro	T	*Terminalia bellirica* (Gaertn) Roxb.	Combretaceae
14	Bel	T	*Aegle marmelos* (L.) Correa	Rutaceae
15	Bhalayo	T	*Semecarpus anarcardium* L.f.	Anarcardiaceae
16	Bhatuwa	T	*Mallotus roxburghianus*	Euphorbiaceae
17	Bhellar	T	*Triwia nudiflora* L.	Euphorbiaceae
18	Botdhayaro	T	*Lagerstroemia parviflora* Roxb.	Lythraceae
19	Chanp	T	*Michelia champaca* L.	Magnoliaceae
20	Chhatiwan	T	*Alstonia scholaries* (L.) R. Br.	Apocynaceae
21	Chilaune	T	*Schima wallichii* (DC) Korth.	Theaceae
22	Chiuri	T	*Diploknema butyracea* (Roxb.) H.J.Lam.	Sapotaceae
23	Dabdabe	T	*Garuga pinnata* Roxb.	Burseraceae
24	Gidari	T	*Premna barbata* Wall.	Verbenaceae
25	Gum	T	*Cordia grandis* Roxb.	Cordiaceae
26	Hade gayo	T	*Bridelia c.f. pubescens* Kurz	Euphorbiacea
27	Harro	T	*Terminalia chebula* Retz.	Combretaceae
28	Jamun	T	*Syzygium cumini* (L.) Skeels.	Myrtaceae
29	Kadam	T	*Anthocephalus chinensis* (Lam.) A.R.	Rubiaceae
30	Kafal	T	*Myrica esculenta* Buch.-Ham. ex D. Don.	Myricaceae
31	Kalikath	T	*Aporusa octandra* Buch.-Ham. ex D. Don.	Euphorbiaceae
32	Kalo dumri	T	*Ficus nervosa* Heyne ex Roth.	Moraceae
33	Kalo sirish	T	*Albizzia odoratissima* (L.f.) Benth.	Mimosaceae
34	Karam	T	*Adina cardifolia* Willd. ex Roxb.	Rubiaceae
35	Katus	T	*Castanopsis indica* (Roxb. ex Lindl.) A. DC.	Fagaceae
36	Kavro	T	*Ficus lacor* Buch. Ham.	Moraceae
37	Khair	T	*Acacia catechu* (L.f.) Willd.	Mimosaceae
38	Khanyo	T	*Ficus sarmentosa* Buch.-Ham. ex Sm.	Moraceae
39	Khareto	T	*Phyllanthus urinaria* L.	Euphorbiaceae

40	Khari	T	*Trema c.f. politoria* (Planch.) Blume	Ulmaceae
41	Koiralo	T	*Bauhinia variegata* L.	Caesalpinaceae
42	Kudmiro	T	*Litsea monopetala* Roxb. Pers.	Lauraceae
43	Lankuri	T	*Fraxinus floribunda* Wall. in Roxb.	Oleaceae
44	Lasune	T	*Sphaerosacme decandra* Wall. Pennington	Meliaceae
45	Latikath	T	*Glochidion velutinum* Wight	Euphorbiaceae
46	Mahua	T	*Madhuca longifolia latifolia* (Roxb.) A. Chev.	Sapotaceae
47	Mayal	T	*Pyrus pashia* Buch. & Ham.	Rosaceae
48	Mulberry	T	*Morus macroura* Miq.	Moraceae
49	Musurekatus	T	*Castanopsis tribuloides* Sm.	Fagaceae
50	Neem	T	*Azadirachta indica* A. Juss.	Meliaceae
51	Nilo tanki	T	*Uraria lagopodioides* (L.) Desv.	Leguminosae
52	Pahele	T	*Litsea glutinosa* (Lour.) C. B. Robinson	Lauraceae
53	Pahelopate	T	*Diospyros montana* Roxb.	Ebenaceae
54	Pakhuri	T	*Ficus hederacea* Roxb.	Moraceae
55	Palas	T	*Butea minor* Buch.-Ham.	Caesalpinaceae
56	Phaledo	T	*Erythrina variegata* Linn.	Leguminosae
57	Phanir	T	*Syzygium jambos* (L.) Alston.	Myrtaceae
58	Pharlat	T	*Syzygium wallichii* (Wight) Walp.	Myrtaceae
59	Phirphire	T	*Firmiana colorata* (Roxb.) R. Br.	Sterculiaceae
60	Pipal	T	*Ficus religiosa* L.	Moraceae
61	Rajbrikchhya	T	*Cassia fistula* L.	Caesalpinaceae
62	Ranikaram	T	*Mitragyna parvifolia* (Roxb.) Korth.	Rubiaceae
63	Ratpate	T	*Odina wodier* Roxb.	Anarcardiaceae
64	Reetha	T	*Sapindus mukorossi* Gaertn.	Sapindaceae
65	Rukh dhaturo	T	*Ehretia laevis* Roxb.	Cordiaceae
66	Saj	T	*Terminalia alata* Heyne. ex Roth.	Combretaceae
67	Sal	T	*Shorea robusta* Gaertn.	Dipterocarpaceae
68	Samipipal	T	*Ficus benjamina* L.	Moraceae
69	Satisal	T	*Dalbergia latifolia* Roxb.	Fabaceae
70	Seto dumri	T	*Ficus racemose* L.	Moraceae
71	Seto sirish	T	*Albizzia procera* (Roxb.) Benth.	Mimosaceae
72	Sigane	T	*Lannea coromandelica* (Houtt.) Merr.	Anarcardiaceae
73	Simal	T	*Bombax ceiba* L.	Bombacaceae
74	Sindure	T	*Mallotus philippensis* (Lam.) Muell.-Arg.	Euphorbiaceae
75	Sirish	T	*Albizzia chinensis* (Osbeck) Merr.	Mimosaceae
76	Sisso	T	*Dalbergia sissoo* Roxb.	Fabaceae
77	Tanki	T	*Bauhinia purpurea* Linn.	Caesalpinaceae
78	Thotne	T	*Ficus hispida* L. f.	Moraceae
79	Thulo bayar	T	*Zizyphus rugose* Lam.	Rhamnaceae
80	Thulo sirish	T	*Albizzia lebbeck* (L.) Benth.	Mimosaceae
81	Timilo	T	*Ficus auriculata* Lour.	Moraceae

82	Tuni	T	*Toona ciliata* M. Roem.	Meliaceae
83	Utis	T	*Alnus nepalensis* D. Don.	Betulaceae
84	Ainselu	S	*Rubus ellipticus* Smith	Rosaceae
85	Angeri	S	*Melastoma malabathricum* L.	Melastomataceae
86	Asuro	S	*Justicia adhatoda* L.	Acanthaceae
87	Bandargeda	S	*Ardisia solanacea* Roxb.	Myrsinaceae
88	Basanta kanda	S	*Randia fasciaculata* (Roxb.) DC	Rubiaceae
89	Bilaune	S	*Maesa montana* A. DC.	Myrsinaceae
90	Chutro	S	*Berberis asiatica* Roxb. ex DC.	Berberidaceae
91	Dhurseli	S	*Colebrookea oppositifolia* Smith	Labiatae
92	Goru ainselu	S	*Rubus rugosus* Sm.	Rosaceae
93	Guyalo	S	*Callicarpa arborea* Roxb.	Verbenaceae
94	Guyesimal	S	*Perilla frutescens* (L.) Britton.	Labiatae
95	Khirra	S	*Holarrhena pubescens* (Buch.-Ham.) Wall.	Apocynaceae
96	Main kanda	S	*Xeromphis spinosa* (Thunb.) Keay	Rubiaceae
97	Nundhiki	S	*Osyris wightiana* Wall. ex Wight.	Santalaceae
98	Rudilo	S	*Pogostemon benghalensis* Brum.	Labiatae
99	Sano bayar	S	*Zizyphus mauritiana* Lam.	Rhamnaceae
100	Sanodhayaro	S	*Woodfordia fruiticosa* (L.) Kurz.	Lythraceae
101	Ban karela	C	*Momorcordia dioica* Roxb. ex Willd.	Cucurbitaceae
102	Bhorla	C	*Bauhinia vahlii* Wight & Arn.	Caesalpinaceae
103	Birale	C	*Pueraria phaseoloides* (Roxb.) Benth.	Leguminosae
104	Dudhelahara	C	*Hedyotis lineata* Roxb.	Rubiaceae
105	Gabjolahara	C	*Milletia extensa* (Benth.) Baker	Leguminosae
106	Ghiraula	C	*Trichosanthes tricuspidata* Lour.	Cucurbitaceae
107	Gidari lahara	C	*Premna scandens* Roxb.	Verbenaceae
108	Janai lahara	C	*Clematis gouriana* Roxb.	Ranunculaceae
109	Kalo ginari	C	*Dioscorea pentaphylla* L.	Dioscoreaceae
110	Kane lahara	C	*Tiliacora acuminala* Lamk. Meers.	Menispermaceae
111	Kukurdaino	C	*Smilax lanceifolia* Roxb.	Liliaceae
112	Lahare gayo	C	*Bridelia stipularis* (L.) Blume	Euphorbiaceae
113	Lahare sirish	C	*Dalbergia volubilis* Roxb.	Fabaceae
114	Pakar	C	*Ficus rumphi* Blume	Moraceae
115	Pani lahara	C	*Tetrastigma hookeri* (Lawson) Planch.	Vitaceae
116	Purne lahara	C	*Ampelocissus sikkimenis* (Lawson) Planch.	Vitaceae
117	Tarul	C	*Dioscorea bulbifera* L.	Dioscoreaceae
118	Amliso	H	*Thysanolaena maxima* (Roxb.) Kuntze.	Poaceae
119	Aule	H	*Croton roxburghii* Balakrishnan	Euphorbiaceae
120	Bamboo	H	*Dendrocalamus strictus* (Roxb.) Nees.	Poaceae
121	Ban siru	H	*Hypoxis aurea* Lour.	Hypoxidaceae
122	Banmara	H	*Eupatorium odoratum* L.	Compositae
123	Besar	H	*Chlorophytum arundinaceum* Baker.	Liliaceae

124	Bhede kuro	H	*Barleria cristata* L.	Acanthaceae
125	Bhiringi jhar	H	*Alternanthera sessilis* (L.) Hara	Amaranthaceae
126	Bokre phul	H	*Gnaphalium affine* D. Don.	Compositae
127	Chiraito	H	*Swertia angustifolia* Buch.-Ham. ex D. Don.	Gentianaceae
128	Dubo	H	*Cynodon dactylon* (L.) Pers.	Gramineae
129	Fern	H	*Dryopteris filix-mas* (L.) Schott.	Dryopteridaceae
130	Gai tihare	H	*Blumea balsamifera* (L.) DC.	Compositae
131	Gande	H	*Houttuynia cordata* Thumb	Saurauraceae
132	Ginger	H	*Zingiber chrysanthum* Roscoe.	Zingiberaceae
133	Gol tapre	H	*Tylophora rotundifolia* Buch.-Ham. ex W.	Asclepiadaceae
134	Halhale	H	*Elephantopus scaber* L.	Compositae
135	Jangali kera	H	*Musa superfa* L.	Musaceae
136	Kade jhar	H	*Tridax procumbens* L.	Compositae
137	Kans grass	H	*Saccharum spontaneum* L.	Poaceae
138	Karkale	H	*Colocasium esculenta* (L.) Schott.	Araceae
139	Kettuki	H	*Agave sisalana* L.	Asparagaceae
140	Khar	H	*Imperata cylindrica var. cylindrica* (L.) P. Beauv.	Gramineae
141	Khole ghans	H	*Ixora undulata* Roxb.	Rubiaceae
142	Khole jhar	H	*Lacanthus peduncularis*	Urticaceae
143	Kurilo	H	*Asparagus recemosus subacerosus* Baker.	Liliaceae
144	Lajjawati	H	*Mimosa pudica* L.	Mimosaceae
145	Magarkanche	H	*Begonia picta* Sm.	Begoniaceae
146	Mitha jhar	H	*Scoparia dulcis* L.	Scrophulariaceae
147	Mothe sag	H	*Cyperus rotundus* L.	Cyperaceae
148	Nigalo	H	*Arundinaria intermedia* Munro.	Poaceae
149	Niuro	H	*Ampelopteris prolifera* (Retz.) Copel.	Aspidaceae
150	Sano gabjo	H	*Milletia fruticose* (DC.) Benth.	Leguminosae
151	Sarp gandha	H	*Rauvolfia serpentina* (L.) Benth. ex Kurz.	Apocynaceae
152	Sarpa makai	H	*Arisaema tortuosum var. curvatum* (Roxb.) Engl.	Araceae
153	Sisno	H	*Urtica dioica* L.	Urticaceae
154	Spear grass	H	*Heteropogon contortus* (L.) P. Beauv.	Poaceae
155	Tapre	H	*Cassia tora* L.	Caesalpinaceae
156	Titepati	H	*Artemisia indica* L.	Asteraceae

Note: T = Tree, S = Shrub, C = Climber and H = Herb

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Feeding ecology of Assamese macaques (*Macaca assamensis*) troops in Kaligandaki and Budhigandaki River basins of central Nepal

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Abstract. *Ghimire SC, Khanal L, Chalise MK. 2021. Feeding ecology of Assamese macaques (*Macaca assamensis*) troops in Kaligandaki and Budhigandaki River basins of central Nepal. Biodiversitas 22: 2625-2634.* Seasonal fluctuations in the availability of key food resources impact the foraging behavior of animals. This study aimed to examine the seasonal variations in feeding time of Assamese macaques (*Macaca assamensis*) in the sub-tropical deciduous riverine forest environment of central Nepal. Two troops of Nepal population of Assamese macaques, a troop from Kaligandaki River Basin (KRBT) and the next from Budhigandaki River Basin (BRBT) were studied by focal animal sampling method. Data from systematic behavioral observations were analyzed with reference to that of the vegetation surveys. Assamese macaques invested more than two-fifths (>40%) of the diurnal time on feeding. The KRBT consumed 71 plant species and the BRBT relied on 69 food plants. Leaves, mature and young, constituted the most dominant food item followed by the fruits and seeds. The two study troops inhabiting highly similar habitats of food plants (Sorensen's Similarity Index = 0.93) didn't have a significant difference in the selection of food-plant parts. However, the remarkable temporal difference in feeding plant parts was observed in concordance with their seasonal availability. Young leaves, when available during the spring and pre-monsoon were the major food items. Contrastingly, mature leaves were the food items during the winter on which animals were forced to rely when young leaves were scarce. We conclude that food choice and time investment on the feeding of different plant parts differ depending on the availability of food in the area. Macaques living in comparable habitats with similar food plants have analogous food choices and time investments.

Keywords: Feeding behavior, food choice, *Macaca assamensis*, seasonal variation, time investment

INTRODUCTION

Food availability and other environmental factors, which vary in time and space, influence the activity budgets of primates (Majolo et al. 2013; McFarland et al. 2014). Seasonal variation in food availability results in many primates altering their ranging patterns, activity budget, and/ or showing dietary flexibility in response to the availability of preferred and fallbacks (Hemingway and Bynum 2005; Knott 2005; Grueter 2017). Primates display a wide array of dietary and behavioral adaptations to maintain adequate food during periods of food scarcity (Serckx et al. 2015; Clink et al. 2017). Among them, frugivores tend to have longer daily travel distances than folivores because fruits are usually more patchily distributed than leaves (Chapman et al. 1995). In response to seasonal food shortages, primates often display behavioral plasticity by incorporation of alternate plant parts and human foods including crops and provisioned items. Additionally, they exhibit differences in activity, ranging and grouping patterns (Cabana et al. 2017; Frechette et al. 2017; McLennan et al. 2017). They maximize net energy intake like energy maximizers when high-quality food is most available and adopt an energy-conserving strategy during periods of lower food availability (Ni et al. 2015).

Assamese macaque (*Macaca assamensis*) is one among six extant species under the Sinica-group of macaques (Khanal et al. 2021). It is categorized as Near Threatened by the IUCN Red List of Threatened Species (Boonratana et al. 2020) and listed on Appendix II of the Convention on International Trade in Endangered Species (CITES). Its Nepalese population, one of the least studied primates, is nationally listed as endangered due to its restricted distribution, population threats, and small numbers in fragmented patches of the remaining habitat (Chalise 2013; Khanal et al. 2019). Additionally, a recent phylogenetic analysis has suggested a distinct species status of the Nepal population of the Assamese macaques emphasizing the need for their conservation intervention (Khanal et al. 2021). It has been reported from the mid-hills of Nepal as a sub-tropical habitat specialist and more than half of the population is residing outside the protected area system (Khanal et al. 2019). The sporadically distributed populations in fragmented habitats, isolated by physiographic barriers like rivers and mountains, display variations in both morphology and behavior at different latitudes and elevations (Chalise 2008, 2013; Khanal et al. 2018, 2019). The species has been described as a crop-raider in many parts of Nepal (Chalise 2010; Paudel 2017; Adhikari et al. 2018; Ghimire and Chalise 2018, 2019). However, the details on its socio-ecology and conservation status are yet to be documented.

The Assamese macaque population in Nepal is distributed along with a narrow elevational range of mid-hills (Chalise 2013; Khanal et al. 2019) and it is a habitat specialist requiring broad-leaved riverine forest (Khanal et al. 2019). They live primarily in subtropical broadleaved forests. They spend a great deal of time in the high canopy and are also seen on the ground (Chalise 2003). More than half of the population currently resides outside protected areas of Nepal (Khanal et al. 2019) and incidents of human-macaque conflict, especially driven by crop-raiding, are high. Therefore, this species' socio-ecology and general ecology need to be examined in detail as such information could be of great importance to the conservation of this macaque species.

Understanding the temporal availability of food to a particular species is crucial when examining the drivers of their feeding strategies (Bessa et al. 2015). Assamese macaques are habitat specialists with a narrow home-range for which the distribution is mainly concentrated in the riverine broad-leaved forests. Such areas experience a remarkable seasonal variation in resource availability. However, the response of the macaques to such variations in the accessibility of food resources is understudied in Nepal. Therefore, this study assessed how seasonal changes in food availability influence the feeding behavior of Assamese macaques. Over a twelve-month period, data from systematic behavioral observations were analyzed with reference to that of the vegetation surveys. We aimed to explore i) major food plants and their parts for the macaque, and, ii) temporal variations in food preference by the Assamese macaques in two different river basins. By the analysis of feeding time investment on different food items, this study improves our understanding of the feeding ecology of Assamese macaques living in the riverine forests of Kaligandaki and Budhigandaki rivers in central Nepal.

MATERIALS AND METHODS

Study area

This study was conducted for 12 months from February 2015 to January 2016 at Kaligandaki River Basin and Budhigandaki River Basin of central Nepal (Figure 1). Kaligandaki River Basin (KRB, Ramdi to Ranimahal covering about 80 km^2) is situated between 27°54'9.34" to 27°92'67"N and 83°38'3.00" to 83°52'78"E including areas of Palpa and Syangja districts (Figure 1). The altitude ranges from 420 m to 656 m above sea level (asl). The mean annual maximum and minimum temperatures of the area are 26.91ºC and 15.18ºC, respectively. This area is rich in biodiversity, which may be due to the presence of alluvial soil along the basin of the Kaligandaki river and high productivity of tropical deciduous riverine forest (Chalise 2013). Mixed types of forest especially tropical deciduous riverine forest, sub-tropical grassland and sub-tropical evergreen forests found in the study area.

Budhigandaki River Basin (BRB, Benighat to Arughat, covering about 192 km^2) is an area of Dhading and Gorkha districts. The study area lies about 2 km north of the confluence of Budhigandaki River with Trishuli River. The study area is situated between 27°48'54.48" to 28°04'68"N and 84°46'33.63" to 84°81'25"E. The altitude ranges from 342 m to 582 m asl. The mean annual maximum and minimum temperatures of the area are 28.15ºC and 16.15ºC, respectively. The area has mixed types of forest especially tropical deciduous riverine forest, sub-tropical grassland, and sub-tropical evergreen forests. Aerial distance between the Kaligandaki riverside (Ramdi) to Budhigandaki riverside (Benighat) is 112.99 km. Study areas have four distinct seasons viz. spring (March-May), summer (June-August), autumn (September-November) and winter (December-February).

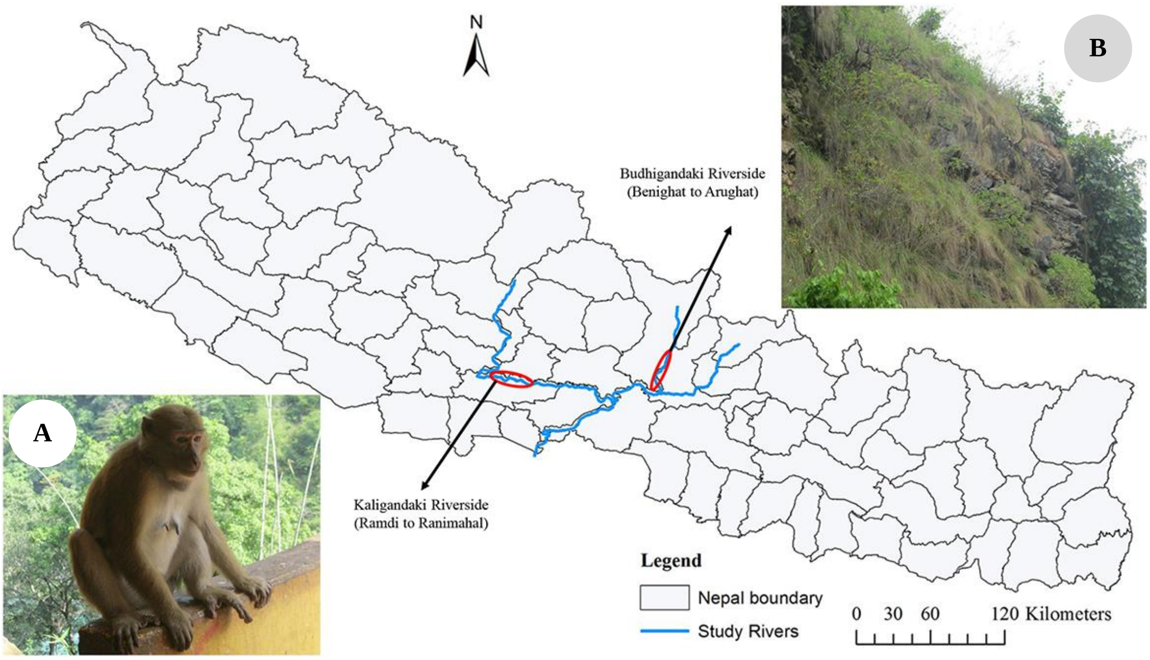

Figure 1. Map of Nepal indicating the study area (Kaligandaki and Budhigandaki River basins) in central Nepal. Photos in the inset indicate: A. An adult female Assamese macaque from KRBT; B. The BRBT troop resting on their resting site

Research troops, vegetation and behavioral survey

Kaligandaki River Basin Troop (KRBT) inhabiting on Ramdi area in Syangja and Budhigandaki River Basin Troop (BRBT) inhabiting the Siurenitar area of the Gorkha district were studied as focal troops from the two river basins. The KRBT had a troop size of 18 individuals (3 adult males, 5 adult females, 3 young males, 2 young females and 5 infants) and the BRBT had 14 individuals (2 adult males, 4 adult females, 3 young males, 3 young females, 2 infants). Behavioral observations of each troop were made for 5 to 7 days each month. The same observer (SCG) observed KRBT and BRBT non-simultaneously for almost equal number of hours. The total observation time for the KRBT was 716 hours whereas the same for the BRBT was 691 hours. Behavioral data were recorded by the focal animal sampling method (Altmann 1974). The individuals of the focal troop of both the study area were identified with the help of different external characters and appearances such as facial features, skin color, cut marks, tail carriage, fur color and body structure.

The diurnal time was divided into four observational sessions, i.e. 06.00-09.00, 09.00-12.00, 12.00-15.00 and 15.00-18.00 hours. One adult focal animal was observed during each session continuously for 60 minutes and then switched to the next focal individual. All behavioral patterns of the focal animal and all behavior directed towards it by troop members were recorded. The choice of an individual was randomly determined among the adults prior to the observation. When the focal individual under observation was partially obscured or moved completely out of sight, the recording was stopped until it was visible again (Altmann 1974; Martin and Bateson 1993).

A total of 16 quadrates (total 32 quadrates for two troops) each of 20 × 20 m^2 were laid on the habitat of each study troop. The distance between the successive quadrates was maintained above 20 m. All the trees within the quadrates were identified to the species level, counted and their diameter on breast height was measured at approximately 1.5 m above the ground. Data on the feeding behavior of Assamese macaques including food plants, food items and feeding time were collected by direct observation in the field following the methods as in Chalise et al. (2013). Different kinds of food plants and parts of plants, including young leaves, mature leaves, fruits, flowers, seeds, barks, and others, which the macaques ate, were noted in datasheet. The food species and plant parts were listed daily and a collective food list of Assamese macaque of each area was pooled.

Data analysis

All data were entered in Microsoft Excel and then analyzed primarily with descriptive statistics using the program Statistica for Windows release 7.0. Data on tree species from the vegetation survey were used to calculate the relative density and relative frequency of the trees.

$$\text{Relative density} = \frac{\text{Density of the species}}{\text{Total density of all the species}} \times 100$$

$$\text{Relative freq.} = \frac{\text{Frequency values of the species}}{\text{Sum of frequency of all the species}} \times 100$$

In order to calculate the similarity in food preference between the two study troops, Sorensen's Similarity Index (S_s) was calculated as follows:

$$S_s = \frac{2a}{2a + b + c}$$

Where:

S_s : Sorensen's similarity coefficient

a : Number of food plants in both communities (joint occurrences)

b : Number of food plants in KRBT but not in BRBT

c : Number of food plants in BRBT but not in KRBT

For overall behavioral data analysis, mean values among the focal animals of each troop were used for the monthly distribution of time spent on different behavioral states and events including feeding. Being specific to feeding, the time spent feeding different food plants and their parts were calculated and expressed in percentages. The difference in time investment in feeding specific plant parts between the two troops were tested for the significance by Kruskal-Wallis H test. The percentage time spent on particular food item was calculated as:

$$\text{Percentage time spent on particular food item} = \frac{\text{Total time spent on a particular food}}{\text{Total time spent on feeding}} \times 100$$

RESULTS AND DISCUSSION

Food items and feeding behavior

Out of the total observation time (716 hours), the KRBT spent 294.7 hours (41.16%) on feeding. Similarly, the BRBT was observed for 691 hours out of which, 306.5 hours (44.36%) was invested in feeding. The highest percentage of time invested on feeding was in January and the least was in August for both the troops (Table 1).

The KRBT fed on 71 different plant species (45 tree species, 11 shrub species, 10 herb species and 5 climber species) and the BRBT fed on 69 plant species (43 tree species, 12 shrub species, 10 herb species and 4 climber species) (Table S1). Among them, 65 food plants were common between the sites that resulted in Sorensen's Similarity Index of 0.93. The trees like *Trichilia connaroides* dominated the habitat of the KRBT, *Schima wallichii*, *Aegle marmelos*, *Ficus hispida*, etc. whereas that of the BRBT was dominated by *Shorea robusta*, *Adina cordifolia*, *Lagerstroemia parviflora*, *Spondias pinnata*, etc. (Table 2). The KRBT used the leaf of *Albizzia chinensis* as their major food plant throughout the year, whereas BRBT used leaves of *Lagerstroemia parviflora* as a major food. The two troops had invested different percentage of time on feeding different plant parts (fruits, mature leaves, young leaves, seeds, flowers, barks, rhizomes) (Figure 2), however, Kruskal-Wallis H test (H = 0.3891, Hc = 0.3918, P = 0.5314) revealed no significant difference on time investment between the two study troops.

Monthly variation of time spent on major food items

Leaves (mature and young), fruits and seeds constituted the major food items (on which macaques invested longer time on feeding or they contributed larger amount of food) of Assamese macaques in both the study troops (Figure 3). The mean time spent for mature leaf-eating was 30.02% (S^2 = 389.6, CV = 65.7) per year by the KRBT and 29.04% (S^2 = 396.9, CV = 68.6) per year by the BRBT. The time spent for mature leaf-eating fluctuated between the months (Figure 3.A). Mature leaves were the major food items for macaques during the winter season (November-January), whereas, the same was less consumed during the spring season (March-May). The mean time spent for feeding young leaf was 19.56% (S^2 = 170.4, CV = 66.7) per year by the KRBT and 20.70% (S^2 = 218.6, CV = 71.4) per year by the BRBT. Consumption of young leaves was the highest during the spring and early summer (March-June) whereas the least during the winter season (Figure 3.B). In the spring season (March, April, and May), new young leaves emerged and were available to the macaques in higher amounts. After the rainy season, leaves become more mature, and in winter, defoliation starts.

Table 1. Monthly feeding time (% of the total observation time) for KRBT and BRBT

Month	KRBT (%)	BRBT (%)
February 2015	52.61	56.42
March	55.23	57.64
April	32.65	34.96
May	31.46	33.83
June	34.33	38.71
July	30.54	34.33
August	24.45	25.92
September	32.42	34.22
October	42.12	46.26
November	48.11	54.72
December	53.64	57.12
January 2016	56.34	58.18
Mean (%)	41.16	44.36

Table 2. Dominant 20 tree species of the Assamese macaque habitats in the study areas

KRBT			BRBT		
Tree species	Relative density	Relative frequency	Tree species	Relative density	Relative frequency
Trichilia connaroides	35.68	8.38	*Shorea robusta*	29.75	8.87
Schima wallichii	18.76	6.58	*Adina cordifolia*	12.82	6.50
Aegle marmelos	9.79	5.38	*Lagerstroemia parviflora*	8.12	4.73
Ficus hispida	8.51	4.79	*Spondias pinnata*	5.98	4.73
Albizzia chinensis	7.65	4.79	*Terminalia alata*	3.41	4.14
Madhuca longifolia	6.53	4.19	*Phyllanthus emblica*	3.41	4.14
Aporosa octandra	6.36	4.19	*Mallotus philippensis*	3.16	4.14
Toona ciliata	5.59	4.19	*Schima wallichii*	3.06	4.14
Semecarpus anacardium	3.96	3.59	*Albizzia chinensis*	2.90	4.14
Ficus hederacea	3.82	3.59	*Aporosa octandra*	2.53	3.55
Lannea coromandelica	3.45	3.59	*Madhuca longifolia*	2.39	3.55
Butea minor	2.36	3.59	*Trichilia connaroides*	2.39	3.55
Uraria lagopodioides	1.98	3.59	*Toona ciliata*	1.96	3.55
Acacia catechu	1.98	3.59	*Butea minor*	1.59	3.55
Terminalia bellirica	1.63	2.99	*Acacia catechu*	1.45	2.95
Lagerstroemia parviflora	1.63	2.99	*Ficus hederacea*	1.33	2.95
Hymenodictyon excelsum	1.45	2.39	*Terminalia bellirica*	1.33	2.95
Castanopsis indica	1.45	2.39	*Sapindus mukorossi*	1.19	2.36
Erythrina variegata	1.45	2.39	*Terminalia chebula*	1.19	2.36
Sapindus mukorossi	1.04	1.79	*Erythrina variegata*	1.19	2.36

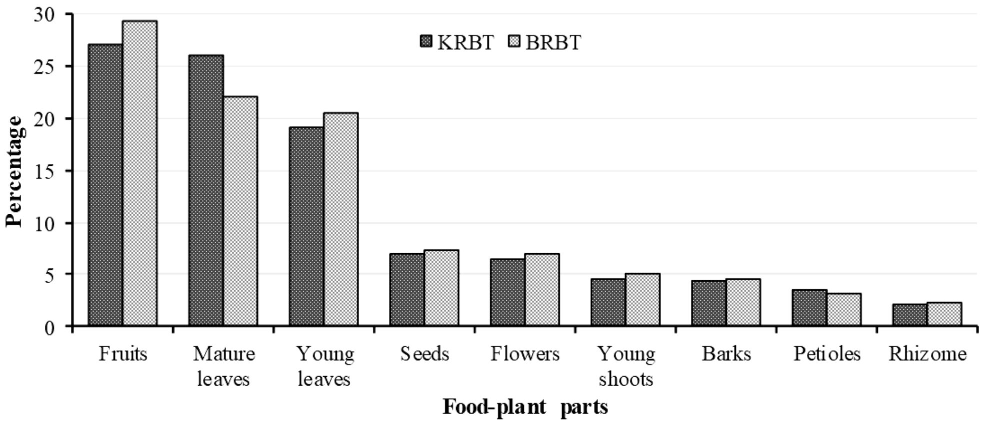

Figure 2. Percentage of time invested on different food-plant parts by the KRBT and BRBT of Assamese macaques (Based on Table S1)

Fruits are a patchy and clumped seasonal resource available in lower density than leaves in the study area. The mean time spent for fruit-eating was 23.80% (S^2 = 226.5, CV = 63.2) per year by KRBT and 25.96% (S^2 = 195.3, CV = 53.8) per year by BRBT (Figure 3.C). Availability of fruits, and hence their consumptions were higher during the early monsoon and winter seasons. The time spent on fruits had two peaks and two faults in a year (Figure 3.C). June-July and November-December were the rising peaks while August-September and January-April were falling faults whereas May and October had contributed near an average time spent for fruits. Seeds were another major food item for the macaques. The mean time spent for seed-eating was 2.71% (S^2 = 5.8, CV = 88.5) per year by the KRBT and 2.07% (S^2 = 3.6, CV = 92.2) per year by the BRBT (Figure 3.D). The seed-eating time percentage was higher during the spring season (March, April), and the time spent was lesser in the months of the beginning of the winter season (November, December) in both study areas.

Monthly variation of time spent on feeding accessory plant parts

The accessory plant parts that formed the component of Assamese macaque food were young shoots, barks, flowers, and petioles (Figure 4). The mean time spent for young shoot eating was 2.00% (S^2 = 4.4, CV = 105.3) per year by the KRBT and 1.50% (S^2 = 1.1, CV = 69.2) per year by the BRBT. The consumption o young shoot peaked twice in a year, once during the late spring and the next during the autumn (Figure 4.A). The average time spent on eating flowers over the year was 0.95% (S^2 = 1.1, CV = 112.8) for the KRBT and 0.85% (S^2 = 0.6, CV = 92.8) for the BRBT. A high peak of the abundance of flower was during the spring season (March and April) and concordance to this the time spent on flowers was highest in April (03.86% for the KRBT and 02.81% for BRBT).

The KRBT spent an average 0.12% (S^2 = 0.0, CV = 88.4) while the BRBT spent average 0.22% (S^2 = 0.1, CV = 104.6) of annual time on bark eating over the year. There was no distinct seasonal pattern on barks consumption. The mean time spent for petiole eating was 0.36% (S^2 = 0.1, CV = 93.5) per year by the KRBT and 0.42% (S^2 = 0.1, CV = 67.7) per year by the BRBT. Petiole consumption peaked during the spring season.

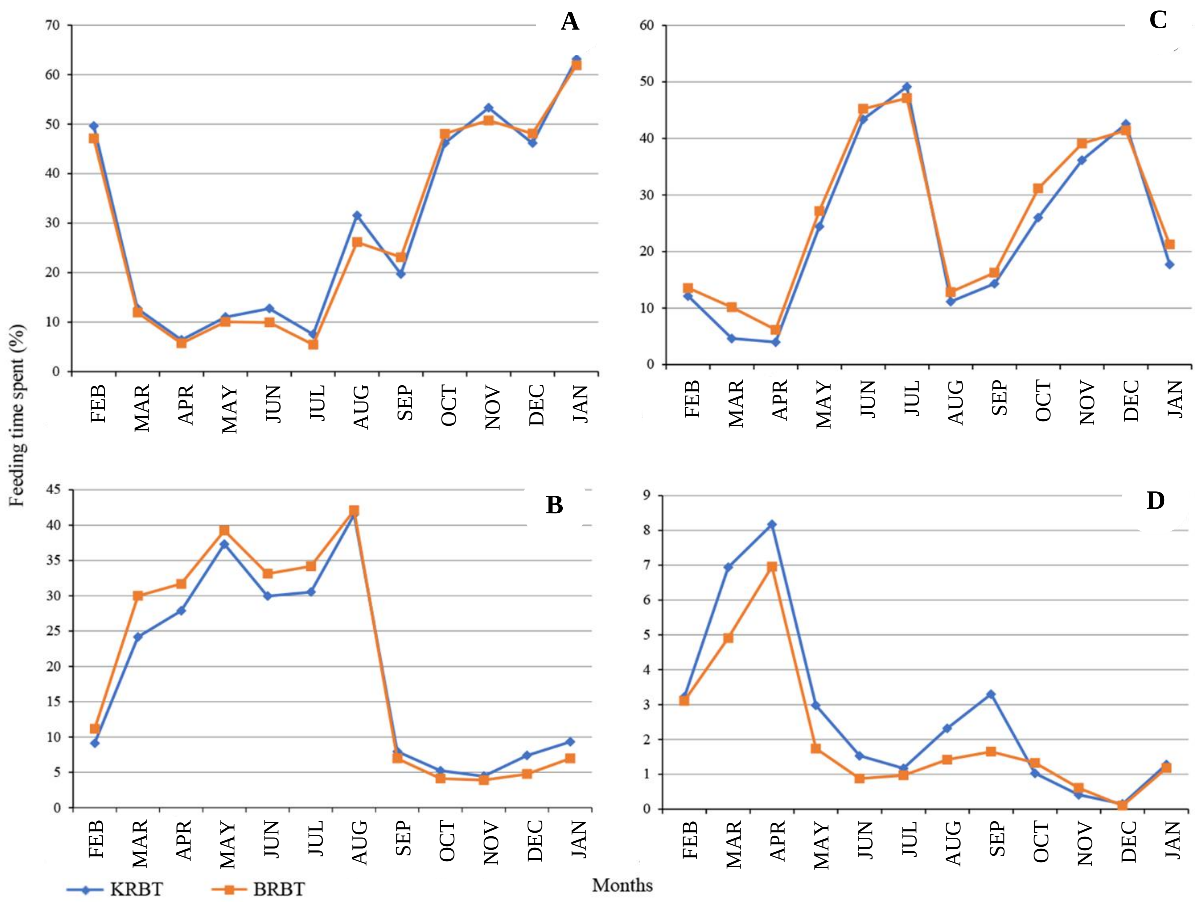

Figure 3. Monthly variation in time spent on feeding major food items by two study troops (KRBT and BRBT) of Assamese macaques; A. Mature leaves, B. Young leaves, C. Fruits, and D. Seeds.

Monthly variation of time spent on other food items

Apart from the aerial plant parts, Assamese macaques were observed consuming other food items, including the rhizome, invertebrates, licking on stone and soil eating (geophagy) (Figure 5). The average time spent on rhizome eating over the year was 0.73% (S^2 = 0.5, CV = 100.5) for the KRBT and 1.02% (S^2 = 0.8, CV = 87.1) for the BRBT. The highest time spent on rhizome eating was recorded during the spring season for both the study troops.

Invertebrates were foraged with an average time of 2.90% (S^2 = 20.4, CV = 155.8) per year by the KRBT and 2.43% (S^2 = 11.6, CV = 139.9) per year by the BRBT. The invertebrate-eating peak time was observed during February and March. Additionally, stone licking and geophagy were the remarkable phenomena of eating inorganic foods observed in both the study troops which licked stones in the sides of both the rivers (Kaligandaki and Budhigandaki). The mean time spent for stone licking was 2.04% (S^2 = 5.5, CV = 115.3) per year by the KRBT and 1.40% (S^2 = 3.9, CV = 141.3) per year by the BRBT. Stone licking was consistently higher in KRBT than the BRBT except for August. The mean time spent for geophagy was 0.55% (S^2 = 0.3, CV = 92.5) per year by the KRBT and 0.33% (S^2 = 0.1, CV = 83.9) per year by the BRBT. Soil eating was highest during March at 01.95% for Kaligandaki while during September at 00.95% for Budhigandaki.

Apart from plant parts consumption and geophagy, both the troops of Assamese macaques were observed drinking water and occasionally feeding on the wastes. The mean time spent for water drinking was 0.99% (S^2 = 0.8, CV = 90.1) per year by KRBT and 0.90% (S^2 = 0.7, CV = 90.5) per year by BRBT. The average time spent for waste eating was 0.21% (S^2 = 0.1, CV = 129.5) per year by the KRBT and 0.13% (S^2 = 0.0, CV = 85.9) per year by the BRBT.

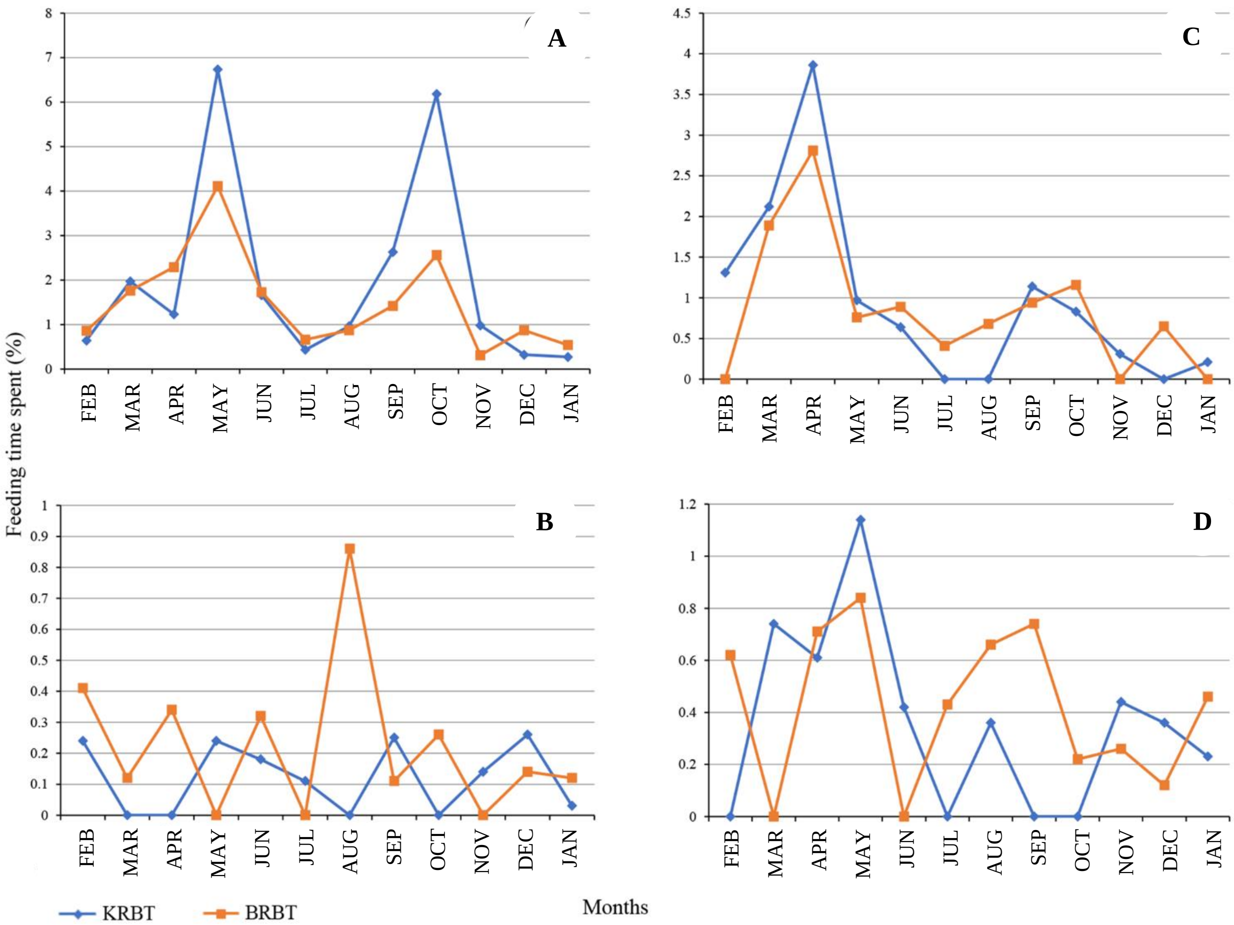

Figure 4. Monthly variation in time spent on feeding accessory plant parts by two study troops (KRBT and BRBT) of Assamese macaques; A. Young shoots, B. Barks, C. Flowers, D. Petioles

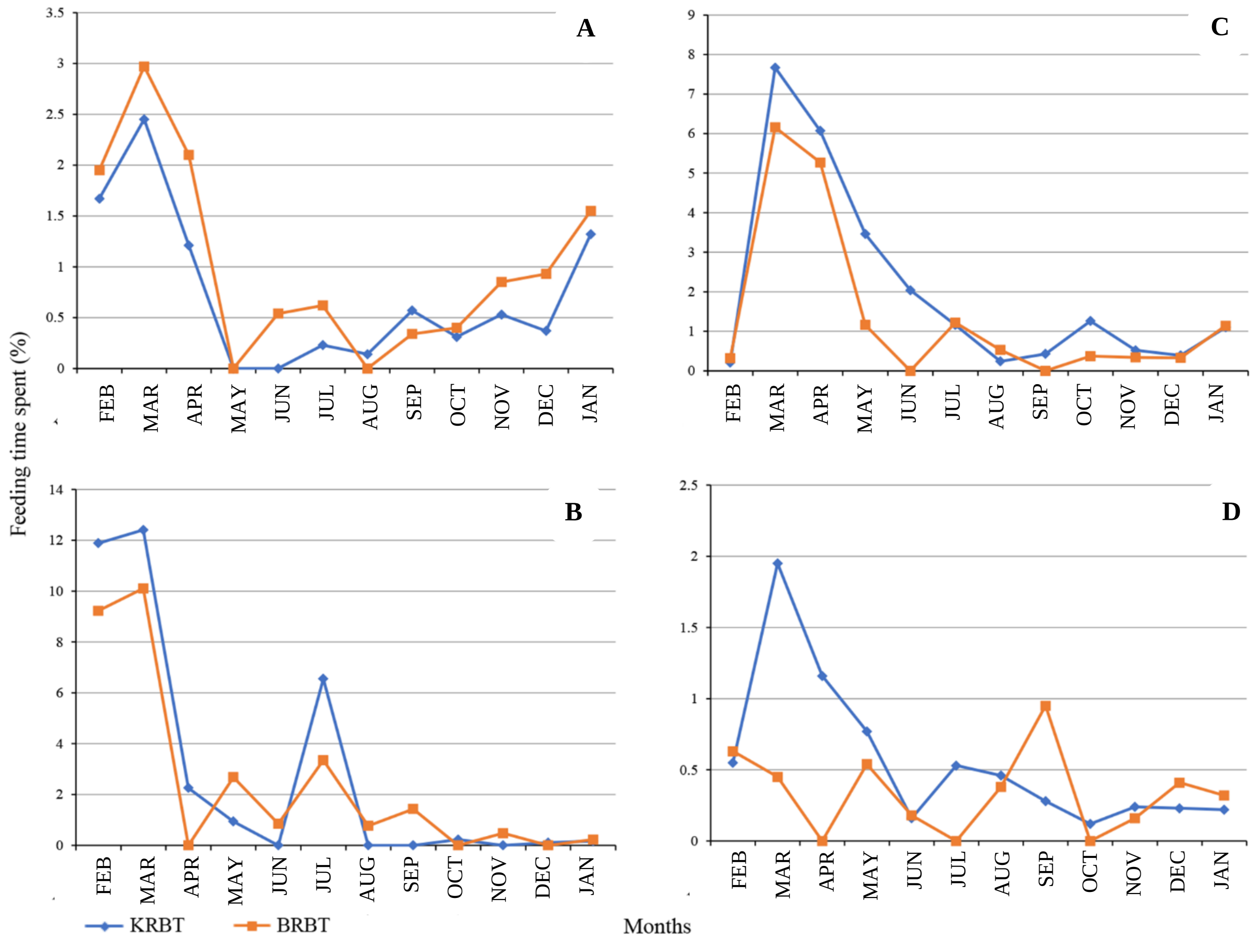

Figure 5. Monthly variation in time spent on accessory food items by two study troops (KRBT and BRBT) of Assamese macaques; A. Rhizome, B. Invertebrates, C. Stone licking, D. Soil eating (geophagy)

Discussion

Assamese macaques in central Nepal invested majority (>40% on average) of their diurnal time on feeding. They devoted more than half of the diurnal time to feeding and foraging during the winter months (December-February) when resources were limited in cold and dry periods. There appears to be a strong seasonality in the availability of food resources in the area, and macaques show plasticity in selecting the food items according to their availability. Similar to our findings, Assamese monkeys in Nonggang Nature Reserve, China spend a greater proportion of time on feeding and less time on resting and grooming in the dry season than in the rainy season (Zhou et al. 2007). Monkeys feed on low-quality, subsistence foods, such as mature leaves, when high-quality foods, such as fruits and young leaves are scarce (Zhou et al. 2006).

Assamese macaques in the study area depicted food specialist nature showing their higher dependence on the less dominant food plants of the habitat. The dominant plants of the habitat were not always the first choice of food for Assamese macaques. The habitat of the KRBT was dominated by the plants like *Trichilia connaroides*, *Schima wallichii*, *Aegle marmelos*, etc., however, the most consumed plant parts were from relatively less abundant *Albizzia chinensis*. The BRBT inhabits the area of higher abundance of *Shorea robusta*, *Adina cordifolia*, *Lagerstroemia parviflora*, etc. and the species third in the rank was the most preferred food plant. Among the different plant parts, leaves formed the major bulk in the diet of Assamese macaques. Although described as omnivorous (Boonaratana et al. 2020), they are primarily dependent upon leaves, fruits and seeds.

The observations on feeding habits revealed that Assamese macaques are adaptable foragers able to modify their diet seasonally, being more folivorous in the dry season and more frugivorous in the wet season. Due to the seasonal variation on availability of different food items, the Assamese macaques had to shift their preference for major food items seasonally. In highly seasonal habitats, food availability is not even over the year, and species cannot rely entirely on preferred foods. Instead, they are expected to include less preferred fallback foods in their diet during a certain period of the year (Marshall and Wrangham 2007). Therefore, it is expected that omnivorous species tune their feeding patterns to seasonal resource availability. Furthermore, climate change is predicted to have significant effects on plant phenology and vegetation structure (Chapman et al. 2005). The seasonal pattern of fruit production sometimes becomes more important than habitat characteristics in determining the diet of primates (Dunn et al. 2010). Seasonal variation in the diet of Assamese macaques was clearly linked to seasonal fluctuation in food availability. For example, they relied heavily on young leaves during the spring season during which consumption of the mature leaves dropped. Such a relationship has been widely demonstrated in primates (Simmen et al. 2003; Norsica et al. 2006). Animals that live in seasonally changing environments concentrate on specific food sources that are available all year round or vary their diet in relation to seasonal changes in availability (Guo et al. 2007).

Assamese macaques are mostly folivores, and the time spent on leaf-eating (mature and young) was nearly half (49.58% in KRBT and 49.74% in BRBT) of their total feeding time. Similar to our findings, young leaves were stapled food items for Assamese macaques inhabiting limestone forests in Nonggang, China, which constituted the bulk of monthly diets almost yearly (Zhou et al. 2011; Huang et al. 2015). There was no significant difference in time investment on different food items between the KRBT and BRBT of Assamese macaques. Koirala et al. (2017) observed significant difference in feeding time investment and diurnal activity pattern between two troops of Assamese macaques, one of which was wild and the other was partially supplemented waste foods. Adhikari et al. (2018) also observed significant alteration in the behavior of a troop of Assamese macaque supplemented human food. Both the troops of this study are in a similar ecological set up of deciduous rainforest and also have highly similar food plant preferences, which might have caused almost similar investment of time on feeding and food selection.

Among other food items apart from leaves, the amount of time invested on fruits, flowers, and seeds was high. It suggests that Assamese macaques like to avoid leaves (especially mature) and try to intake other more nutritive food whenever possible. The species in Thailand has been reported to invest the largest part of feeding time (42.4%) on fruits (Schulke et al. 2011). In Nonggang Nature Reserve, China, Assamese macaques invested less than 20% time on feeding fruits, suggesting their folivorous habits (Zhou et al. 2011; Huang et al. 2015). Some primates eat barks during the dry season when the least amount of food is available, providing food with water (Sugiyama 1964). Bark assumed leading importance in the diet of Bornean orangutans when major fruits did not ripen (Nishida 1976). Bark eating was recorded in Assamese macaques when young leaves and fruits were under-supplied. It suggests that Assamese macaques utilize bark as food whenever other foods are less abundant.

The availability of food in the deciduous forests of Kaligandaki River Basin and Budhigandaki River Basin is highly seasonal. The effect of such seasonality on food availability is reflected in the feeding behavior of Assamese macaques. Food distribution determines search strategies and animal movement patterns that in turn affect the time investment on feeding (Reyna-Hurtado et al. 2018). Species that experience large and unpredictable seasonal variations in food availability tend to grow and reproduce at slower rates than species with more predictable environments (Wright et al. 2015). During the scarcity of high-energy foods, animals reduce most energy-demanding activities, travel less and over shorter distances, but use their home range more broadly (Nagy-Reis and Setz 2017). Similar to these observations, Assamese macaques in central Nepal switched between the young leaves and mature leaves according to their availability, but the higher preference was to the young leaves.

In conclusion, the Assamese macaques of Kaligandaki and Budhigandaki river basins contributed to leaf-eating, followed by fruits and seeds. Assamese macaques in Kaligandaki River Basin frequently utilized leaves of *Albizzia chinensis* and that of Budhigandaki River Basin chose leaves of *Lagerstroemia parviflora* as their major food plant throughout the year. This indicates that Assamese macaques of both river basins are mostly folivorous. Food choice and time investment on the feeding of different plant parts may differ depending on the food availability in the area. Macaques living in the wild at comparable ecological setups with similar nutrient concentrations of staple foods have analogous food choices and time investments.

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Table S1. List of food plants and their parts used by Assamese macaque troops

KRBT		BRBT	
Scientific name	**Part used as food**	**Scientific name**	**Part used as food**
Acacia catechu	Mature leaf	*Acacia catechu*	Mature leaf
Aegle marmelos	Fruit	*Adina cardifolia*	Young leaf
Albizzia chinensis	Mature leaf, young leaf	*Aegle marmelos*	Fruit
Alstonia scholaries	Young leaf	*Albizzia chinensis*	Mature leaf, young leaf
Anthocephalus chinensis	Young leaf, flower	*Alstonia scholaries*	Young leaf
Antidesma acidum	Mature leaf	*Anthocephalus chinensis*	Young leaf, flower
Antidesma ghaesembilla	Mature leaf	*Antidesma acidum*	Mature leaf
Aporusa octandra	Young leaf, flower	*Aporusa octandra*	Young leaf, flower
Ardisia solanacea	Fruit	*Ardisia solanacea*	Fruit
Arisaema tortuosum	Seed	*Arisaema tortuosum*	Seed
Arundinaria intermedia	Young shoot	*Arundinaria intermedia*	Young shoot
Bauhinia purpurea	Fruit, young shoot	*Bauhinia purpurea*	Fruit, young shoot
Bauhinia vahlii	Seed	*Bauhinia vahlii*	Seed
Bauhinia variegata	Flower, bark	*Bauhinia variegata*	Flower, bark
Begonia picta	Mature leaf	*Berberis asiatica*	Fruit
Berberis asiatica	Fruit	*Bombax ceiba*	Young leaf
Bombax ceiba	Young leaf	*Callicarpa arborea*	Mature leaf
Callicarpa arborea	Mature leaf	*Castanopsis indica*	Seed
Castanopsis indica	Seed	*Castanopsis tribuloides*	Seed
Castanopsis tribuloides	Seed	*Colebrookea oppositifolia*	Flower
Colebrookea oppositifolia	Flower	*Colocasium esculenta*	Young leaf
Colocasium esculenta	Young leaf	*Cynodon dactylon*	Mature leaf
Cynodon dactylon	Mature leaf	*Dendrocalamus strictus*	Young shoot
Dendrocalamus strictus	Young shoot	*Dioscorea bulbifera*	Rhizome, young leaf, petiole
Dioscorea bulbifera	Rhizome, young leaf, petiole	*Diploknema butyracea*	Fruit
Diploknema butyracea	Fruit	*Dryopteris filix-mas*	Mature leaf
Dryopteris filix-mas	Mature leaf	*Eupatorium odoratum*	Young leaf, petiole
Eupatorium odoratum	Young leaf, petiole	*Ficus benghalensis*	Fruit
Ficus benghalensis	Fruit	*Ficus benjamina*	Fruit
Ficus benjamina	Fruit	*Ficus hispida*	Fruit, bark
Ficus hispida	Fruit, bark	*Ficus lacor*	Young leaf
Ficus lacor	Young leaf	*Ficus nervosa*	Young leaf
Ficus nervosa	Young leaf	*Ficus racemose*	Young leaf
Ficus racemose	Young leaf	*Ficus religiosa*	Fruit
Ficus religiosa	Fruit	*Ficus sarmentosa*	Fruit
Ficus sarmentosa	Fruit	*Hedyotis lineata*	Bark, petiole
Hedyotis lineata	Bark, petiole	*Justicia adhatoda*	Flower
Justicia adhatoda	Flower	*Lagerstroemia parviflora*	Young leaf
Lannea coromandelica	Young leaf, flower	*Lannea coromandelica*	Young leaf, flower
Madhuca longifolia	Mature leaf	*Madhuca longifolia*	Mature leaf
Maesa montana	Mature leaf, young shoot	*Maesa montana*	Mature leaf, young shoot
Magnifera indica	Fruit	*Magnifera indica*	Fruit
Mallotus philippensis	Mature leaf	*Mallotus philippensis*	Mature leaf
Melastoma malabathricum	Fruit	*Melastoma malabathricum*	Fruit
Melia azedarach	Mature leaf	*Melia azedarach*	Mature leaf
Michelia champaca	Young leaf	*Michelia champaca*	Young leaf
Milletia extensa	Mature leaf	*Milletia extensa*	Mature leaf
Milletia fruticose	Mature leaf	*Milletia fruticose*	Mature leaf
Morus macroura	Fruit, mature leaf	*Morus macroura*	Fruit, mature leaf
Musa superfa	Fruit	*Myrica esculenta*	Fruit, mature leaf
Myrica esculenta	Fruit, mature leaf	*Osyris wightiana*	Mature leaf
Odina wodier	Mature leaf	*Phyllanthus emblica*	Fruit, mature leaf
Osyris wightiana	Mature leaf	*Prunus cerasoides*	Fruit, mature leaf
Phyllanthus emblica	Fruit, mature leaf	*Pyrus pashia*	Fruit
Premna scandens	Mature leaf, young leaf	*Rubus ellipticus*	Fruit
Prunus cerasoides	Fruit, mature leaf	*Rubus rugosus*	Fruit
Pyrus pashia	Fruit	*Shorea robusta*	Young leaf, flower
Rubus ellipticus	Fruit	*Spondias pinnata*	Fruit
Rubus rugosus	Fruit	*Syzygium cumini*	Fruit, young leaf
Shorea robusta	Young leaf, flower	*Syzygium jambos*	Fruit
Sphaerosacme decandra	Mature leaf	*Terminalia alata*	Young leaf, seed, bark
Spondias pinnata	Fruit	*Terminalia bellirica*	Fruit
Syzygium cumini	Fruit, young leaf	*Terminalia chebula*	Fruit, mature leaf
Syzygium jambos	Fruit	*Thysanolaena maxima*	Young shoot
Terminalia alata	Young leaf, seed, bark	*Toona ciliata*	Mature leaf
Terminalia bellirica	Fruit	*Trichilia connaroides*	Fruit
Terminalia chebula	Fruit, mature leaf	*Woodfordia fruiticosa*	Mature leaf, young leaf, flower
Thysanolaena maxima	Young shoot	*Zizyphus mauritiana*	Fruit
Toona ciliata	Mature leaf	*Zizyphus rugose*	Fruit
Trichilia connaroides	Fruit	–	–
Woodfordia fruiticosa	Mature leaf, young leaf, flower	–	–

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Research Article

CROP RAIDING STATUS BY ASSAMESE MONKEYS (*Macaca assamensis*) ALONG THE KALIGANDAKI RIVER, WESTERN NEPAL

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ABSTRACT

A study on Assamese monkeys (*Macaca assamensis*) in Kaligandaki river basin at Ramdi of Palpa and Syangja districts of western Nepal was performed. The field study was conducted from February 2015 to January 2016 spending 1804 hours to explore the ecology and feeding behavior of Assamese macaque. The study mainly focused the Ramdi village area. A total of 24 individuals of Assamese monkeys were counted towards Palpa district and 18 individuals were counted towards Syangja district. Crop raiding status was examined each year by questionnaire survey method for local household villagers as well as direct observation by the researcher. It was found that maize (47.14 %) was the highest raided among the crops, followed by fruits (16.43 %), wheat (11.13 %), millet (5.72 %), rice (4.58 %), potato (4.27 %), lentil (4.07 %), mustard (1.26 %), pumpkin (1.14 %), bread (0.96 %), brown lentil (0.81 %), broad beans (0.80 %), sesame (0.60 %), black pulses (0.35 %), dal (0.20 %), cauliflower (0.14 %), tomato (0.1 %), egg (0.1 %), *samosa* (0.1 %) and gram (0.1%).

Keywords: *Macaca assamensis*, Crop raid, Questionnaires, Local villagers, Kaligandaki riverside

INTRODUCTION

Among several species of macaques found in the world, three species have been reported from Nepal. These are the Rhesus macaque (*Macaca mulatta*, Zimmerman 1780), Hanuman Langur (*Semnopithecus entellus*, Dufresne 1797) and the Assamese macaque (*Macaca assamensis*, McClelland 1839). Information on the distributions, behavioral ecology and conservation status of these species are provided by Bishop (1979), Southwick *et al*. (1982), Johnson *et al*. (1988), Jackson (1990), Chalise (1995, 1997, 1998, 1999, 2000, 2000a, 2000b), Chalise *et al*. (2001) and Khanal *et al.* 2018. *Macaca assamensis* inhabits the foot-hills of the Himalayas and the adjoining mountain chains of south-east Asia including Nepal, Bhutan, north-eastern India, northern and eastern Burma, southern China, northern and western Thailand, Laos and northern Vietnam, besides an isolated record in south-western Bangladesh.

The species of Assamese macaque was recorded from north Thailand ranging from 610 m to 1830 m above the sea level (asl) (Sanjay *et al*. 2003). Chalise (2013) recorded it from 284 m asl in Abukhaireni, Tanahu to 2350 m asl in Langtang of Nepal. It was reported to cover wider geographic ranges, with fragmented population, distributed along rivers in the tropical and subtropical areas. In Nepal, the reported areas of Assamese monkeys covered Kankai valley of Ilam, Sabhaya valley and its range further extended west to Makalu-Barun National Park, Melamchi, Langtang National Park (Chalise 2003), Nagarjun area of Shivapuri Nagarjun National Park, Makwanpur, Dhading, Myagdi, Ramdi of Palpa and Syangja districts, Achham district (Chalise, 2003 & 2008; Wada, 2005), Baglung and Parbat to Chamelia river basin at 1607 m asl of Api Nampa Conservation Area (Chalise, 2013).

Assamese monkeys have been categorized as endangered species by International Union for Conservation of Nature (IUCN) red list category and one of the protected species by National Parks and Wildlife Conservation Act 1973 due to the low population and conservation threats (Jnawali *et al*. 2011). They are kept as Appendix II of Convention on International Trade in Endangered Species (CITES) (Chalise 2013).

MATERIALS AND METHODS

Study area

The study was carried out in Ramdi village area of Palpa and Syangja districts of Lumbini and Gandaki zones, respectively. It lies in the western developmental region of Nepal, but according to the constitution of Nepal 2015, Palpa district lies in Province No. 5 and Syangja district lies in Province No. 4. The study area, Ramdi village area lies about 27 km east of Tansen of Palpa district, at the mid-point of Siddhartha (Sunauli-Pokhara) Highway. The study area is situated between 27°54'9.34" N latitude and 83°38'3” E longitude. The altitude is 433 m above the sea level.

This area is rich in biodiversity which may be due to presence of alluvial soil along the basin of Kaligandaki River and high productivity of tropical deciduous riverine forest (Chalise 2013). Mixed type of forest especially tropical deciduous riverine forest, sub-tropical grassland and sub-tropical evergreen forest are the forest types found in the study area.

Methods

Information on the data of crop raiding were collected each year from local household villagers as per the pre-set questions format as well as by direct observation of the researcher. More than 200 respondents were randomly selected from the people living around the Ramdi area for this study. The pre-set questionnaires formats were used to get the information on human-monkey conflicts. The respondents were interviewed separately to ensure the independence of the individual response. To minimize the bias, questions were asked to the villagers on the expected production of crops without crop raiding and the amounts of crops after raiding. The data were compiled together and calculated in terms of percentages.

Fig. 1. Location of study area (Ramdi area) in the map of Nepal

RESULTS

In this study all the wards of Darlamdanda village development committee and Khanichhap village development committee of Palpa district and Malunga Tunibot village development committee of Syangja district were found affected by monkey species of Rhesus, Langur and Assamese. Among all these wards, Darlamdanda-2, Ramdi village; Darlamdanda-6, Sunadi village; Khanichhap-2, Ramdi village; Khanichhap-2, Bardanda village; Khanichhap-9, Padhari village of Palpa district and Malunga Tunibot-6, Ramdi village of Syangja district were the most affected by the Assamese monkeys. According to 33 respondents of Darlamdanda-2, Ramdi village, a total of 18.98 quintals crop was damaged by the monkeys. The crop damaged in Darlamdanda-6, Sunadi village, according to 25 respondents was recorded 31.15 quintals. It was found 1.97 quintals of crop loss in Khanichhap-2, Ramdi village responded by 8 people. In Khanichhap-2, Bardanda village and in Khanichhap-9, Padhari village, the crop loss was recorded 2.3 quintals and 2.2 quintals, respectively. According to 29 respondents of Malunga Tunibot-6, Ramdi village, the total crop damage by the monkeys was found 42.04 quintals. The highest crop damage due to monkeys was recorded in the crop field of Raj Kumar Shrestha. The total of 11.4 quintals crop was damaged in his field which included 5.4 quintals maize, 1.8 quintals wheat, 1.8 quintals millet, 0.6 quintal fruits, 0.3 quintal lentil, 0.3 quintal broad beans and 1.2 quintals mustard. This huge loss may be due to the proximity of field to the forest being less than 100 m.

The crop loss data were collected to make a generalized scenario of the area and calculated in average percentages. It was found that maize (*Zea mays*) was the highest raided crop, followed by fruits, wheat (*Triticum aestivum*), millet (*Eleusine coracana*), rice (*Oryza sativa*), potato (*Solanum tuberosum*), lentil (*Lens culinaris*), mustard (*Brassica nigra*), pumpkin (*Cucurbita maxima*), bread, brown lentil, broad beans (*Vicia faba*), sesame, black pulses (*Vigna mungo*), dal, cauliflower, tomato (*Lycopersicum esculentum*), egg, *samosa* and gram (*Cicer arietinum*). The percentage of crop raided was calculated as 47.14 %

maize, 16.43 % fruits, 11.13 % wheat, 5.72 % millet, 4.58 % rice, 4.27 % potato, 4.07 % lentil, 1.26 % mustard, 1.14 % pumpkin, 0.96 % bread, 0.81 % brown lentil, 0.8 % broad beans, 0.6 % sesame, 0.35 % black pulses, 0.2 % dal, 0.14 % cauliflower, and 0.1 % each of tomato, egg, *samosa* and gram. The percentage of total crop raided was calculated as 30.06% and the average loss of crop items was calculated as 23.62 % (Fig. 2).

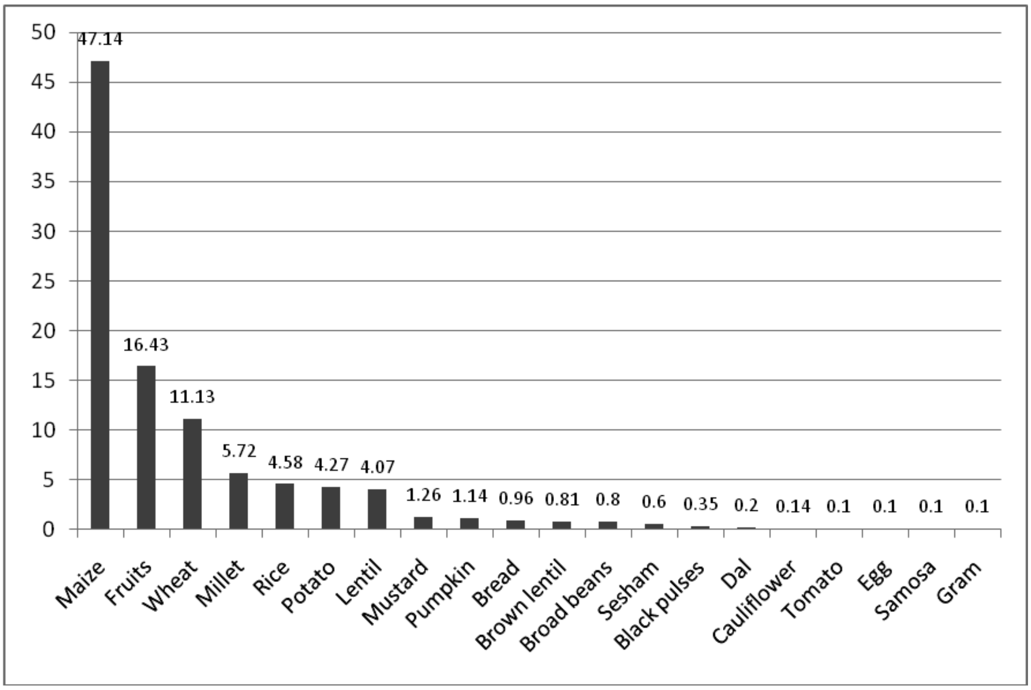

Fig. 2. Percentage of crop raid by Assamese monkeys

DISCUSSION

Crop damage by the monkey species is very common in Nepal. Upreti (1985) reported that the buckwheat and barley raided by wild animals in Langtang and Rara National Parks. Similarly, Jackson (1990) also recorded the damage to crops by monkeys in the southern boundary of the Makalu-Barun Conservation Area (MBCA). In many parts of the distribution range, anthropogenic habitat alteration has forced the non-human primate into conflict interactions with humans and their livelihood activities, especially through crop raiding (Priston *et al.* 2012). Crop damage caused by raiding primates is one of the most widespread and common examples of human-primate conflicts in the areas where local people are mainly subsistence farmers (Hill, 1998). When the supply of natural food is not enough, high quality and easily digested human food is a good alternative form of nutrition for primates, which could be the most important cause of the intensity of crop raiding (Khatun *et al.* 2013).

It was recorded the highest percentage of crop damage by monkey species was maize 34.12 % which was followed by potato 23.05 %, rice 12.01 %, fruits 11.68 %, wheat 9.57 %, millet 5.13 %, buckwheat 2.38 % and pulses 2.06 % in Bandipokhara-Palpa of Nepal (Ghimire 2000). Chalise (1997, 1999) recorded that crop depredation proportions in different crops. In his investigation in Makalu-Barun Conservation Area (MBCA), the highest percentage of damage on maize was 32 %, which followed by potato 24 %, rice 14 %, fruits 12 %, millet 11 %, wheat 4 %, buckwheat 2 % and pulses 1 %. Chalise (2001) recorded that crop loss in Lakuwa village due to monkey species was maize 7.76 % and pulses 4.14 %. During a study in Shiva village, Chalise (2001) noted that crop loss by the monkey species was maize 13.88 %, fruits 41.86 %, rice 19.16 %, wheat 8.97 %. Adhikari *et al.* (2018) recorded the crops raided by monkeys in Ramdi area as maize (35 %), vegetables (20 %), pulses (13 %), fruits (13 %), potato (6 %) and rice (2 %). In this study, it was found that highest raided crop by Assamese monkeys was the maize 47.14 % which was followed by fruits 16.43 %, wheat 11.13 %, millet 5.72 %, rice 4.58 %, potato 4.27 %, lentil 4.07 %, mustard 1.26 %, pumpkin 1.14 %, bread 0.96 %, brown lentil 0.81 %, broad beans 0.8 %, sesame 0.6 %, black pulses 0.35 %, dal 0.2 %, cauliflower 0.14 %, tomato 0.1 %, egg 0.1 %, samosa 0.1 % and gram 0.1 %. The highest crop damage was found the maize (47.14 %) and the lowest loss was the tomato (0.1 %) as well as other cooked food items such as egg (0.1 %), samosa (0.1 %) and gram (0.1 %). The average loss of crop items was found 23.62 %. The total crop raided percentage was found 30.06 %. Present study shows the highest crop raid maize (47.14 %) in the Kaligandaki river basin as compared to Ghimire (2000), Chalise (1997, 1999, 2001) and Adhikari *et al.* (2018), those recorded low crop loss in Bandipokhara, Palpa, Makalu-Barun Conservation area (MBCA) and Ramdi, respectively. The main reasons for these differences are due to less availability of natural food plants for the monkeys and destruction of their habitats (constructing Kaligandaki corridor) which tends to move the monkeys to the human settlements and crop fields to raid the crops.

The frequency of crop raiding is affected by the availability of natural food as well as number of individuals of the monkeys in the area. Crop raiding is an essential component of the ecology of primates inhabiting human settlements (Naughton-Treves *et al.* 1998) but it is likely to minimize the tolerance of subsistence farmers towards conservation of such crop-raider threatened primate species (Khatun *et al.* 2013). This fact may be useful in predicting the vulnerability of the Assamese monkey survival in Kaligandaki riverside area. Artificial provisioning causes changes in the diet, home range and habitat and even the behavior of the monkey (Southwick *et al.* 1976). In Ramdi area monkeys are habituated to human because of provisioning of foods, therefore their diet, home range, habitat and behavior are also changed. Most of the respondents believe the scarcity of food, increase in monkey population, loss of habitat, behavioral changes of monkeys due to artificial provisioning by Hindu Pilgrims etc. are the major causes of monkeys turning into crop-raiders. Monkeys living in the habitat with fewer wild food resources are more likely to utilize human settlements and areas around them with dependence on crop foods (Yamada & Muroyama 2010). The food provided by the Hindu Pilgrims in temple areas of Ramdi might have caused behavioral changes and increased their dependence to provisioned food rather than foraging from the wild. The food supplied in the temples may not be enough and to meet the nutrients requirement the monkeys enter the crop fields, orchards or even the grain storage houses instead of foraging the wild food, which increase the conflicts with local people. Crop raiding by monkey species is one of the serious problems in the village area (Chalise 1997). Although they raid the crops, they also help in dispersal of wild seeds in the forest (Chalise 1999). Monkeys raid the crops, mainly due to the scarcity of wild edible foods and reduction of their habitat. Such situation forces them to survive on human crop field and settlements. The detail assessment of the habitat quality and its management would minimize the human-monkey conflicts and it will be helpful in conservation of the endangered and protected Assamese monkey species along the Kaligandaki riverside of western Nepal.

CONCLUSION

The highest raided crop by Assamese monkeys was maize (47.14 %) along the Kaligandaki river basin of western Nepal. Crop damage by the monkey species is a common problem in the mid-hills of Nepal. Monkeys raid crops, mainly due to the scarcity of wild edible foods and reduction of habitat. Human-monkey conflict in Ramdi area was found to be a serious social problem which may be due to the proximity of forest to the settlements, artificial provisioning, availability of palatable crops and abundance of safe hiding sites on the rocky outcrops on the bank of Kaligandaki River. Under a systematic management scheme, we should educate people on the importance of wildlife including the endangered and protected Assamese monkey species of Nepal.

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Status of crop raiding by Assamese monkeys (*Macaca assamensis*) along the Budhigandaki river, central Nepal

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ABSTRACT

Crop depredation study was done on Assamese monkeys (*Macaca assamensis*) in Budhigandaki river basin lying on Dhading and Gorkha districts of central Nepal. The field study was conducted from February 2015 to January 2016 spending 1804 hours to explore the ecology and feeding behavior of Assamese monkeys. The study mainly focused at Kalleri village of Salang village development committee of Dhading district and Baseri, Majhitar and Siurenitar villages of Ghyalchok village development committee of Gorkha district. A total of 16 individuals of Assamese monkeys were counted at Rigdi khola of Sigrepakha community forest of Salang village development committee of Dhading district whereas a total of 13 individuals of Assamese monkeys were counted at Sandkhola of Benigam community forest and a total of 14 individuals of Assamese monkeys counted at Siurenitar of Ghyalchok village development committee of Gorkha district. Crop raiding data were collected by questionnaire survey method to local households in the nearby villages and also by direct observation. It was found that maize (58.43%) was the highest raided, followed by rice (11.34%), lentil (8.74%), peanut (4.35%), soyabean (4.18%), wheat (3.22%), fruits (2.97%), black pulses (1.87%), potato (1.67%), sesham (0.92%), tomato (0.79%), millet (0.67%), mustard (0.36%), broad beans (0.25%), brown lentil (0.18%) and pumpkin (0.06%).

Keywords: *Macaca assamensis*, crop raid, questionnaires, local villagers, Budhigandaki riverside

INTRODUCTION

Human non-human primates conflict are increasing to the developing countries than developed countries due to greater biodiversity and lack of prevention measures such as farm fences, livestock guard (Seoraj-Pillai & Pillay, 2016). In addition, behavioral adaptability of the macaques facilitates to invading human settlement, and as a result conflicts occur. However, the interaction between the primates and people is referred to as human primate's conflict, which has negative impact on the resources, habitats of both primates and people (Hill *et al.,* 2002; Hockings & Humle, 2009; Khatun *et al.,* 2013; Ahsan & Uddin, 2014).

Crop raiding primates is the example of human-primates' conflicts, where most of the local people are subsistence farmers (Hill, 1988). Crop raiding is a major issue for human-primates' conflict and conservation of primates (Hill, 1988; Ahsan & Uddin, 2014). Human primates conflicts are increasing because of conversion to agricultural lands to human settlements as a result primate invade human settlement for food and damage crops that are mostly eaten by them. In some cases, primates especially baboons damage unpalatable crops that they don't eat but destroy as their own entertainment (Hill & Webber, 2010).

Assamese macaques (*Macaca assamensis*) of Nepal are considered as 'Nepal Population' by Conservation Assessment and Management Plan (CAMP) workshop 2002 due to taxonomic confusion. This population is different from Assamese monkeys described so far from south and east Asia (Jolly, 1985; Sanjay *et al.,* 2003) in respect to the head-body length, tail length, T/HB ratio and weight. The body coloration also differs than so far described one. This population is considered as a new subspecies and needs further taxonomic investigation. Assessment was carried out at the population level to highlight the status of this unique form endemic to Nepal. However, a distinct difference in color is also found in higher and lower elevations of the country, as it is recorded from the altitude of 284 m in Abukhaireni, Tanahu to 2350 m in Langtang, Rasuwa of Nepal.

Local people are more aggressive towards primates when they find economic loss due to crop damage by primates (Beisner *et al.,* 2015). Palatable and unpalatable crops are damaged by primates and it depends on the availability and scarcity of food in the areas. Also, the aggressive human behaviors influence the primates to damage unpalatable crops (Khatun *et al.,* 2013; Beisner *et al.,* 2015). In Nepal, conflict between human and primates are increasing due to increased population and primates tried to coexist with human settlement areas. So human primates' conflicts are increasing. The present study reveals the crop damage by Assamese monkey (*Macaca assamensis*) of the human settlement areas during conflict with local people in Budhigandaki river basin village of Dhading and Gorkha districts of central Nepal.

MATERIALS AND METHODS

Study area

The study area lies at Kalleri village of Salang village development committee of Dhading district and Baseri village as well as Majhitar and Siurenitar villages of Ghyalchok village development committee of Gorkha district. This is the confluences of Budhigandaki river with Trishuli river. According to the new constitution of Nepal 2015, Dhading district lies in Province No.3 and Gorkha district lies in Province No.4.

FIG. 1. Location of research site in the map of Nepal.

The study area lies about 3 km north from Benighat bazaar of Prithvi Highway. Benighat bazaar is located at about 85 km west from Kathmandu, the capital of Nepal. The study area is situated between 27° 48' 54.48" N latitude and 84° 46' 33.63" E longitude. The altitude is 401m above the sea level. The area is rich in biodiversity. Mixed type of forest especially tropical deciduous riverine forest, sub-tropical grassland and sub-tropical evergreen forest are the major types of forest along the Budhigandaki river basin (fig. 1).

Data collection

Data of crop raiding were collected from local household villagers as per the pre-set questions format as well as by direct observation of the researcher. Stratified random sampling method was used to select respondent for the questionnaire survey. Questionnaire survey was carried out to estimate the crop damage by the macaque with the local inhabitants in the Budhigandaki river basin VDCs. The main habitats of the Assamese monkeys were along the Budhigandaki river basin. More than 200 respondents were selected as sample size from the study area. The respondents were interviewed separately to ensure the independence of the individual response. The questionnaires were designed to obtain the people's perception on Assamese monkey population change in Budhigandaki river basin area and different aspects of crop raiding by the monkeys such as frequency, time of the day, types of the crop damaged, amount of annual loss due to crop raid and methods adopted to prevent the crop raid. To minimize the bias, questionnaires were asked to the villagers on the expected production of crops without crop raiding and the amounts of crops after raiding. The data were compiled together and calculated in terms of percentages as well as in quintals.

RESULTS AND DISCUSSION

The Kalleri village, Ratmate village, Tarebhir village, Chalise village, Basanta village, Kostar village and Jharlanditar village of Salang village development committee of Dhading district and Baseri village as well as Majhitar village of Ghyalchok village development committee of Gorkha district were found affected by monkey species (Rhesus, Langur and Assamese). Among all these village areas, the Kalleri village and Baseri village as well as Majhitar village were found the most affected areas by the Assamese monkeys. As shown in table 1, according to 23 respondents of Kalleri village, the total crop damage by the monkeys in this village was found 54.6 quintals in which the highest crop loss (6 quintals) was of household person Kashai Ram Darlami. The proximity of his damaged crop field to the forest is about 200 m. It was recorded 4.5 quintals loss in Ratmate village responded by 2 people. In Tarebhir village, the total loss of 9.6 quintals according to 3 respondents was found. The Chalise village crop loss was recorded 1.5 quintals responded by 2 people. It was recorded 4.8 quintals crop loss in Basanta village, 5.7 quintals crop damage in Kostar village and 0.9 quintal crop loss in Jharlanditar village. According to 25 respondents, the total crop damage by the monkeys in Baseri village was found 70.5 quintals in which the highest crop loss was recorded at Sabitri Gurung's crop field which was 7.5 quintals. The main reason of the huge amount of crop loss by the monkeys in her crop field is the proximity of damaged crop field to the forest is about 100 m. In the Majhitar village, the total crop damage by the monkeys was found 82.04 quintals which was responded by 42 local household people. In this village, the highest crop loss was recorded in two household persons' crop field namely Resham Lal Shrestha and Bir Bahadur Gurung which was 5.4 quintals each. The main reason of this huge amount of crop loss by the monkeys in both the household persons' crop field is that the proximity of damaged crop field to the forest is about less than 100 m.

TABLE 1. Village-wise crop damage in quintal by Assamese monkeys.

S.N.	Name of village	Quintals
1.	Kalleri village	54.6
2.	Ratmate village	4.5
3.	Tarebhir village	9.6
4.	Chalise village	1.5
5.	Basanta village	4.8
6.	Kostar village	5.7
7.	Jharlanditar village	0.9
8.	Baseri village	70.5
9.	Majhitar village	82.04

From the study it was found that maize (*Zea mays*) was the highest raided crop, then it was followed by rice (*Oryza sativa*), lentil (*Lens culinaris*), peanut (*Arachis hypogaea*), soyabean (*Glycine max*), wheat (*Triticum aestivum*), fruits, black pulses (*Vigna mungo*), potato (*Solanum tuberosum*), sesham, tomato (*Solanum lycopersicum*), millet (*Pennisetum glaucum*), mustard (*Brassica nigra*), broad beans (*Vicia faba*), brown lentil and pumpkin (*Cucurbita pepo*). The crop raided percentage was calculated as maize 58.43%, rice 11.34%, lentil 8.74%, peanut

4.35%, soyabean 4.18%, wheat 3.22%, fruits 2.97%, black pulses 1.87%, potato 1.67%, sesham 0.92%, tomato 0.79%, millet 0.67%, mustard 0.36%, broad beans 0.25%, brown lentil 0.18% and pumpkin 0.06%. The total crop raided percentage was calculated as 24.62% and the average loss of crop items was calculated as 29.24% (fig. 2).

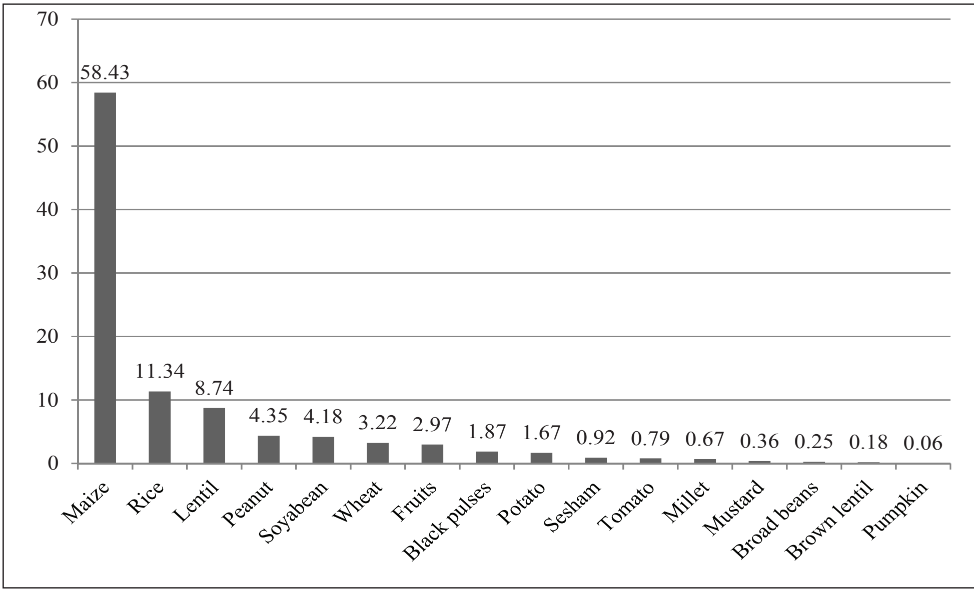

FIG. 2. Percentage of crop raids by Assamese monkeys.

In the study area, a total of 32.21 hectares of crop land was found affected by the monkey species. In that land area, total yield of crop was expected to be 951.15 quintals but 717.01 quintals was observed yield during the study period. It indicates simply that 234.14 quintals of crops was lost by the macaques. The individual crop loss in quintal is tabulated in table 2.

TABLE 2. Individual crop loss in quintal by Assamese monkeys.

S.N.	Crops	Quintals	S.N.	Crops	Quintals
1.	Maize	136.81	9.	Potato	3.91
2.	Rice	26.55	10.	Sesham	2.15
3.	Lentil	20.46	11.	Tomato	1.85
4.	Peanut	10.19	12.	Millet	1.56
5.	Soyabean	9.80	13.	Mustard	0.84
6.	Wheat	7.54	14.	Broad beans	0.58
7.	Fruits	6.95	15.	Brown lentil	0.42
8.	Black pulses	4.38	16.	Pumpkin	0.15

In Nepal, crop damage problem due to primate species especially monkeys species is acute. Crop raiding was found as a major cause of conflict though physical hurt and harassment, taking and grabbing of food materials were also reported as the problems caused by monkeys. Upreti (1985) reported that buckwheat and barley were raided by wild animals in Langtang and Rara National Parks. Similarly, Jackson (1990) also recorded the damage to crops by monkeys in the southern boundary of the Makalu-Barun Conservation Area (MBCA). Hill (1997) reported that maize was a staple and preferred crop and was less vulnerable to other forms of damage. Chalise (2000b) reported that cereals, fruits and tubers are the most preferred and vulnerable for raiding by macaques in Makalu-Barun Conservation Area. Khatry (2006) also supports that maize is the prominently vulnerable crop for raiding by primates.

During the study in Langtang National Park (LNP) area, Chalise (2010) recorded that the crop depredation due to monkey species was highest in maize (43%) followed by potato (20%), millet (16%), wheat (13%), rice (7%) and buckwheat (1%). Ghimire (2000) recorded in Bandipokhara, Palpa that the highest crop loss due to monkey species was maize (34.12%) followed by potato (23.05%), rice (12.01%), fruits (11.68%), wheat (9.57%), millet (5.13%), buckwheat (2.38%) and pulses (2.06%). Paudel (2016) at his study in Kaligandaki river basin VDCs of Baglung and Parbat districts recorded the highest raided crop as maize 46.95% followed by 15.91% paddy, 15.11% potato, 10.84% millet, 6.88% wheat, 2.05% pulses, 1.59% fruits and 0.66% vegetables whereas Adhikari *et al.* (2018) at Ramdi area of Kaligandaki river recorded the raided crop as maize (35%), vegetables (20%), pulses (13%), fruits (13%), potato (6%) and rice (2%). In this study, it was found that the highest raided crop by Assamese monkeys was the maize 58.43% which was followed by rice 11.34%, lentil 8.74%, peanut 4.35%, soyabean 4.18%, wheat 3.22%, fruits 2.97%, black pulses 1.87%, potato 1.67%, sesham 0.92%, tomato 0.79%, millet 0.67%, mustard 0.36%, broad beans 0.25%, brown lentil 0.18% and pumpkin 0.06%. The average loss of crop items was found 29.24% and the total crop raided percentage was found 24.62%. Chalise (2001) collected the information of crop raiding by the interviews in Lakuwa village of Makalu-Barun Conservation Area and reported that Rhesus and Assamese macaques were the most crop raiders and Langurs visited the least and the villagers blamed that among the two species, Assamese monkey was the terrible than Rhesus. He stated that monkey raid heavily to the maize field 29% then followed potatoes 23% (tubers also), rice 13%, fruits 12%, and millets 12%. The tubers and fruits came to be 35% of the total loss and the total cereals came to be 65% loss in Lakuwa village. Adhikari (2013) found crop raiding by Assamese monkey in Lamjung area, 44% maize followed by 27% potato, 13% millet, 7% wheat, 4% paddy, 3% fruits and 2% vegetables. Regmi (2008) reported crop raiding in Langtang National Park by 62% for maize, 23% for potato, 7% for millet, 6% for buckwheat and 2% for other, which result (maize) is similar to the finding of the present study. The availability of natural edible food items as well as individual number of the monkeys affect the frequency of crop raid in the area.

In this study, a total of 32.21 hectares of crop land was found affected by the monkey species. In that land area, total yield of crop was expected to be 951.15 quintals but 717.01 quintals was observed yield during the study period. It is indicated that 234.14 quintals of crops was lost by the macaques. Paudel (2016) at his study in Kaligandaki river basin VDCs of Baglung and Parbat districts recorded 61.18 hectares of land utilized for the cultivation of crops in which total yield of crop was expected to be 688.29 quintals but 567.74 quintals was observed yield during the study time and only 120.55 quintals of crops was lost by the macaques. This shows the productivity of the land is higher in Budhigandaki river basin area as compared to that of the Kaligandaki river basin area of Baglung and Parbat districts. The much higher crop loss household person due to Assamese monkeys was Sabitri Gurung of Baseri village, Ghyalchok village development committee of Gorkha district, which was 7.5 quintals. The main reason of the huge amount of crop loss by the monkeys in her crop field is the proximity of damaged crop field to the forest is about 100 m. and only the women who were for guardening the monkeys in the crop fields. On the other hand the very little amount of crop loss due to Assamese monkeys was found on the household person Suku Maya Majhi of Majhitar village, Ghyalchok village development committee of Gorkha district, which was 0.04 quintal. The reason for very little crop loss is the nearer distance of crop fields with the human settlements which is less than 100 m. that help for guardening the monkeys.

Conflicts between people and macaques occur in three broad contexts, all stemming from the macaques' dependence on humans for food, whether directly (i.e. provisioning) or indirectly (crop-raiding, food-stealing). First, macaques damage subsistence and/or cash crops in rural locales (Chakravarthy & Thyagaraj, 2005; Chalise & Johnson, 2005; Hashim *et al.,* 2009; Priston, 2005; Riley, 2007; Supriatna *et al.,* 1992; Suzuki & Muroyama, 2010). Consequently, in agricultural areas, macaques may be viewed as serious vertebrate pests (Engeman *et al.,* 2010; Knight, 1999; Marchal & Hill, 2009; Wang *et al.,* 2006; Wheatley, 2011). In rural Morocco, macaques damage commercially valuable timber by stripping the bark (Camperio Ciani *et al.,* 2001). Second, macaques habituated to close interaction with people at temples and tourist attractions frequently show undesirable behaviors associated with provisioning, including human-directed aggression and food-snatching (Fa, 1992; Fuentes & Gamerl, 2005; Zhao, 2005). Third, in urban towns and cities, macaques are sometimes regarded as a worrisome, potentially dangerous nuisance. Typical problem behaviors include physical aggression towards people, snatching bags, entering and damaging property, stealing food and other items, fouling and raiding garbage (Chauhan & Pirta, 2010a; Cortes & Shaw, 2006; Imam *et al.,* 2002; Md-Zain *et al.,* 2011; Sha *et al.,* 2009; Shek, 2011; Southwick *et al.,* 2005). The 'monkey problem may reach such proportions that urban macaques are regarded as a serious menace (Southwick & Siddiqi, 2011; Southwick *et al.,* 2005; Srivastava & Begum, 2005). A further area of 'conflict' arising from close interaction between people and macaques concerns the potential for zoonotic disease transmission (Fuentes, 2006a; Jones-Engel *et al.,* 2006; Lane *et al.,* 2010).

Considering their wide geographical distribution and taxonomic diversity, the macaques are perhaps the most notorious and successful of 'pest primates'. All species raid crops. Indeed, certain macaque species- the so- called weeds (Richard *et al.,* 1989)- show a preference for foraging in the mosaic of habitats created by human settlement, cultivation and pastoralism and derive a substantial portion of their diet directly or indirectly from people (Richard *et al.,* 1989). Unlike their 'pest' counterparts in Africa- the baboons and vervets-macaques have formed a commensal relationship with people in many Asian nations (Lane *et al.,* 2010; Sha *et al.,* 2009; Singh & Rao, 2004; Southwick *et al.,* 2005). Across Asia, macaques are found in proximity to villages and towns (Aggimarangsee, 1992; Southwick *et al.,* 1961; Watanabe & Muroyama, 2005); some even make a living in densely populated urban areas (e.g. *M.*

mulatta in Indian cities: Mathur & Manohar, 1990; Srivastava & Begum, 2005; *M. fascicularis* in residential Singapore: Lee & Chan, 2011; Sha *et al.,* 2009). This close association with people is facilitated by human cultural attitudes that imbue monkeys with religious and/or symbolic significance (Burton, 2002; Knight, 1999; Wheatley, 1999; Wolfe, 2002). For example, in Hindu mythology, monkeys are revered as representatives of Hanuman, the monkey god, following his key role in the Ramayana, a Hindu Sanskrit epic. Although Hanuman is usually depicted as a langur (*Semnopithecus entellus*), in many Hindu cultures, he has come to represent all monkeys, including macaques. Consequently, orthodox Hindus consider it their sacred duty to feed macaques (Pragatheesh, 2011). More generally, macaques are commonly found in association with Hindu and Buddhist temples throughout south and southeast Asia and southern China, where they are provisioned by devotees and, at some sites, tourists (Aggimarangsee, 1992; Jones-Engel *et al.,* 2006; Loudon *et al.,* 2006; Medhi *et al.,* 2007; Southwick *et al.,* 1961; Wheatley, 1999; Zhao, 2005). Whether the monkeys themselves are objects of worship or rather the sacred temples and shrines they often inhabit (Fuentes *et al.,* 2005), cultural beliefs held in many parts of Asia have traditionally provided a context for tolerance and a measure of protection for macaque populations. Nevertheless, this close coexistence between humans and macaques inevitably leads to conflicts. Moreover, conflicts are increasingly challenging traditional relationships between people and macaques (Knight, 1999; Southwick & Siddiqi, 2011).

Some Assamese monkeys are killed each year due to their crop raiding habit. The local villagers believe that after killing some, other monkeys would scare to raid crops. Though their anger seems natural but this is against the Law and such practice will ultimately hamper the population of endangered and protected wild monkeys of Nepal. If the villagers get chance to alter their crops instead of traditional one, there seems to be no crop raiding.

The highest raided crop by Assamese monkeys was found on maize (58.43%) i.e., 136.81 quintals among the raided crops along the Budhigandaki river basin of central Nepal. Crop damage in Budhigandaki river basin area was found to be a serious social problem which may be due to the proximity of the forest to the human settlements, availability of palatable crops, abundance of safe hiding sites on the rocky outcrops on the bank of Budhigandaki river. Crop damage by wildlife including monkey species is a common problem in the mid-hills of Nepal. Wildlife becomes pest whenever a natural system is weakened. Under a systematic management scheme, such intensity can be balanced. We should educate people on the importance of wildlife and over populated species should be cropped for the well being of people and wildlife themselves.

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