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Comparative investigations on Feeding Behaviour of Rhesus Monkey (*Macaca mulatta*, Zimmerman 1780) in Two Habitats of Different Altitude in Nepal

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ABSTRACT

Geospatial and openness of food resources determine the foraging behaviour of rhesus monkey. The study of a year duration was conducted in rhesus monkeys (*Macaca mulatta*, Zimmerman 1780), on natural habitats-low and high altitude with the aim to evaluate the major parts of plants eaten and to assess variation in feeding time of preference in two different habitats (Sorenson's Similarity index of vegetation=0.093). Feeding behavior of a troop of rhesus monkey from Ramdhuni forest (93 masl *Sorea* dominated) and Dhankuta forest (1200 masl and *Pinus* dominated) was evaluated by recording by focal animal sampling method with reference to the vegetation. Diurnal time investment on feeding was 32% in Ramdhuni and 37.75% in Dhankuta. Ramdhuni and Dhankuta troop consumed 57 and 30 species of trees respectively and in both the habitats they consumed fruits from maximum number of plants. There was no significant relation on choosing parts of plants and also no significant relation on time investment on major eight food items but significant relation on some minor items in two habitats. We conclude the time allocation on particular items of food depends on their seasonal availability. Better understanding the feeding behaviour will give hope to sustainable management of rhesus monkey.

Key words: *Fruit, IVI, Leaf, Time investment, Wastes*

Introduction

Primates utilize a variety of foraging strategies as a key means of environmental adaptation (Cui *et al.*, 2019; Green *et al.*, 2020). Numerous foraging theories have been put forth by researchers to explain the foods that animals select and how much of each meal they consume (Felton *et al*., 2009). Availability of foods and other climatic and topographic factors have an impact on allocation of time in different activities by primates (Majolo *et al.*, 2013; McFarland *et al*., 2014). On the basis of openness of food items, the primates show dietary flexibility (Hemingway and Bynum, 2005; Knott, 2005; Grueter, 2017). All the ecosystems are fluctuated by availability of abiotic and biotic factors (Sengupta and Radhkrishna, 2016). Environmental diversity shapes demographical measures, processes and also the behaviour of animal (Clutton-Brock and Harvey, 1977). Feeding behavior's temporal distribution can change to accommodate shifting energy demands over time (Raemaekers, 1978; Fan *et al*., 2008; Ma *et al*., 2014). Difference in behaviour is determined by availability of food for primates (Altmann, 1974; Chalise, 2000). Availability of food which depends on the vegetation type was the key to determine daily activities e.g. foraging, locomotion and social activities in primates (Chalise, 2000; Sarkar *et al.*,

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2012). Most primate follow the strategy that all individuals of a group could intake their dietary needs and forage in group (Son, 2014). Climatic factors, seasonal changes and sociobiology also affect the animal behaviour (Bernstein, 1975). Rhesus monkey (*Macaca mulatta*) a least concerned species (Singh *et al.*,2020) is distributed in all geographical regions of Nepal, ranging from low land to higher Mahabharat (2500 masl) (Chalise, 2013).

Study of feeding ecology is the foremost requirement to understand the ecological adaptation of species to environment (Chalise, 2000). The knowledge on diet is also very significant because it examines the ecology and sociobiological problem (Chalise, 2004). The feeding ecology should be understood as it is one of fundamental requirements to design the policy for the sustainable conservation of the species (Gupta, 2005). Determining the activity patterns and time budgets of animals in different activities are essential for understanding their behavioral characteristics (Janson, 1992; Dunbar *et al.*, 2009). Food plays crucial primary factor for the regulation of day to day activity profiles of animals (Sarkar *et al.*, 2012).

This study aims to explore the major plants and parts of plants eaten by rhesus monkeys and to assess variation in food preference by rhesus monkey in two different altitudes. This type of study improves the understanding of the feeding ecology of rhesus monkeys in different altitudinal habitats which finally gives hope to scientific management of this problematic species.

Materials and Method

Study sites

Ramdhuni forest (Figure 1) is a forest dominated by Sal tree vegetation, situated in Sunsari district, Koshi province, Nepal. It is located at the latitude 26° 41' 23" N and longitude 87° 7' 44" E. It offers Monsoon-influenced humid subtropical climate (Minidat, 2023). The annual temperature ranges from 10^0C to 40^0C and receives 1600 mm precipitation (Ramdhuni Bhasi Municipality, 2022).The heavenly Hindu sanctuary is found within the center of this spiritual woodland, it is additionally known as Ramdhuni (Dhuni). Around 20.4 sq. km of Ramdhuni woodland is situated approximately 10 km east of Koshi Tappu Wildlife Reserve and the

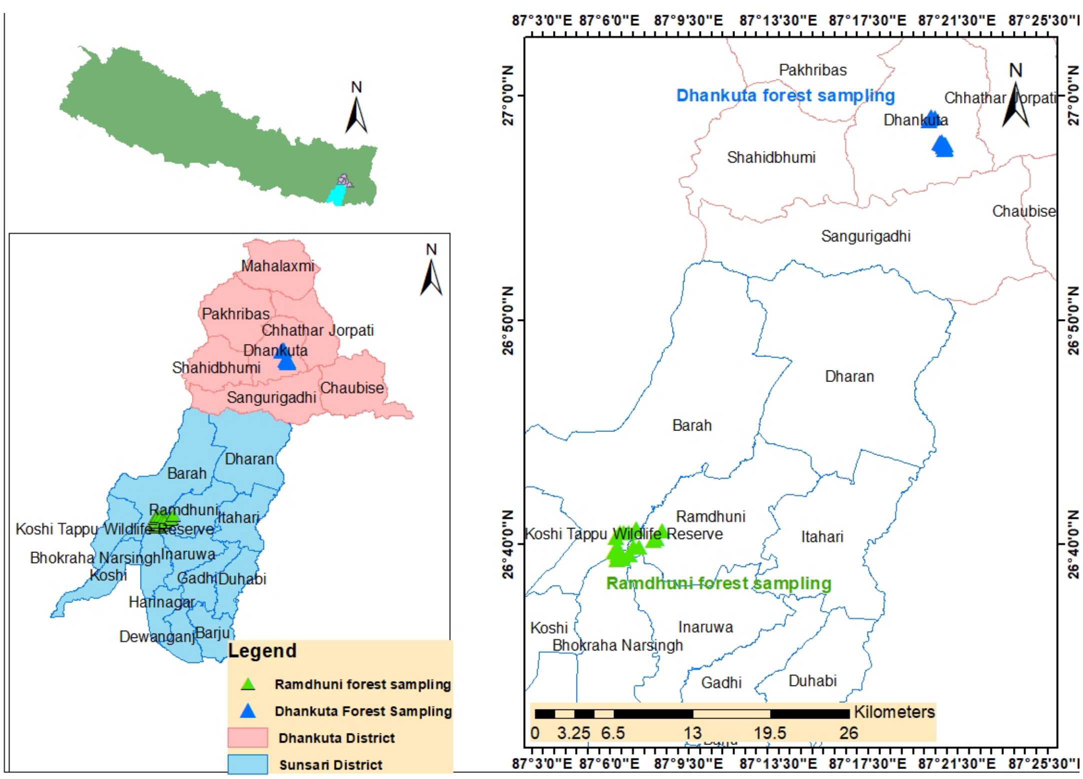

Fig. 1. Map showing study sites: Ramdhuni and Dhankuta

Koshi river (the largest river of Nepal). Around the edge of this woodland there are human settlements and farming. The entertainment center within the woodland is ordinarily utilized by individuals. Seraha stream and Sunsari waterway both pass through the forest (Dahal *et al.,* 2016).

The next study area Dhankuta (Figure 1) is situated in Dhankuta district in Mahabharat range. The municipality covers a geographical area of 111.6 sq.km. It is situated between 26°59′59′′ and 27°02′55′′ North latitude and 87°17′52′′ and 87°23′09′′ East longitudes. The elevation ranges from 250 masl to 2144 masl. The temperature ranges from 12 ^{0}C to 30 ^{0}C and annual average rainfall is 2603 mm (Dhankuta Municipality, 2023). The study was focused on elevation above 1000masl. The study area has the vegetation of temperate forest. A well-preserved forest (Chuli Ban) spreads along a ridge line on the north west side with well-developed mature stands of rhododendron and Sallo (Pine) trees. Located towards the North-west of the main town is 'Salleri ban' which, as the name suggests, comprises majorly of Pine trees (Subba, 2023). In both the study area the seasonal changes occur and four clearly distinct seasons can be observed. They are spring (March-May), summer (June-August), autumn (September-November) and winter (December-February).

Vegetation analysis

The quadrates of size of 20 × 20 m^2 was laid on each habitat of different altitudes. About 20 m. distance was maintained between the successive quadrates. All the trees within the quadrates were counted and identified to the species level with the help of literature and experts and diameter was measured at breast height (1.37 m) as followed by (Zobel *et al.,* 1987; Ghimire *et al.*, 2021).

Importance Value Index (IVI) = (Relative frequency + Relative density + Relative Basal area)

Index of Dominance (C) = Σ (ni/Nö ²

To compare the vegetation of different habitat Shannon and Wiener's index of general diversity (H) = – Σ (ni/Nö log (ni/N) was applied.

Or, Diversity (H)= – Σ (pi.log $_2$ pi

Where, ni = importance value N = Total no. of importance value, pi=Proportion of individuals of i-th species in a whole community (Odum, 1996).

In order to calculate the similarity in food preference given by monkeys in different habitat Sorensen's Similarity Index (Ss) was calculated as follows:

Similarity index (Ss) = 2c/ a+b+2c

Where: Ss : Sorensen's similarity coefficient c : Number of food plants in both communities a : Number of food plants in one (example: in Ramdhuni forest) but not in other(example: in Dhankuta forest) b : Number of food plants in next (in Dhankuta forest) but not in first(in Ramdhuni forest).

Troop selection

For a few days, a group of monkeys was regularly observed in the Ramdhuni and Dhankuta forests. By looking at traits such marking color, body size, tail size, behavior, and group leadership, we were able to identify specific individuals. The troop was then easily identifiable by looking at their height, body size, body color, and body proportion (Roonwal and Mohnot, 1977; Chalise, 1995).According to their physical size, color, and behavior, the troop's members were divided into adult males, adult females, subadult males, young adult females, juveniles, and newborns (Chalise, 1995).

In light of this: 1. Adult male: The big, dangling scrotal sacs on adult males were their defining characteristic. 2. Adult females: They can be identified by their prominent nipple and short head.3. Young and sub adult: They are self-sufficient, have typically reached adulthood, but are immature when it comes to sexual and physical development. 4. Juvenile: These are the people who have been weaned and left with no breast touch; they mostly rely on natural foods and family ties. 5. Infant: These are the ones who still use their mother's nipple as their primary food source when they cling or follow her. As a result, we classified infants, juveniles, and sub adults as immature.

Behaviour recording

The observation was done from May 2022 to April 2023. We planned field visit for 10 days per month per study area. The behavior recording time began before sun rising and terminated after sunset. Daily observation hours ranged from 9 to 13 hours per day. There was a total of 110 jungle visiting days for each spot. Monkey watching hours were 918 hours in each study area and totally 1836 hours. In the field study, the continuous observation of one adult focal animal for 60 minutes was made, after which the focus was shifted to the next focal individual. Every behavioral pattern shown by the focus animal as well as every action group member took in its direction was noted. Prior to the observation, a random selection was made from the adult population. The recording was halted until the primary taken individual under observation became visible again if it became partially or totally occluded (Altmann, 1974; Martin and Bateson, 1993). The time was determined and regulated in stop clock.

By using the same techniques as (Chalise *et al.,* 2013), data on the feeding habits of rhesus macaques, such as food plants, food items, and feeding times, were gathered through direct observation in the field. The datasheet listed the many food plants and plant components that the rhesus macaques consumed, such as immature and adult leaves, fruits, flowers, seeds, bark, and other materials.

The time spent on feeding by the focal animal was calculated as: the time spent on feeding activity × 100/ total time spent in all activities

Again, the percentage of time investment in particular food item was calculated as: time used in eating particular food item × 100/ total time spent on feeding.

Statistical Analysis

To analyze the result, average, standard deviation, standard error of data of twelve months were calculated. Again, the difference in time investment by the troops of different habitats was tested by ANOVA. The statistical analysis was done in Microsoft Excel 2010.

Population composition

The population of the focal troop in Ramdhuni was 61. Among them number of male was 19, female 27 and immatured 15. The population of focal troop in Dhankuta was 23. Among them the number of male was 7, female 11 and immature 5.

Results and Discussion

Vegetation study

Important Value Index of tree species

The Important Value Index (IVI) of tree species in

Table 1. Tree species in Ramdhuni with higher IVI

1.	Dipterocarpaceae	*Shorearobusta* Gaertn.	Sakhuwa	53.33
2.	Combretaceae	*Terminalia myriocarpa* Heurck & Muell.-Arg.	Paani Saj	21.897
3.	Lythraceae	*Lagerstroemia parviflora* Roxb.	Botdhayero	19.324
4.	Euphorbiaceae	*Croton roxburghii* N.P. Balakr.	Auliya	15.234
5.	Myrtaceae	*Cleistocalyxoperculatus* (Roxb.) Merr & Perry.	Kyamuna	8.123
6.	Myrtaceae	*Syzygiumcuminii* (L.) Sekeels	Jaamun	9.786
7.	Ebenaceae	*Diospyrostomentosa* Roxb.	Kalikath	9.908
8.	Lecythidaceae	*Careyaarborea* Roxb.	Kumbhi	7.673
9.	Euphorbiaceae	*Mallotusphilippinensis* Muell.-Arg.	Sindure	5.132
10.	Euphorbiaceae	*Phyllanthus emblica* L.	Amala	5.098
11.	Euphorbiaceae	*Sapium insigne (Royle)* Benth. Ex Hook.*f.*	Khirro	2.782
12.	Rubiaceae	*Anthocephaluscadamba* Miq.	Kadam	4.908
13.	Alangiaceae	*Alangiumsalviifolium* (L.f.) Wangerin	Ashare	6.053
14.	Leguminosae	*Cassia fistula* L.	Raajbriksha	3.061
15.	Bignoniacae	*Stereospermumsuaveolens* DC.	Pithari	5.891
16.	Euphorbiacae	*Aporusaoctandra* Buch-Ham. ex D. Don	Hade	5.342
17.	Lamiaceae	*Tectonagrandis* L.f.	Tik	3.128
18.	Leguminosae	*Dalbergiasissoo* Roxb. ex DC.	Sissoo	4.098
19.	Moraceae	*Ficusglomerata* Roxb.	Dumri	7.702
20.	Moraceae	*Ficussemicordata* Buch.-Ham ex J.E. S.	Khaniu	2.124
21.	Anacardiaceae	*Semecarpusanacardium* L.	Bhalayo	4.452
22.	Dilleniaceae	*Dilleniapentagyna* Roxb.	Tantari	6.642
23.	Leguminosae	*Albiziamollis* (Wall.) Benth. Ex Baker	Ratosiris	7.784
24.	Rhamnaceae	*Ziziphusmauritiana* Lam.	Bayer	4.456
25.	Apocynaceae	*Alstoniascholaris* R. Br.	Chhatiwan	4.892
26.	Combretaceae	*Terminalia chebula* Retz.	Harro	3.0123

Ramdhuni and Dhankuta was calculated and presented (Table 1 and Table 2). The IVI is actually a measure that exposes the quantity of the importance of particular species in the plant community of a place.

Indicies of vegetation

We calculated indices of vegetation of tree species in two habitats (Table 3). The index of dominance of Ramdhuni was 0.28 and that of Dhankuta was 0.13 indicating that there was not specific dominance of particular species. Shannon Wienner's index of diversity was 2.32 in Ramdhuni and 2.47 in Dhankuta. It not less than 1.5 and not much than 3.5 indicating moderate species of plants.

The similarity index between the vegetation of Ramdhuni and Dhankuta was 0.093 (a=57, b= 30, c=5)

In Ramdhuni Sorea was the most dominant species with maximum IVI but the monkey likes its flower and fruits, so they did not give much time for other parts. The second most dominant was Terminalia but monkey fed only its apical young leaf in the particular seasons.

In Dhankuta the dominant species with maximum IVI was Pinus plant but the monkeys were not found staying on this species and they ate only the young seed of Salla. Similarly, Alnus was the second species having higher IVI but monkey did not like that much more. Frequently they fed on the fruits and apical leaf of Alnus. It matches with the findings in Kaligandaki and Budhigandaki river basin as Assamese monkeys selected other plants as foods rather than the dominant species (Ghimire, 2023). Despite being referred to as omnivores, main sources of nutrition of monkeys are leaves, fruits,

Table 2. Tree species of Dhankuta with higher IVI

S.N.	Family	Scientific Name	Local Name	IVI
1.	Pinaceae	*Pinaceae Pinusroxburghii* Sarg.	Salla	100.5735504
2.	Betulaceae	*Alnusnepalensis* D. Don	Uttis	25.43705469
3.	Fagaceae	*Castanopsisindica* (Roxb. Ex Lindl.) A.Dc.	DhalneKatus	23.15361477
4.	Fabaceae	*Erythrinastricta*Roxb.	Siris(Dhole)	22.48914276
5.	Theaceae	*Schimawallichii* (D.C) Korth.	Chilaune	16.17872142
6.	Moraceae	*Ficusreligiosa* L.	Bar	15.95944502
7.	Lythraceae	*Lagerstroemia parviflora* Roxb.	Botdhamero	11.53286715
8.	Moraceae	*Morusindica* L.	Kimbu	11.49496267
9.	Euphorbiaceae	*Sapium insigne* (Royle) Benth. ex Hook.f	Khirro	9.578316631
10.	Myrtaceae	*Psidumguajava* L.	Jamun	8.513087458
11.	Myrtaceae	*Syzygiumamboanum*	Ambak	6.834558965
12.	Moraceae	*Ficussemicordata Buch.*-Ham ex sm.	Khunyoo	6.446551197
13.	Elaeocarpaceae	*Elaiocarpussphericus (*Gaertn.) K. schum.	Rudrakchya	5.527769267
14.	Sapotaceae	*Madhucalongifolia (*Koenig) Mac	Mauwa	4.665595063
15.	Moraceae	*Artocarpuslakooch* Wall.	Pipal	4.168574425
16.	Bignoniaceae	*Oroxylumindicum*	Totalo	4.092416477
17.	Fabaceae	*Albiziajulibrissin* Durazz.	Tanki	3.196046317
18.	Fabaceae	*Bauhinia perpurea* L.	Faledo	3.194489488
19.	Rosaceae	*Pyruspyrifolia* (Burm.f.) Nak.	Naspati	3.121750104
20.	Moraceae	*Ficusbenghalensis*	Badahar	2.958299357
21.	Lauraceae	*Litseamonopetala* (Roxb.) Pers	Kutmiro	2.909726313
22.	Euphorbiaceae	*Phyllanthusemblica* L.	Amala	2.014943287
23.	Palmae	*Wallichiadisticha*	Thakal	1.939728743
24.	Anacardiaceae	*Magniferaindica* L.	Aanp	1.475633306
25.	Rhamnaceae	*Zizyphusmauritiana* Linn.	Bayar	1.375297546
26.	Sapendaceae	*Sapindusdetergens*	Riththa	1.167925065

Table 3. Index of dominance and Shannon Wienner's index of diversity of two study sites

S.N.	Study sites	Index of dominance	Shannon Wienner's index of diversity
1	Ramdhuni	0.28	2.32
2	Dhankuta	0.13	2.47

and seeds (Boonaratana *et al*., 2020). Residing in alpine forests the primates fed less on flowers and more on lichens but not in production of pine tree (Tsuji *et al.,* 2013).

Time allocated for foraging

Time allocated for foraging was maximum in April (as mentioned in Table 4) (38.25%) in Ramdhuni but maximum in March (42%) in Dhankuta. The least time was allocated in month of July(27.5%) in Ramdhuni but in September (35%) in Dhankuta. In average Ramdhuni troop spent less percentage of time than Dhankuta troop. Deviation of allocation of time was higher in Ramdhuni (3.81) than in Dhankuta (2.10). There was significant relation between the altitude (differences in habitats) and time allocation to eating (df=22, Fcal= 20.89, Fcrit= 4.300 and p= 0.00015).

Table 4. Time allocation by rhesus monkey for foraging

S. No.	Months	Time allocated in foraging (in Percentage)	
		Ramdhuni	Dhankuta
1.	June, 2022	30.25	37
2.	July	27.5	37.5
3.	August	29.25	36.5
4.	September	29.75	35
5.	October	29.75	36.5
6.	November	30.5	36.5
7.	December	30.5	36.5
8.	January , 2023	31	37
9.	February	31.5	37.5
10.	March	39.5	42
11.	April	38.25	41
12.	May	36.25	40
	Average	32%	37.75%
	Standard Deviation	3.81	2.10
	standard error	1.099	0.6062

We recorded the rhesus monkey of Ramdhuni forest used 32% of total diurnal time on eating but in Dhankuta the focal troop allocated much more time (37.75%). We found there are many types of food plants and more food resources in Ramdhuni than in Dhankuta. So less time is enough to collect the foods. The more deviation in Ramdhuni shows that the food availability and other climatic and topographic factors may have role. In both the cases the dry seasonal months, there was scarcity of food, so they spent much time for searching food and eating. Contrary to our findings the rhesus monkey in Yedagun hill allocated only 19% for eating (Htun and Sein, 2021) but nearly resemblance with previous study in Ramdhuni as time for foraging was 26.67% (Adhikari, 2023). Next study on Bir Bara ban conservation reserve showed the maximum time was allocated for feeding by rhesus monkeys (Sikerwal *et al.,* 2023). Not matching to our finding, in Nawalpur, in average the time allocated to eating was in third rank (22.92%) but the female used maximum time on feeding along with grooming (Kshetri *et al.,* 2023). The finding in high altitude rhesus monkey in China resembled to our result as they spent maximum time (33%) on eating (Zhang *et al*., 2023).

Parts of plant eaten

Both the the Ramdhuni troop and Dhankuta troop loved mostly for fruit eating (Table 5). Ramdhuni troop used fruits of 35.08% of total available plants where as Dhankuta troop used fruits of 36.66% plants. of and they ate bud at least number. Both the troop consumed least percentage of resin of tree. There was not significant relation between parts of plant chosen with differentiation of habitat (F cal= 1.446, F crit= 4.493, p- value =0.246, df=16).

Our finding showed that Ramdhuni troop fed on the fruits of 20 species and Dhankuta troop on 11 species of plants. Secondly Ramdhuni troop consumed leaf of 13 species and Dhankuta troop consumed flower of 9 species of plants. A research found that macaques primarily consumed young leaves (28.0 ± 33.1%) and plant roots (30.9 ± 30.1%). The food item chosen was positively connected with the availability of food for the monkeys. They fed on roots, barks, and fallen leaves when the availability of favored foods was low (Zhang *et al.,* 2023). We recorded monkey fed upon the parts of all tree plants. The finding of study on Margalla hill resembled to it that the monkey fed upon 29 dietary plant species among 30 plant species observed in the field and 83% of the dietary requirement was filled up by plants. No animal noticed depending on derived food component. The results revealed that food composition consisted of 83% plant diet (Aslam *et al*., 2022). The rhesus monkeys in Shiva Puri national park consumed different parts of 88 species of plants and to the comparison of Assameses monkey the rhesus consumed more flowers, seeds, and pods (Khatiwada *et al*., 2020). A research on high mountain of China identified 105 plant species of plants eaten by rhesus monkey

Table 5. The parts of plant eaten

S. No.	Plant parts	Ramdhuni		Dhankuta	
		Number of plants	Percentage	Number of plants	percentage
1	Leaf	13	22.8	3	10
2	Fruit	20	35.08	11	36.66
3	Shoot	5	8.77	1	3.33
4	Flower	7	12.28	9	30
5	Bud	1	1.75	0	0
6	Seed	2	3.5	3	10
7	Pod	3	5.26	2	6.66
8	Resin	1	1.75	1	3.33
9	Unknown	5	8.77	0	0
	Total	57	100	30	100
	Standard deviation		11.12		13.22
	Standard error		3.70		4.40

which were belonged to 44 genera and 30 families (Shao *et al.*, 2023). Among the plants available the rhesus monkeys consumed parts of 29 species in Binijor however they preferred the fruits of 25 species (Rathi and Bhatt, 2020).

Time investment in different items of food plants: In Ramdhuni and Dhankuta

Time investment of Ramdhuni troop for different plant parts was evaluated. Leaf was consumed maximally in January which was followed by December and November when other items were scarced. The fruit consuming time was maximum in September and least in April. In winter months January, February, March monkey utilized time maximum time for consuming shoot than other months. The resin was the least choosen items among foods on the basis of time spending.

Time investment in leaf eating

The average annual time spent by monkey in leaf eating was 26.666% in Ramdhuni and 28.666% in Dhankuta. The maximum time was consumed as 41% in both the habitat and in January but it was least in March and May (11%) and in Dhankuta in March (11%).

The standard deviation of time investment in leaf eating in Ramdhuni was 12.264 with standard error 3.540 and the standard deviation of time investment in leaf eating in Dhankuta was 9.801 with standard error 2.829. There was no relation between time investment in leaf eating in different altitudes (P value= 0.194 F calculated = 0.663, F crit=4.300, df= 22).

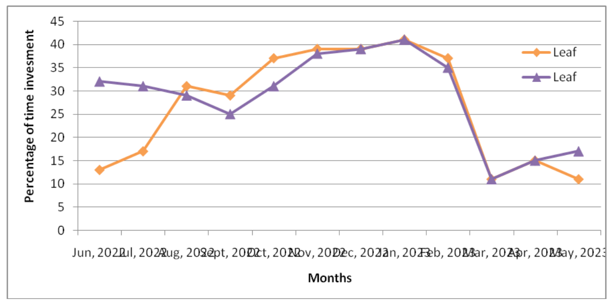

Fig. 2. Comparison of time investment on leaf eating in two habitats

Time investment in fruit eating

The average annual time used in fruit eating in Ramdhuni was 25.91% whereas that in Dhankuta was 24.75%.The maximum time was in Ramdhuni was 44% in September and in Dhankuta also in the same month(43%). The least time for fruit eating in April (8%) in both the habitats.

The standard deviation of time investment in fruit eating in Ramdhuni was 12.816 with standard error 3.699 and standard deviation of time invest-

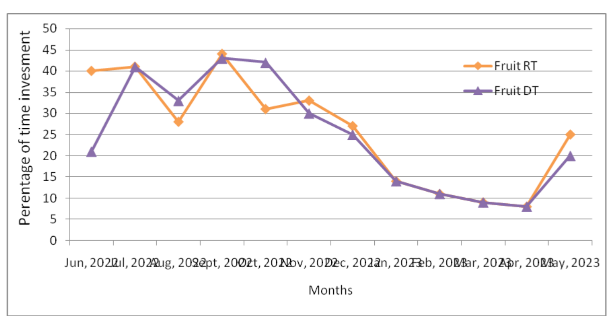

Fig. 3. Comparison of time investment on fruit eating in two habitats

ment in fruit eating in Dhankuta was 13.004 with standard error 3.754. There was not significant relation between time investment in fruit eating by monkeys of different troop in different altitudinal habitats (P value=0.826, F cal= 0.048, F crit=4.300, df=22)

Time investment in shoot eating

The average annual time spent in shoot eating in Ramdhuni and Dhankuta were 7.75% and 9% respectively. The maximum time was used in February (13%) and least in September and November (3%) in Ramdhuni. In Dhankuta the maximum time was used in January (15%) and least in September (2%).

The standard deviation of time investment in shoot eating in Ramdhuni was 3.570 with standard error 1.030 and standard deviation of time investment in fruit eating in Dhankuta was 5. 257 with standard error 1.517 There was not significant relation between time investment in shoot eating by monkeys of different troop in different altitudinal habitats (P value=0.502, F cal= 0.464, F crit=4.300, df=22)

Time investment in flower eating

The average annual time used in flower eating was 8% in Ramdhuni and 7.75% in Dhankuta. The maximum time in both habitats Ramdhuni and Dhankuta was 25% in April. The minimum time consumed in flower eating was 3% and 2% in Ramdhuni and Dhankuta respectively in the same month July.

The standard deviation of time investment in flower eating in Ramdhuni was 7.096 with standard error 2.08 and standard deviation of time investment in fruit eating in Dhankuta was 7.072 with standard error 2.041. There was not significant relation between time investment in flower eating by

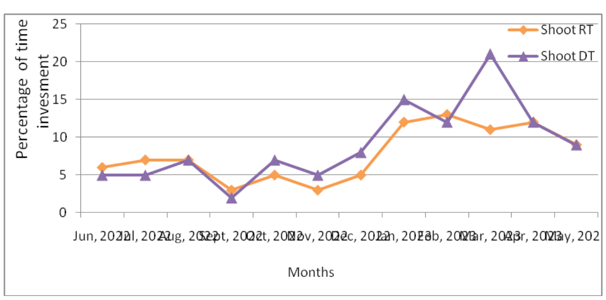

Fig. 4. Comparison of time investment on shoot eating in two habitats

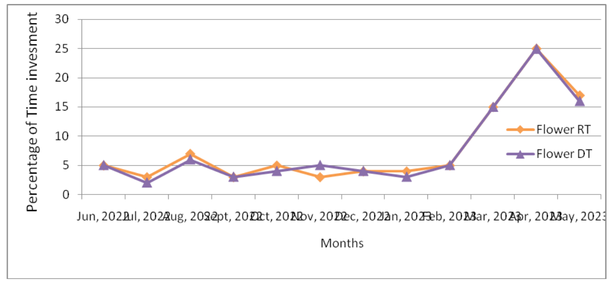

Fig. 5. Comparison of time investment on flower eating in two habitats

monkeys of different troop in different altitudinal habitats (P value=0.931 F cal= 0.007, F crit=4.300, df=22).

Time investment in bud eating

The average annual time used for bud eating was found same as 8.25% in both Ramdhuni and Dhankuta. The maximum time used in this food item was 25% in March and least in August for the both habitat, 3% and 2% respectively.

The standard deviation of time investment in bud eating in Ramdhuni was 6.850 with standard error 1.977 and standard deviation of time investment in bud eating in Dhankuta was 6.929with standard error 2.000. There was not significant relation between time investment in bud eating by monkeys of different troop in different altitudinal habitats (P value=1 F cal= 0, F crit=4.300, df=22).

Time investment in seed eating

The average annual time using in seed eating in Ramdhuni and Dhankuta was allocated 3.33% and 4.91% respectively. The most time on seed was spent in July (8%) and least in October, November and December (1%) in Ramdhuni. But in Dhankuta the maximum in June, August, November, January and February (7%) and least in September, October, March and May (3%).

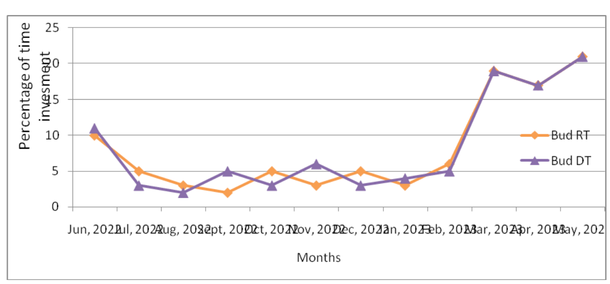

Fig. 6. Comparison of time investment on bud eating in two habitats

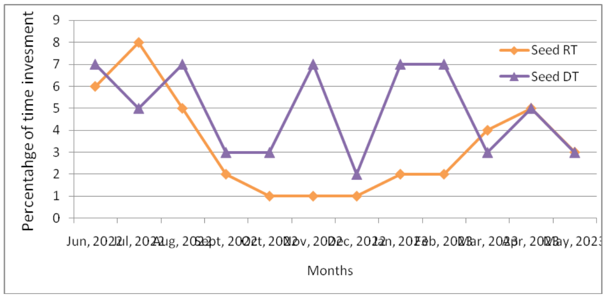

Fig. 7. Comparison of time investment on seed eating in two habitats

The standard deviation of time investment in seed eating in Ramdhuni was 2.269 with standard error 0.655 and standard deviation of time investment in seed eating in Dhankuta was 2.020 with standard error 0.583. There was not significant relation between time investment in seed eating by monkeys of different troop in different altitudinal habitats (P value=0.084 F cal= 3, F crit=4.300, df=22).

Time investment in pod eating

The average annual time allocated to pod eating by focal individual was 5.5% and 5.16% in Ramdhuni and Dhankuta respectively. The maximum time spent for this item was 9% in January in Ramdhuni and 8% in April in Dhankuta. Similarly the minimum time to pod eating was allocated in June, August and September (3%) in Ramdhuni. But in Dhankuta the least time was 2% for pod in October.

The standard deviation of time investment in pod eating in Ramdhuni was 2.067 with standard error 0.596 and standard deviation of time investment in pod eating in Dhankuta was 1.898 with standard error 0.548. There was not significant relation between time investment in pod eating by monkeys of different troop in different altitudinal habitats (P value=0.684 F cal= 0.169, F crit=4.300, df=22).

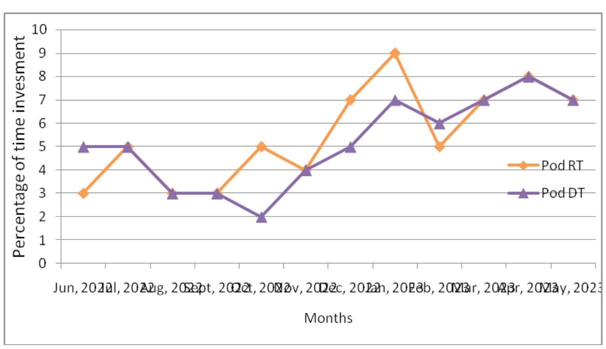

Fig. 8. Comparison of time investment on pod eating in two habitats

Time investment in resin eating

The average time allocated in resin was 1.91% in Ramdhuni and 2.5% in Dhankuta. The most time for this item was August, January, February and April (3%) and least in two months June and July (0%) in Ramdhuni. But in Dhankuta it was maximum in March (5%) and minimum in four months (1%).

The standard deviation of time investment in resin eating in Ramdhuni was 1.164 with standard error 0.336 and standard deviation of time investment in resin eating in Dhankuta was 1.243 with standard error 0.358. There was not significant relation between time investment in resin eating by monkeys of different troop in different altitudinal habitats (P value=0.248 F cal= 1.407, F crit=4.300, df=22).

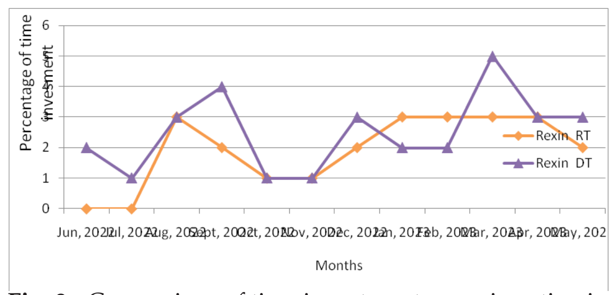

Fig. 9. Comparison of time investment on resin eating in two habitats

Time investment in other items of food

The average annual time allocated for other food eating was 12.66% in Ramdhuni and 8.75% in Dhankuta. The maximum time was spent to other foods in the same month February in both the habitats (18% and 17% in Ramdhuni and Dhankuta respectively). The minimum time in May in Ramdhuni (5%) and least in November and May (4%) in Dhankuta.

The standard deviation of time investment in other foods eating in Ramdhuni was 4.51 with standard error 1.304 and standard deviation of time investment in other foods eating in Dhankuta was 3.695 with standard error 1.0668. There was significant relation between time investment in other foods eating by monkeys of different troop in different altitudinal habitats (P value=0.0295 F cal= 5.400, F crit=4.300, df=22).

The choice of food depended on the availability of particular item. For example, in both the habitats the monkey was found leaf eating maximally in January when other items were not available. They mostly ate fruits in September because according to the phenology, most of the flowering plants give fruits in these months. The apical shoot was the major food when they were available. April is the flowering and march is the budding time of most of the angiosperms so monkey enjoyed on them most in these special months. Food availability is not constant throughout the year in highly seasonal settings, therefore species cannot solely depend on their favored meals. Rather, it is anticipated that individuals will incorporate less favored fallback items into their diet at specific times of the year (Marshall and Wrangham, 2007). When selecting a primate's diet, seasonal patterns in fruit production can occasionally take precedence over features of their habitat (Dunn *et al*., 2010). When the consumption of the adult leaves decreased in the spring, they became increasingly dependent on the new leaves. Numerous studies on primates have shown that this association exists (Simmen *et al*., 2003; Norsica *et al.,* 2006). According to (Guo *et al.*2007), animals that inhabit settings with varying seasons tend to focus on year-round food sources or adjust their diet to accommodate seasonal fluctuations in availability. There was no significant difference in time investment by Assamese monkey on different food items between the Kaligandaki river basin and Budhigandaki river basin (Ghimire *et al.,* 2023). Due to their identical food plant choices and similar biological settings in deciduous rainforests, the two study groups may have expended nearly equal amounts of time choosing and serving their food (Ghimire *et al*., 2023). With the regards of feeding habit of rhesus monkey, fruit availability and consumption showed a strong correlation, but fruit preference seemed to be a major factor as well; 16% of all the fruit species they ate were responsible for more than half of the fruit feeding data (Sengupta and Radhkrishna, 2016). Our study was done in different habitat having different altitudes, geographical features, vegetation and other factors but there was not significant relation of time investment on feeding on most items of plant parts with the altitude. The mentality of selecting food items and time allocation was dependent on their availability. In spring and summer, when seeds were scarce, leaves were major food source and occupied about 60.3% of their diet, in autumn and winter, when seeds were available in enough amount, they contributed about 68.5% of the diet. Although the bark and twigs were available in all seasons, the macaques only fed on them in winter (Cui *et al*., 2019).

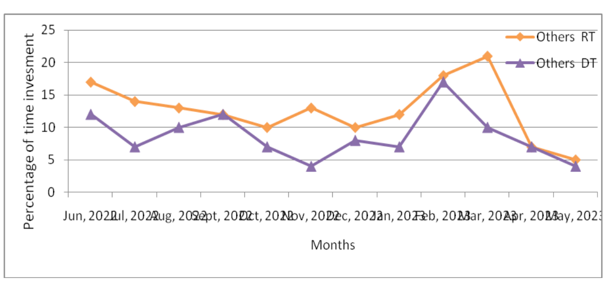

Fig. 10. Comparison of time investment on other parts eating in two habitats

Regarding food kinds, this aligns with the documented eating habits of macaques in temperate-alpine forests, where they often consume a greater variety of leaves and other materials like bark and fungi (Tsuji *et al*., 2013). Nine major food groups were included in the macaques' diet which varied significantly over the seasons (Shao *et al.,* 2023). However, fruits made up only 2.5% of the high-altitude macaques' total diet, which is significantly less than the average of 48.0% for Asian macaques and even less than the average of 29.0% for Asian colobus monkeys (Tsuji *et al.* 2013). In our findings the monkeys of both Ramdhuni and Dhankuta relied on the other types of foods when there was scarcity of natural foods. In high altitude above 3500 the monkeys mostly fed on lichen in the absence of other foods (Cyril *et al*., 2012).

Conclusion

The time allocated for foraging was higher in high altitude (Dhankuta) where less number of food items was available. The maximum time for foraging was in the months when there was scarcity of food in dry season and least time in the season when a variety of food available. In both the habitats they consumed fruits from maximum number of plants, hence they loved fruits maximally. In Ramdhuni (Low altitude) monkeys used time in decreasing order as for leaf, fruit, others, bud, flower, shoot, pod, seed and resin. In Dhankuta they allocated time in decreasing order as for leaf, fruit, shoot, others, bud, flower, pod, seed and resin. In both the habitats monkey spent most of the time on leaf eating, then fruit and least time spent in resin eating. Up to the level of availability, they enjoy maximum time in eating particular item. There was not a significant relation between time investments in particular food items except other foods which comprised minor food including wastes. The pattern of food choice and time allocated for particular food more or less similar in both the habitats according to the seasonal changes.

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Authors contribution

Ram Chandra Adhikari developed concept and designed the study and performed field work. Kaushik Chakraborty supervised and advised for the work and revised the manuscript. Both the authors gave final approval for publication.

Conflict of interest

The authors declare no conflict of interest.

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