

2 /

**COMPARISON OF FEEDING ECOLOGY OF TWO ENDEMIC SPECIES OF
LANGURS,
HIMALAYAN GREY LANGUR (*Semnopithecus ajax*) AND TUFTED GREY LANGUR
(*Semnopithecus priam*)**

By

AAKIB HUSSAIN PAUL

(2017 – 17 – 009)

THESIS

Submitted in partial fulfillment of the requirements for degree of

MASTERS OF SCIENCE IN FORESTRY

Faculty of Forestry

Kerala Agricultural University



DEPARTMENT OF WILDLIFE SCIENCE

COLLEGE OF FORESTRY

VELLANIKKARA, TRISSUR – 680 656

KERALA, INDIA

2019

DECLARATION

I, hereby declare that the thesis entitled “**COMPARISON OF FEEDING ECOLOGY OF TWO ENDEMIC SPECIES OF LANGURS, HIMALAYAN GREY LANGUR (*Semnopithecus ajax*) AND TUFTED GREY LANGUR (*Semnopithecus priam*)**” is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

Vellanikkara,

Date: 13-AUG-2019



Aakib Hussain Paul

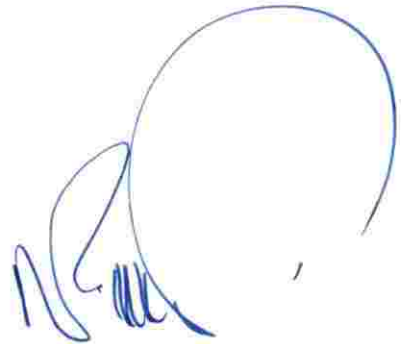
(2017 – 17 – 009)

CERTIFICATE

Certified that the thesis entitled “**COMPARISION OF FEEDING ECOLOGY OF TWO ENDEMIC SPECIES OF LANGURS, HIMALAYAN GREY LANGUR (*Semnopithecus ajax*) AND TUFTED GREY LANGUR (*Semnopithecus priam*)**” is a record of research work done independently by Mr. Aakib Hussain Paul under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

Vellanikkara,

Date: 13 Aug 2019



Dr. P.O. Nameer

(Major advisor, Advisory committee)

Professor and head of department

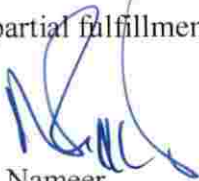
Department of Wildlife Science

College of Forestry

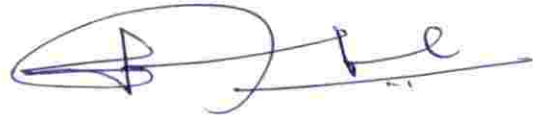
Vellanikkara.

CERTIFICATE

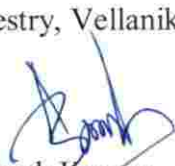
We, the undersigned members of the advisory committee of Mr. Aakib Hussain Paul, a candidate for the degree of Master of Science in Forestry with major in Wildlife Science, agree that the thesis entitled **“COMPARISION OF FEEDING ECOLOGY OF TWO ENDEMIC SPECIES OF LANGURS, HIMALAYAN GREY LANGUR (*Semnopithecus ajax*) AND TUFTED GREY LANGUR (*Semnopithecus priam*)”** may be submitted by Mr. Aakib Hussain Paul, in partial fulfillment of the requirement for the degree.



Dr. P. O. Nameer
(Chairman, Advisory committee)
Professor and Head
Department of wildlife Science
College of Forestry, Vellanikkara.



Dr. T. K. Kunhamu
(Member, Advisory committee)
Professor and Head
Department of Silviculture and Agroforestry
College of Forestry, Vellanikkara.



Dr. A. V. Santhosh Kumar
(Member, Advisory committee)
Professor and head
Department of Forest Biology and Tree Improvement
College of Forestry, Vellanikkara.



Dr. Khursheed Ahmed
(Member, Advisory committee)
Asst. professor and Head
Department of Wildlife Science
Faculty of Forestry,
SKUAST – K, Srinagar.

ACKNOWLEDGEMENT

5

*With deep admiration, I express my heartfelt gratitude to my major advisor, **Dr. P.O. Nameer**, professor and Head, Department of Wildlife Science, College of Forestry for his invaluable guidance, support, inspiration, critical advices encouragement and friendly co – operation throughout the course of my research work. I consider myself very lucky to him as my advisor.*

*I owe my sincere thanks to my advisory committee member **Dr. T. K. Kunhamu**, Professor and Head, Department of Silviculture and Agroforestry, and member of advisory committee for his co-operation and intellectual advice extended to me during the course of my study.*

*I extend my whole heart thanks to **Dr. A.V. Santhosh Kumar**, Professor and Head, Department Forest Biology and Tree Improvement, and member of advisory committee for his valuable suggestions and support, provided to me throughout the course of the study.*

*My earnest and sincere thanks to **Dr. Khursheed Ahmed**, Asst. Professor and Head, Division of Wildlife Science, SKUAST – K and advisory committee member for wholehearted co-operation and valuable advice given to me during the course of the study.*

*I take this opportunity to recognize **Dr. K. Vidyasagar**, Dean, College of Forestry for his support during the study.*

*My sincere thanks to Chief Wildlife Warden, Jammu and Kashmir. Many thanks and heart felt gratitude to Jammu and Kashmir Department of Wildlife Protection, **Mr. Altaf Hussain KFS**, wildlife warden, Central division, **Mr. Showket Ahmed**, Range officer central division, **Mr. Nazir Ahamed Malik**, Assistant range officer, **Shabir Ahamad**, Beat officer and **Mohammad Younis**, Beat officer for sanctioning the permission for carrying out the research work and for providing field staff, support, information and successful completion of the research work.*

*I express my earnest gratitude to **Ms. Syamili M S**, **Mr. Sreekumar E R**, **Mr. Arjun Ramachandran**, and **Mr. Aftab Faisal** for sincere co-operation and intellectual advice during the course of the study.*

*The help rendered by **Mr. Sachin Krishna M V, Wahiba Irshad Humam, Ms. Devika Sangamithra, Ms. Shaheena Nowshad, Ms. Devika and Ms. Smitha S Govind**, during the course of study is heartwarming and remembered with immense gratitude.*

*I am whole-heartedly obliged to **Ms. Bisma Jan**, for her timely advice, moral support, constant aid and everlasting support during the course of study.*

*Special gratitude to **Mr. Abhi Jamatia**, for the unconditional support, encouragement and unconditional help whenever I was in need.*

*I sincerely thanks my **Mother, Father, Brothers** who have supported me a lot during the entire duration of the course.*

Well wishes, lots of love, encouragement and blessings from my colleagues, seniors and juniors were great support for me during the study.

Above all, I owe my sincere thanks to Almighty Allah for making this study happen and continuously showering blessings upon me.

AAKIB HUSSAIN PAUL

CONTENTS

7

CHAPTER NO.	TITLE	PAGE NO.
1.	INTRODUCTION	1 – 5
2.	REVIEW OF LITERATURE	6 – 18
3.	MATERIALS AND METHODS	19 – 32
4.	RESULTS	33 – 110
5.	DISCUSSION	109 – 120
6.	SUMMARY	121 – 126
7.	REFERENCES	127 – 136

LIST OF TABLES

8

Table No.	Title	Page No.
1.	List of plant species on which Himalayan grey langur feeds their family, common name, season of feeding, time duration, and percentage duration	41 – 42
2.	The plant species fed during summer, their family, part fed, time duration and percentage duration of feeding	46
3.	The list of plant species, their family, part fed, time duration of feeding and percentage duration of feeding during winter season	57
4.	The plant species fed, their family, part fed, time of feeding and percentage duration of feeding by Tufted Grey Langur at Wayanad Wildlife Sanctuary	63 – 64
5.	The mean duration of various activities performed by the Himalayan Grey Langur during the summer season	84
6.	The mean duration of activities of the Himalayan Grey Langur during the winter season at Dachigam National Park	88
7.	The percentage duration of time budget activity of the Himalayan Grey Langur across the different seasons	90
8.	The percentage frequency of activities performed by the Himalayan Grey Langur at Dachigam National Park across the different seasons	92
9.	The population density of the Himalayan Grey Langur at Dachigam National park	95
10.	The detection probability and cluster size of the Himalayan Grey Langur at Dachigam National Park	96
11.	The relative density and abundance of tree species in Dachigam National Park	98 – 99
12.	The IVI of the tree species in Dachigam National Park	107 – 108
13.	Important Value Index of the tree families in Dachigam National Park	109 – 110

LIST OF FIGURES

9

Figure No.	Title	Page No.
1.	Location of Dachigam National Park	20
2.	Location map of Wayanad Wildlife Sanctuary	25
3.	The schematic view of Line transect method	29
4.	Illustration of Line transect method	29
5.	The overall time spent by Himalayan grey langur on feeding various plant species	36
6.	The percentage duration of time spent on various food items by Himalayan Grey Langur at Dachigam National Park	38
7.	The average feeding height of the Himalayan grey langur at Dachigam National Park	39
8.	The feeding incidences of various feeding items of Himalayan Grey Langur at Dachigam National Park	40
9.	The average feeding height of the various plant species at Dachigam National Park	43
10.	The average feeding height of various food items fed by the Himalayan grey langur at Dachigam National Park	44
11.	The percentage duration of time spent on feeding different plant species by Himalayan Grey Langur at Dachigam National Park	48
12.	The number of feeding incidences and the feeding item during summer season by Himalayan Grey Langur at Dachigam National Park	49
13.	The percentage duration of time spent by the Himalayan Grey Langur in feeding different food items during the summer season	51
14.	The average feeding height various plant species during the summer season	52
15.	The average feeding height of Himalayan Grey Langur of different feeding items during the summer season	53
16.	The percentage utilization of various feeding habitats during the summer season	54

17.	The number of feeding encounters for each food item by Himalayan Grey Langur during the winter season	58
18.	The percentage contribution of various feeding items in the diet of Himalayan grey langur during the winter season	59
19.	The average height of feeding for various plant species during the winter season	60
20.	The average feeding height of various feeding articles during the winter season	61
21.	Percentage utilization of different feeding habitats during the winter season by the Himalayan grey langur	62
22.	The number of encounters for each tree species at Wayanad Wildlife Sanctuary	64
23.	The contribution of various food items in the diet of Tufted grey langur at Wayanad Wildlife Sanctuary	65
24.	The number of encounters for each feeding item at Wayanad Wildlife Sanctuary	66
25.	The percentage duration of time spent feeding on each tree species by Tufted grey langur at Wayanad wildlife sanctuary	67
26.	The percentage duration of time spent on feeding on each food article by the Tufted grey langur at Wayanad wildlife sanctuary	68
27.	The average height of feeding of various trees species at Wayanad wildlife sanctuary	69
28.	The average feeding height of various food articles at Wayanad wildlife sanctuary	70
29.	The time duration of various activities performed by the Himalayan grey langur at Dachigam National Park	72
30.	The Activity time budget of the Himalayan grey langur at Dachigam National Park	73
31.	The mean duration of activities of the Himalayan grey langur at Dachigam National Park	74
32.	The percentage frequency of activities by the Himalayan grey langur	
33.	The average height of various activities performed by the Himalayan grey langur at Dachigam National Park	76
34.	The percentage duration of time spent on various activities during the summer season	81
35.	The percentage frequency of various activities during the summer season	82

36.	The average height of various activities performed by the Himalayan grey langur during the summer season	83
37.	Mean duration of activities during the summer season	85
38.	The percentage time budget activity of Himalayan grey langur during the winter season	86
39.	The frequency of various activities during the winter season	87
40.	The average height of various activities performed by the Himalayan grey langur during winter season	89
41.	The percentage duration of time budget activities across different seasons	90
42.	The percentage frequency of activities across the different seasons the summer season, the animal rested much higher than winter season	92
43.	The average height of feeding across different seasons	92
44.	The sighting of Himalayan grey langur in various habitats of Dachigam National Park	94
45.	The relative percentage of trees species in Dachigam National Park	100
46.	Girth class distribution of all tree species (above 10 cm GBH) in Dachigam National Park	101
47.	The girth class distribution of <i>Pinus wallichiana</i>	102
48.	The girth class distribution in broadleaved deciduous forest type in Dachigam National Park	103
49.	Height class distribution of trees in Dachigam National Park	104

12

LIST OF PLATES

Plate No.	Title	Between pages
1.	The Himalayan grey langur effectively using forelimbs for feeding at Dachigam National Park	33 – 36
2.	The Himalayan grey langur effectively using canines to break Oaks seeds at Dachigam National Park	33 – 36
3.	Himalayan grey langur searching for and feeding on insects near a small stream at Dachigam National Park	46 – 48
4.	The Himalayan grey langur feeding on the roots of <i>Populus deltoides</i> at Dachigam National Park	49 – 51
5.	The Himalayan grey langur feeding on <i>Sorghum halepense</i> at Dachigam National Park	55 – 57
6.	(6A) an adult female self – grooming with infants in the laps at Dachigam National Park (6B) allogrooming between adult and juvenile female at Dachigam National Park	77 – 79
7.	(7A) the Himalayan grey licking the gate wall at Dachigam National Park (7B) The Himalayan grey langur drinking water from Dachigam nallah at Dachigam National Park	78 – 79
8.	Oak Patch in Dachigam National Park	98 – 100

INTRODUCTION

INTRODUCTION

14

Primates are the Eutherian mammals consisting the order Primates. Primates arise nearly 85 – 55 million years ago from small terrestrial mammals called Primatophora. The primate characteristics represent adaptations to the challenging environments, which include large brains, visual acuity, Color vision, altered shoulder girdle and dexterous hands. Primates range in size from Madame Berthe's Mouse Lemur weighing 30 grams to Eastern Gorilla weighing more than 200 Kilograms. India harbors near about 22 species of primates whose habitat range varies from the moist temperate forests in the north to the tropical forest of south (Menon, 2014). The Hanuman Grey Langur (*Semnopithecus entellus*) is the most widely distributed non – human primate in the Indian – subcontinent. According to Orlando (2003) there are ten sub – species of grey langurs, however in 2001 it was recommended that several distinctive former sub – species should be given full species status; as such seven species viz., Nepal Grey Langur (*Semnopithecus schistaceus*), Kashmir Grey Langur (*Semnopithecus ajax*), Tarai Grey Langur (*Semnopithecus hector*), Northern Plains Grey Langur (*Semnopithecus entellus*), Black-footed Grey Langur (*Semnopithecus hypoleucos*), southern Plains Grey Langur (*Semnopithecus dussumieri*) and Tufted Grey Langur (*Semnopithecus priam*) were recognized (Groves, 2001, 2005). The grey langurs are found widely distributed in India, Pakistan, Nepal, Burma, Sri Lanka and Bangladesh. The least know among the grey langurs is the Himalayan Grey or Kashmir Grey Langur (*Semnopithecus ajax*), which is also known as “Handsome Langur” due to its beautiful face and structure. The Himalayan Grey Langur earlier considered to be a sub – species of Hanuman Langur (*Semnopithecus entellus*) can be distinguished from other grey langur species found in various altitudinal zones by its larger size and the outer side of both the forelimbs and hind limbs covered with the silvery – dark colored hair (Roberts, 1997). The long tail of Himalayan Grey Langur always form abroad arc over its back curving towards the head when they are on ground. The Himalayan Grey Langur belongs to the family *Cercopithecidae* and sub – family *Colobinae* that includes all old world folivorous monkeys (Thorington and Anderson, 1984).

The Himalayan Grey Langur is a species of langur formerly considered as sub – species of *Semnopithecus entellus*. Species name of the Himalayan Grey Langur i.e., *S. ajax* is derived from the Greek whose reference is there in Trojan war where two character having name Ajax was there but as Pocock (1928), compared *Pithecus entellus ajax* with *P. e. achilles* and presumably had in

mind the bravest and handsome of the Greeks after Achilles, the Ajax, king of Salamis and son of Telmon. Ajax well-matched Hector in many combats then ran amok and killed Achilles' divine armor was awarded to Odysseus posthumously. In opposition to the generic name, Ajax is a masculine nominative singular proper noun and therefore, it is declined to agree in gender with that of the genus.

The Himalayan Grey Langur is dark eyed langur, which can be distinguished from the other grey langur species of the family Cercopithecidae by their large body dimensions and the thick silver dark colored hair on the outer sides of both the fore and hind limbs (Wilson and Reddeer, 1992). The Himalayan Grey Langur carries a long tail, which forms a broad arc over their back towards the head region when the Himalayan Grey Langur moves on the ground (Jay, 1965). The Himalayan Grey Langur belongs to the family of *Cercopithecidae* and the sub – family Colobinae that includes all the old world monkeys having the folivorous habit.

In India, the Himalayan Grey Langur is endemic to the western Himalayan states of Himachal Pradesh and Jammu and Kashmir. In Himachal Pradesh, the species is confined to the Great Himalayan National Park, Kallatop – Kajiir and Manali wildlife Sanctuaries (Walker and Molur, 2004). In the state of Jammu and Kashmir, the species is found in Dachigam National Park and scattered population is found at Baderwah forest areas (Sharma and Ahmed, 2017). Besides India, the Himalayan Grey Langur is reported to be found in Nepal and Pakistan. In Nepal, the distribution of Himalayan Grey Langur is confined to the Lang Tang National Park of the Central province (Groves and Molur, 2004). In Pakistan, the distribution of Himalayan Grey Langur is confined to Azad Jammu and Kashmir, Mansehra, Palas Kohistan, Bakand, and Pattan (Roberts, 1997).

The Himalayan Grey Langur is mainly folivorous belonging to the old World monkeys. Although they mainly feed on leaves, yet they are also found to consume fruits, flowers, roots, bark and twigs (Minhas *et al.*, 2010). They also feed on cultivated crops, seeds with high toxins, like strychnine, and other distasteful vegetation usually avoided by other animals. The animal is exclusively herbivorous feeding on young leaves, buds, bark, fruits and other vegetation but the studies in recent past suggest that they also feed on insects to level their salt and ionic concentration in their bodies and this insectivory is particularly prevalent during the period of June to September (Srivastava, 1991).

The Himalayan Grey Langur or Kashmir Grey Langur are ecologically very flexible and adoptable to wide range of habitats. It does not like any particular habitat and migrates frequently from one habitat to another in a particular season. Their home range usually lies in the altitudinal zone of 2,200 – 4,000 m above sea level. They inhabit variety of habitats including moist temperate forests, coniferous, deciduous, alpine scrubs and grasslands (Nowak, 1999). The Himalayan Grey Langur is diurnal and arboreal species who prefer to jump from tree to tree through branches while foraging.

The Himalayan or Kashmir Grey Langur is a social animal and prefers to live in groups with definite structure and composition. The Himalayan Grey Langur lives usually in groups of 20 – 40 individuals but may exceed up to more than 100 individuals depending upon the location and food availability. The competition for food and infanticide largely determine the troop size, composure and composition, these factors may be limiting in deciding the sociality of langurs (Koenig *et al.*, 1997). The social system and troop size largely varies from place to place and the troop composition include one- male bisexual group, multi-male bisexual group and all-male band group. The denser the group larger is defense coalitions and increased vigilance. The bisexual troops are usually matrilineal and mostly remain with the natal group while as males emigrate as juveniles to join all-male band. The males start mating at the age of six or seven years and prevent other males of lower age from mating even though they are sexually mature. The females start mating at three and half years. Ecological conditions, feeding competition as well as the physical conditions of female effects the reproductive events of females. Breeding season varies from location to location with gestation period of 190 – 210 days (Roonwal and Mohnot, 1997). The young ones are born in the months from March – June. The Himalayan Grey Langur usually give single birth but twins and triplets have also been recorded (Mohnot, 1974).

All the primate taxa including the Himalayan Grey Langur are under severe threats. The common and major threats, which Himalayan or Kashmir Grey Langur faces throughout its habitat range include the habitat loss and degradation through illegal and unethical encroachment, overgrazing, building of roads through its home range and lopping of forest trees for domestic cattle, thus depriving them of food, deforestation, forest fires, unchecked and unregulated expansion of agricultural lands at the cost of forest ecosystems, unavailability of food during certain periods of the year, predation by large carnivores and several bacterial and viral diseases.

The present and future threats are mainly due to ever-increasing expansion of agricultural land at the cost of forest ecosystems and other developmental activities. Thus, International Union for Conservation of Nature and Natural Resources (IUCN) has classified the Himalayan Grey Langur (*Semnopithecus ajax*) as “Endangered” in 2008 (IUCN, 2018). This species is listed on CITES Appendix I, and Schedule II Part I, of the Indian Wildlife Protection Act, 1972 amended up to 2002 (Molur *et al.*, 2003).

At the ecosystem level, the primates including the Himalayan Grey Langur exert very vital feedback control on the vegetation of the forest ecosystem. They are the essential component of the forest ecosystem to maintain the vitality and the homeostasis of the forest ecosystems, especially being critical for the regeneration and the survival of the major forest ecosystems. The primate species could be projected as the flagship or the umbrella species in the forest ecosystems and by projecting these primates as the flagship or umbrella species, the whole habitat and the forest ecosystem can be protected. The primates perform certain essential ecological services that are very important to maintain the health and vigor of the forest ecosystems such as the seed dispersal, pollination as well as being food for some of the top predators. The primates are essential and integral part of the biodiversity and are cognizable link between the humans and the nature. There is certain kind of bond still existing between primates and humans in some of the peculiar primate zones, which can be effectively used for the biodiversity conservation by projecting the primates as flagship and umbrella species (Southwick and Lindburg, 1986). Although most of the areas where the Himalayan Grey Langur is found are the protected areas, still special efforts are required to protect and conserve this valuable and “Endangered” species. Concrete identification of the species, physical characteristics along with the molecular techniques should be employed while studying the species.

Understanding the distribution and ecology of any animal species are the key features for understanding the conservation status of a species. Sound knowledge of the ecology of any species is the foundation to formulate sound conservation strategies. Understanding the ecology of Himalayan or Kashmir Grey Langur has become even more significant as very little is known about the ecology of this species. Even the basic information regarding its distribution, population status as well as ecology is still unexplored until now. Most of the information available about the ecology of Himalayan Grey Langur is by virtue of Hanuman langur (*Semnopithecus entellus*), studied as generic langur or a sub – species of it while later got status of a separate species recently

(Groves, 2005). A few studies have been conducted on Himalayan Grey Langur (Minhas *et al.*, 2010, 2012, 2013). However, no systematic study have been carried out in the state of Jammu and Kashmir, India on the ecology of Himalayan or Kashmir Grey Langur and hence the current study. The current study is of great relevance as it will be the first elaborative attempt to study the feeding ecology of Himalayan Grey Langur, which will be of immense help in planning and formulating the long – term strategies for the conservation of the Endemic Himalayan Grey Langur which has been categorized as “Endangered” by the International Union for Conservation of Nature and Natural Resources (IUCN) (Groves and Molur 2008).

The objective of the present study is to:

- Study food and feeding habits of Himalayan Grey Langur
- Study food and feeding habits of Tufted grey Langur
- Population estimation of Himalayan Grey Langur
- Social behavior of Himalayan Grey Langur
- Vegetation sampling of the habitat of Himalayan Grey Langur

REVIEW OF LITERATURE

2.1 Status and distribution all over world

Primates belong to the highest order Primate of the class Mammalia encompassing six sub-orders which include the Lemurs, the Lorises and Galagos, the tarsiers, the new world monkeys, the Old World monkeys, Apes and Humans (Blanford, 1992). The non-human primates are represented by 63 genera and near about 600 species or sub species spread in over 92 countries with Brazil topping the list by having 77 species. Out of all recorded species of the primates, 25 are found to be on Indian subcontinent (Rajpurohit, 2005). India is known to harbor near about 22 species of primates habituating from the temperate forests in the north to the tropical forests in the south (Menon, 2014). Langurs are the versatile mammals and occupy a prime position in the food chain of many forest ecosystems in India. Langurs are a preferred prey species for large carnivores such as leopard, Tiger and Black bear (Karanth and Sanquist, 1995). The grey langurs are found in variety of forest ecosystems and are most widespread in the Indian Sub-continent. The langurs are the old world leaf feeding monkeys consisting of the genus *Semnopithecus*. Traditionally all the taxa of grey langurs were included under the banner of single species *Semnopithecus entellus*.

The Himalayan Grey Langur or Kashmir Grey Langur is the least known primate owing to habitat preference in the steep, rugged and inaccessible mountain ranges of the western Himalayan region. All primate taxa in the South Asia including the Himalayan Grey Langur face greater threats. The common and major threats faced by the Himalayan Grey Langur and other taxa of primates include the habitat loss, degradation, habitat fragmentation through human encroachment, overgrazing, building roads through forests, lopping of trees for cattle and fire wood, deforestation, unregulated and unchecked expansion of agricultural lands at the expense of forest ecosystems, fires, unavailability of food particularly during the lean period, predation by carnivores (tigers, leopards, Bears) and attacks by several viral and bacterial diseases (Nandi *et al.*, 2003). Nowadays the unregulated and unchecked expansion of agriculture at the cost of forest ecosystems is the main threat to its survival. Besides this, the constant decline in population due the habitat fragmentation, human intervention and destruction of its natural habitat are forcing this species at the verge of extinction. Owing to these threats to its survival, this species is placed in "Endangered" category in the IUCN red list (IUCN, 2012).

Groves (2005) recognized seven species, which includes; *S. ajax* (Kashmir Grey Langur), *S. dussumieri* (Southern Plains Grey Langur), *S. entellus* (Northern Plains Grey Langur), *S. hector* (Terai Grey Langur), *S. hypoleucos* (Black-footed or South - Western Grey Langur), *S. priam* (Tufted or South - Eastern Grey langur) and *S. schistaceus* (Himalayan or Nepal Grey langur). Numerous Morphology based classification schemes have been proposed to resolve the generic level taxonomy of the langurs with little or no success (Kranth *et al.*, 2008). The earlier classifications suggest that the taxonomy of langurs is in deep flux. In this context the recent molecular studies on the langurs of Indian Sub-continent are of great importance. The molecular and phylogenetic studies are based on the nuclear and mitochondrial markers (Nag *et al.*, 2010). Phylogenetic studies on the langurs suggest that the genus *Semnopithecus* consists of at least three species: Hanuman Langur (*Semnopithecus entellus*), Nilgiri Langur (*Semnopithecus johnii*) and Purple faced Langur (*Semnopithecus vetulus*).

Among all primate species and particularly of langurs least is known about the Kashmir Grey Langur, fondly described as “Handsome Langur” due to its beautiful facial structure (Pocock, 1928). The Kashmir Grey Langur inhabits the steep, rugged and unscrupulous mountain ranges of Western Himalayan ranges. The Kashmir Grey Langur is an old world leaf-feeding primate distributed in small pockets in some parts of India, Pakistan and Nepal (Minhas *et al.*, 2010). In northern and Western Himalayas the species exhibits a great geographical range, ranging from Uttarakhand to Azad Kashmir (Pakistan) (Groves, 2001). In India, the Himalayan Grey Langur is restricted to the States of Jammu and Kashmir, Himachal Pradesh and certain small pockets of Uttarakhand (Roberts, 1997; Walker and Molur, 2004). In Himachal Pradesh, the Himalayan Grey Langur is found in the Great Himalayan National Park, Kallatop-Kajhar, Manali wildlife sanctuaries and Chamba valley. In Jammu and Kashmir the species have been recorded from Dachigam National Park (Mir *et al.*, 2015), Wadwan area of Kishtwar National Park (Brandon-Jones, 2004). Towards west, the Himalayan Grey Langur has been reported from Maneshra, Palas Kohistan, Bankad, Dubair and Pattan (Roberts, 1997). It also inhabits the Neelum and Jhelum valleys, Hillian, Phallla game reserves and Bagh (Ahmed *et al.*, 1999; Iftikhar, 2006) and Machiara National Park Azad Kashmir, Pakistan (Groves, 2001; Minhas *et al.*, 2012, 2013; Mir *et al.*, 2015). The distribution of Himalayan Grey Langur in Nepal is confined to the Lang Thang National Park of the central province (Walker and Molur, 2004).

2.2 TIME BUDGET ACTIVITY

The time budget activity of most of the folivorous colobines is mostly influenced by their diet (Schneider *et al.*, 2010). The ease of access to the food and feeding resources plays a significant role in determining the time budget activity of these primates. The langurs usually spend their time in resting and comparatively less time in feeding and other behavioral activities (Clutton-Brock, 1977; Standford, 1991; Fleagle, 1999). However, during the time when the food resources are scarce or during the winter season in temperate areas the langurs spent more time in foraging than other social activities. This more time devotion to foraging and sacrificing time of other activities is attributed to the fact that the food resources are at the lowest ebb. The feeding time in winter may also be high as the energy consumption during winters increases for thermoregulation, as the outer temperature is very low (Hill, 2006). This increased energy requirement may be having a negative impact on the energy budget of animal during winters, therefore requires more food to level this energy requirement, the animal has to devote more time in foraging. Therefore, langurs respond to the harsh conditions such as snowfall, or when the food resources are scarce by increasing the time on foraging and maximizing feeding efficiency and attempting to ingest more and more food (Van Doorn *et al.*, 2010; Majolo *et al.*, 2013). The juveniles spend comparatively more time in social behavior activities as compared to adults. This spending of more time in such types of social activities is associated with their physical, social and behavioral development (Poirier, *et al.*, 1978).

2.3 Feeding Ecology and Habitat preference

The primates exhibit broad range of pattern of habitat association and diet both within and among the species (Kirkpatrick and Grueter 2010; Kirkpatrick 2011). The food resource availability and preferences are reflected in foraging behavior such home range size, daily time spent in foraging daily route length covered in foraging and altitudinal preference (Curtin, 1982; Bennett, 1986; Matsuda, *et al.*, 2009; Li *et al.*, 2010; Zhou *et al.*, 2011; Grueter *et al.*, 2012).

The Himalayan Grey Langur is mainly folivorous. They also feed on fruits, bark, leaf buds agricultural crops and other distasteful vegetation usually avoided by other animals (Minhas *et al.*, 2010). The animal is exclusively herbivorous feeding mainly on the young leaves, buds and other vegetation parts (Roberts, 1997), but the observation in the open scrubs areas reveal that the grey langurs also feeds on insects and this habit of insectivory is particularly prevalent during the

months of July-September (Srivastava, 1991). Moore (1985), in a study of langurs of all - male bands also observed five episodes of active insect predation.

Sayers and Norconk (2008) reported the Himalayan Grey Langur feeding on 43 plant species at Langtang, Nepal. The diet of the Himalayan Grey Langur comprised of the leaf parts, including deciduous mature leaf parts, herb leaves, coniferous needles and evergreen mature leaf petioles, ripe, unripe and herbaceous fruits constituted 22.4 % of the total diet. The flowers and flower buds contributed 6.9 % of the total diet of the Himalayan Grey Langur while as the bark contributed only 5.4 % of the total diet.

The Kashmir Grey Langur or the Himalayan Grey Langur prefer a variety of habitats and are very flexible about their habitat choice. They are correspondingly found in a wide range of habitats ranging from the deciduous forests to evergreen coniferous forests, from alpine pastures to the open scrubs and grasslands (Sugiyama 1976; Oppenheimer 1977; Bennett and Davies, 1994). They inhabit the area lying between 2,200-4,000 m above the mean sea level, in the subtropical tropical moist temperate, alpine, coniferous, broadleaved forests and scrublands (Nowak, 1999; Hilton and Taylor, 2000; Roberts, 1997). The Himalayan Grey Langur is an arboreal and diurnal species and prefer to jump from tree to tree through branches when foraging particularly during the lean period few individuals in the troop may become accustomed to the human settlements (Tritsch, 2001).

The Himalayan Grey Langur is endemic to the precipitous Himalayan region and the animal has to face some very tough and harsh climatic conditions during the winter period and has to overcome various challenges such as scarce food availability and its haphazard and uneven distribution, shortened day length, and extreme climatic conditions like very heavy snowfall and extreme cold conditions. During this lean period, the frequency of extreme climatic conditions like heavy snowfall and rainfall increases which ultimately increases the energy requirements of the animal. The Himalayan Grey Langur adopt various behavioral strategies, which maintain their energy balance in these harsh environmental conditions. To overcome the scarce food resources during these harsh environmental conditions, the Himalayan Grey Langur adopts two strategies:

- (I) Increase the travel distance in foraging the food or invest and more time for foraging their favorite foods from their time budget activity. However, this strategy of more

foraging and in addition, travelling more distance is not energetically efficient and it is energy draining process (Sayers and Norconk, 2008; Harris *et al.* 2010).

- (II) The Himalayan Grey Langur decreases the distance covered, spent less time in foraging And modify their diet spectrum to less preferred but easily available foods (Ganas and Robins, 2005; Fan *et al.*, 2005).

Food accessibility and food availability is the major cause of competition in the troop especially during the unfavorable weather conditions, in scarcity of the food particularly during the winter months. The food resource availability is one of main causes of the competition and dominance in the troop. The competition for food usually involves the one superior individual using threat or substantial attack to displace some other individuals from the food patch. These attacks are also meant for averting the access of other individuals to a food patch that was suitable for utilization (Minhas *et al.*, 2010). Most of the competition among the langurs is on the food resources and the langurs seem to be highly competitive for the finite food commodities, which are scarcely distributed in their home range (Rajpurohit, 2005). The phenomena such displacement of some individuals in a troop and dominance behavior shown by Alpha males or Alpha females strongly indicate that these sorts of behaviors are directly or indirectly related to acquisition of food resources. When the langurs are confronted to decreased food resources or less availability of food in a particular area or season, they resort to increased competition (Hrdy, 1997).

2.4 SOCIAL BEHAVIOR AND ORGANISATION

The langurs are social animals and usually live in groups socially bound together with one heading the troop. The troop may consist of uni-male bisexual group, Multi-male bisexual group or it may comprise of all-male band group. The langurs usually live in groups and the group size ranges from 40-60 individuals per group (Roberts, 1997). There are various factors affecting the troop size the langurs. The feeding competition within a group is conventionally believed to be a main constrain towards the group size of the langurs. Besides the feeding competition, the infanticide may be the other key factor limiting the group size and sociality of the langurs (Koenig *et al.*, 1997). The social system of the langurs varies from location to location. The troop may comprise of one male bisexual troop, multi - male bisexual troop and all male band. The troop size

in the multi male-multi female troop may comprise of the individuals ranging from 120-125 per troop. The density of individuals in such kind of troops results in larger defense coalitions and higher vigilance against any kind of predators. In such kind of groups, there are higher number of females compared to other social groups (Mohnot, 1971, Treves and Chapman, 1996). The troops consisting of bisexual individuals are generally the matrilineal. In such troops the females usually stay for lifetime in their natal troops, while as the male individuals emigrate during the juvenile stage in the all-male band group. The resident males of such troops are replaced on average of two and half years. The replacement of resident males occurs through two processes either the replacement can be abrupt or the replacement of the resident male is gradual process and takes some time to replace the resident males. During the process of resident male replacement, the invading male candidate from the all-male band invades the troop and drive out the resident male out of the resident troop. The superior male who gets the highest ranking among the invaders subsequently sets himself as the new 'Resident Male'. The setting up of the new resident male is followed by the expulsion of the weaned male juveniles (Rajpurohit, *et al.*, 1995, 2003). In the troops consisting of uni-male, the resident male is under constant pressure from the other invading males to take over the troop. When a group of males from all-male Band take over the troop, they usually kill the infants (Strusaker and Leland, 1987) and mate with the females (Sugiyama, 1965; Mohnot, 1971; Vogel and Loch, 1984). During the mating, a competitive behavior is observed. When there is more than one female in the estrous cycle the higher-ranking females are always mated first (Minhas *et al.*, 2010). During the mating season, the resident male usually acts aggressively towards other members of troop to show its dominance. The infant transfer or allomothering by real mothers to other troop members is a peculiar characteristic feature of the colobine social behavior. Allomothering is common phenomena among the langurs. The Allomothering is the way of caring in which the original mother of the newborn, allow other females to take care of the newborn baby. The immature females in a group spend significantly more time in close proximity of the other group members. These immature females groom more in addition, have more contact that is physical with the other group members compared to the immature males in the same group. The other immature females of the troop are the preferred social partners of such females. The immature males of the troop also prefer the like-aged immature females. These immature males restrict their relationship with the other immature males of same age group found in the proximity of the troop (Nikolei and Borries, 1997).

Social grooming among the langurs is a type of tactile communication, which the langurs use to reinforce the bonds between the individuals within the troop. The langurs communicate with each other in a troop via making different calls. The langurs make different types of vocal sounds for communication, for mating, connecting with other individuals of the troop and danger detection and alarming each other in the troop. In such vocal communication by the langurs in a troop, Whooping is a call given by adult male usually designated as “Alpha Male” of a troop that keeps the individuals of a troop in touch with each other. Such type of whooping call maintains the cohesion of the troop when feeding undisturbed on the branches. The whooping call is also emitted during the troop movements. The first individual of the troop when sights a threat utters a warning cough or a danger call hearing on which all individuals of the troop scatter on the treetops (Tritsch, 2001).

When a group of males takes over the troop, they will usually kill the infants and one of the males will establish himself as the ‘Resident Male’ or the “Alpha Male” of the troop (Newton, 1986; Strusaker and Leland, 1987; Borries, 1997). It has been observed that the new resident male will mate with the females soon after taking over the troop (Sugiyama, 1965; Mohnot, 1971; Vogel and Loch, 1984). The infanticide is common phenomena prevalent among the troop of langurs. The males may kill the infants to gain the reproductive advantage, as the females go in to the estrous shortly after the loss of infants (Hrdy, 1974).

2. 5 REPRODUCTIVE BIOLOGY

The male langurs start breeding at the age of six or seven years. The mature males in the troop prevent any of the males below this age from mating, though they may be sexually mature. The females come into the estrous in about three and a half year of age in the natural habitat conditions (Roberts, 1997) whereas in captivity the females reach maturity at the age between three to five years (Harley, 1988). The menstrual cycle among the females varies widely in length, with an average of 26.8 days and menstruation lasts for five to six days (David and Ramaswami, 1969). As the langurs, perform multi-male mating, the length of estrous length increases significantly as female tend to mate with as many as resident males available within the group (Borries *et al.*, 1991). In captivity, the menstrual cycle length varies from 18 to 45 days with mean of 26.3 ± 3.6 days and the menstruation lasts for two days (Lohiya *et al.*, 1988). The reproductive

characters and reproductive events in females are significantly influenced by the ecological conditions, feeding competition, ranging in various habitats as well as the physical conditions (Koenig *et al.*, 1997).

The breeding season of the langurs varies from location to location. The gestation period of langurs varies from 190-210 days (Roonwal and Mohnot, 1977). The young ones are generally born between January and March until June (Prater, 1965), with most births around the energetically worst period of the year. In contrast to several other non-human primate species, the female langurs give birth too early to meet the optimum requirements of the lactation (Koenig *et al.*, 1997). Langurs usually give single birth, but twins and triplets have also been recorded (Mohnot, 1974; Rajpurohit, 1987).

The Himalayan Grey Langur like other non-human primates breed from February to September. The young are born in the months of March to June which resending the peak birthing season (Minhas *et al.*, 2010). Most of the births are recorded in the months of March and April and low birth rates are recorded in the months of November and December (Rajpurohit *et al.*, 1994). The birthing season varies from one location to other location. Such differences in the reproductive character may be due to the crop raiding by the langurs or provisioning during the dry periods that may allow the langurs to breed throughout the year. The seasonality in births is found in populations, which are away from such conditions *e.g.*, the populations in the forest area. Thus, mating, birthing and other reproductive characters are greatly linked with habitat characteristics in general and food availability in particular (Harley, 1985; Newton, 1987). The timing of the reproductive events in the langurs is influenced by the ecological conditions, the ranging and feeding behavior, and the physical conditions of the females (Koenig *et al.*, 1997). The seasonality and timing of births is also influenced by the seasonal shortfall of the resources influencing the ability of females ovulate (Minhas *et al.*, 2010). In terms of natural selection, the reproductive events take place at some favorable place and favorable season to increase survival chances and future reproduction of both females and off springs (Lancaster and Lee, 1965). The nutrition and food availability largely determines the production, rearing of infants as it energetically costly, and energy draining process. Thus, nutrition availability of food resources greatly influence the reproductive characters as well as the birthing of infants (Lee and Bowman, 1995). During the

time of birth and following months of early and peak lactation, the ample food availability accessibility and great food quality can reduce the metabolic costs of nursing; increase the survival chances of infants, growth rate of infants and consequently shortened the weaning period and increasing chances of early subsequent conception (Sadleir, 1969; Lee, 1987).

2.6 STUDIES ACROSS THE INDIA AND WORLD

2.6.1 Distribution and habitat

Sharma and Ahmed (2010), studied the distribution of Endangered Himalayan Grey Langur in Bhaderwah, Jammu and Kashmir, India and found the extent of distribution of the Himalayan Grey Langur in upper Bhaderwah along an elevation range of 2635-3228 m. Ten troops of 142 individuals, numbering 3-27 each were sighted. The habitat of Himalayan Grey Langur in this area from temperate forests, sub-alpine forests to the rangelands. The study found that the distribution with respect to habitat was restricted to the interfaces between forests, blanks and rangelands. The number of sightings increased with increase in altitude. The healthier population at higher elevations is attributed to intact and contagious forest stands virtually devoid of anthropogenic stresses and conflicts thereof. Food and seasonal migration may be the other factors, which limit the distribution of Himalayan or Kashmir Grey langur.

Minhas *et al.*, (2012) studied the distribution pattern and population estimation of Himalayan Grey Langur (*Semnopithecus ajax*) in Machiara National Park, Azad Jammu and Kashmir, Pakistan. The study determined the distribution pattern and population status of Himalayan Grey Langur using 'All count method' during the transect surveying. The langur troops were confined to the elevation between 1,790 m-4,000 m. The population of langurs was organized in seven uni-male bisexual troops, two multi-male bisexual troops and three all-male band troops. The habitat comprised mainly of mixed coniferous and sub alpine scrubs. The distribution varied with location, elevation and month of year.

Minhas *et al.*, (2010) studied the habitat utilization and feeding biology of Himalayan Grey Langur in Machiara National Park, Azad Jammu and Kashmir, Pakistan and found that in winter season the most preferred habitat of Himalayan Grey Langur was the moist temperate coniferous

forests intercepted by deciduous trees. During the summer season the Himalayan Grey Langur, prefer to migrate sub-alpine scrub forest areas at high attitudes. In most of the habitats, they preferred the moist temperate forests with dominant deciduous vegetation. The Himalayan Grey Langur sometimes overlapped the habitat of Rhesus monkeys. These two species during the winter are sometimes found together. Most of the langur troops preferred the habitats where the water was available in plenty.

Minhas *et al.*, (2013) studied the Ranging and foraging of Himalayan Grey Langurs (*Semnopithecus ajax*) in Machiara National Park, Pakistan and found that Himalayan Grey Langur occupy a variety of habitats ranging from the lowland forests to the semi-arid desert forests. Three groups of langurs of different sizes and compositions were examined and the effect of ecological and social factors on feeding and ranging.

2.6.2 POPULATION ESTIMATION

Mir *et al.*, (2015) studied the Seasonal population and winter survival strategies of Endangered Kashmir grey langur in Dachigam National Park, Jammu and Kashmir, India using the distance sampling method. 170 sighting were recorded in 748 surveyed transects. The groups ranged from one solitary male to 103 individuals ranging across the various habitats.

Minhas *et al.*, (2012) reported the Himalayan Grey Langur population to 783 individuals at Machiara National Park, Azad Kashmir, Pakistan. The population of Himalayan Grey Langur was distributed in seven uni-male bisexual troops, two multi-male bisexual troops and three all male bands. The density of the Himalayan Grey Langur was reported to be 16.01 Km² with mean troop size of 72.77 and mean band size of 42-66.

2.6.3 FOOD AND FEEDING ECOLOGY

Minhas *et al.*, (2010) studied the habitat utilization and feeding biology of Himalayan Grey Langur in Machiara National Park, Azad Kashmir, Pakistan and found that langurs were mainly folivorous in their feeding habits and were found to be feeding on more than 49 plant species. The diet mostly composed of a combination of fruits, leaves, buds, bark, roots, and flowers. They were also seen feeding on insects. The mature leaves (consisting 36.12 % diet) were preferred over young leaves (consisting 27.27 %). Besides leaves food comprised of fruits (17 %), roots (9.45

%), Bark (6.69 %), flowers (2.19 %) and Stems (1.28%) of various plant species. During the dry season, the number of plant species consisting of the langur diet goes down drastically and with the onset of rains plant taxa on which the langur feeds increased manifolds reaching maximum in the month of August.

Mir *et al.*, (2015) studied the winter survival strategies of endangered Kashmir Grey Langur (*Semnopithecus ajax*) in Dachigam National Park, Kashmir, India and found that langurs feed on 13 plant species belonging to the 12 families. During the winter season, the langurs consumed substantial amount of bark (37.4 % of diet). The langurs fed on various plant parts, which include bark, leaf buds, fruits, leaves. Bark constituted the main food item consisting 37.4 %, followed by Leaf buds 24.2 %, fruits 17.1 %, leaves 13.8 %, seeds 7.5 %. During the winter, season when there is scarcity of food almost 50 % of the langur diet comprised of *Aesculus indica* and *Ulmus wallichiana*.

Minhas *et al.*, (2013) studied the ranging and foraging of Himalayan Grey Langurs (*Semnopithecus ajax*) in Machiara National Park, Pakistan and found that during the winter season the Himalayan Grey Langur employ high energy costs and high return foraging strategy during the winter season. During the winter season, langurs at Machiara National Park mainly fed on fruits of *Aesculus indica*, and *Quercus incana*, which have higher nutritional value. The Himalayan Grey Langur in alpine forests, where the production of leaves is very less as compared to the lowland forest area the langurs have to employ high-cost, high-yield strategy in response to food storage.

2.6.4 SOCIAL BEHAVIOR AND ORGANISATION

The Himalayan or Kashmir Grey Langur is a social animal preferring to live in groups with definite structure and composition. Minhas *et al.*, (2010) studied the social organization and Reproductive Biology of Himalayan Grey Langur (*Semnopithecus ajax*) in Machiara National Park, Pakistan and found that langurs were distributed in nine troops including three all-male bands. The Himalayan Grey Langur is very much social in its behavior and organization. Variable social organization was observed in the Himalayan Grey Langurs. They were found to be living in groups of uni-male bisexual troop, multi-male bisexual troops and all-male bands. Bisexual troops were generally matrilineal groups comprising of the adult and sub-adult females and juveniles with uni-male or more than one male i.e. multi-male bisexual troop. Usually the bisexual troops were

more organized and having much stronger associations than the all-male band troop as in all-male band troop there were loose gathering with very weak social hierarchy. Langurs spent most of the time in feeding, vigilance and resting. The time budget activity include 31.71 % of time spent in feeding, 22.75% in vigilance and monitoring, 21.08 % in dozing, 12.43 % in movements, 10.02 % in grooming and only 2.01 % in sexual and other activities. During the grooming, the high ranked females were always groomed by the low ranked females. Much of the time by langurs was spent on feeding.

The daily activities started very early in the morning and were initiated by the resident male with the morning “whoops”. The dozing activities included sleeping, resting or when the animal was motion less in their behavior. The animal remained vigilant, watching keenly around its surroundings. The grooming included the allogrooming and auto or self-grooming. The allo-grooming may be between female-female, female-male or adult female-juvenile female or an adult individual with the younger one. The other social activities performed by the Himalayan Grey Langur include playing, copulation, chasing, displacement, aggression etc.

In Machiara National park, the langurs breed from February to September with the maximum births between March to June, which represents the peak birthing period. There were no births recorded in the months October to January. In case of mating, a competitive behavior was observed when there were more than one female in the cycle, the high-ranking females always mate first. During the mating, the resident males usually acted more aggressively towards the other members of the troop showing its dominance. Allomothering is prevalent among the Himalayan Grey Langur where in an infant is transferred from the real mother to other troop members. The remaining females having no infants always try to get and carry infants while some resisted or rejected to carry the infants. The Alpha or higher-ranking females seemed to be less interested in carrying the infant babies. The females carrying the infants always try to get a scheduled place where nobody could disturb.

Sayers and Norconk (2008), reported that the Himalayan Grey Langur at the Langtang National Park, Nepal spend 39.8 % of their time budget activity in feeding, 17.5 % in moving and travelling activities, 29.2 % in resting while as 9.5 percent of the total time budget activity was spent on grooming.

MATERIALS AND
METHODS

3.1.1 STUDY AREA (Dachigam National Park)

3.1.1.1 Area, location and extent

The name of the Dachigam National Park comes from the Kashmiri word *Dah* that means ten, *chi* means are and *gam* means villages, so “Ten Villages”. Before the existence and formation of the national park there were ten villages inhabiting the area, which were translocated by the Maharaja of Jammu and Kashmir to form the game reserve. The name of the national park was given in the memory of those translocated ten villages. The Dachigam National Park covers an area of 141 Km² and extends between 34° 05' N and 34° 11' N and 74° 54' E – 75° 09' E in Zaskar range of the Great Himalayas. The area of Dachigam National Park comes under 2.38.12 (Himalayan Highlands) Biogeographical province and 2A Biogeographic zone. The Dachigam National Park is bounded by two steep mountain ridges, one originating from Harwan water reservoir on the south west side of the park and other originating from Dara Khimber side at an elevation up to 3,000 m. Dachigam National Park is bounded by the Sindh Valley in the north – east, Tarsar and Lidderwath, Kohlai of Lidder valley and Overa Wildlife sanctuary in the far east. Tral range in the south – east and Harwan, Brain and Nishat in the west and south – west. Moreover, the artificial boundaries are demarcated in the field with proper fencing and pillars installed to maintain integrity of area and law enforcement. The Dachigam National Park comes the civil jurisdiction of Srinagar, Pulwama, Ganderbal and Anantanag districts.

3.1.1.2 Significance of study area

Dachigam is worldwide famous as it holds the last surviving viable population of Red deer Sub – species – Hanglu (*Cervus hanglu hanglu*) and one of the best populations of Asiatic black Bear (*Ursus thibetanus*). Dachigam is home to a number of threatened and endangered species like Himalayan Grey Langur (*Semnopithecus ajax*), Himalayan Yellow-throated Marten (*Martes flavigula*), Common Leopard and many others. Dachigam National Park is single compact catchment area in Central Kashmir having unique flora and fauna. Dachigam National Park occupies almost half of catchment zone of world famous Dal Lake and is important source of drinking water to the Srinagar city. The flora, fauna, the ecological, geomorphological significance together with the proximity to the Srinagar city has added splendor shine to the glory of Dachigam as gene pool for reboisement, protection and propagation of wildlife.

34

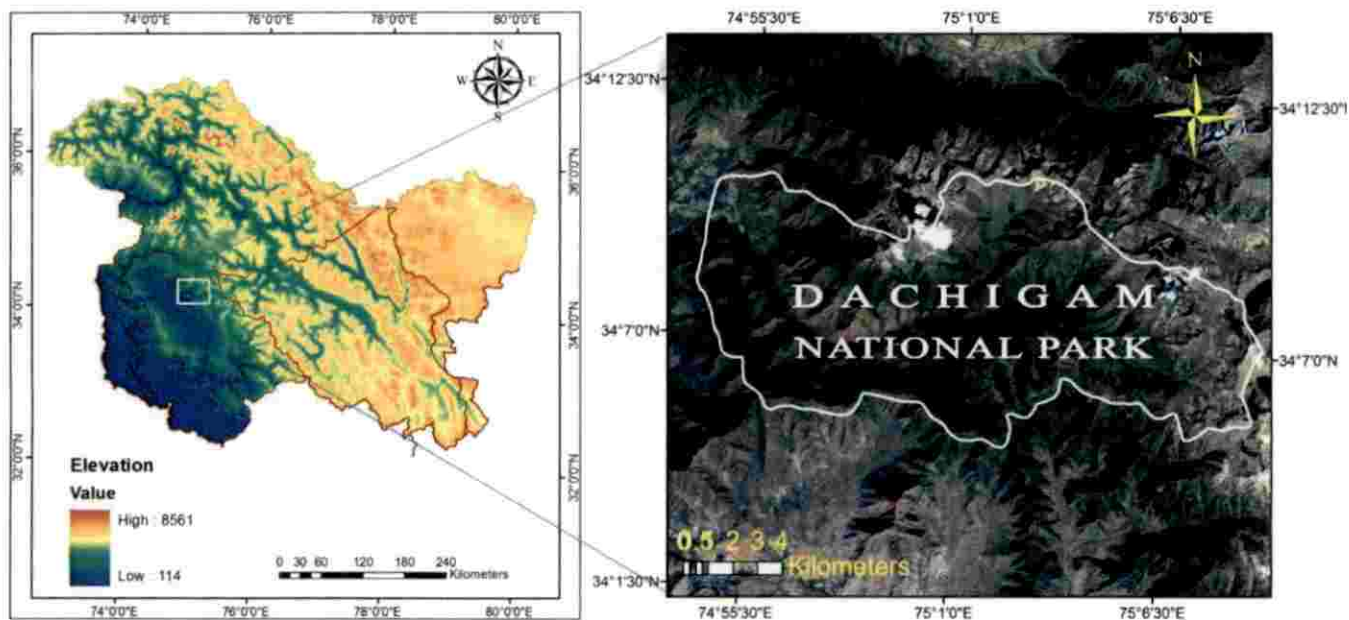


Figure. 1. Location of Dachigam National Park, Jammu and Kashmir

3.1.1.3 Geology, rock and soil

The entire area of the Dachigam National Park is highly mountainous and consists of crystalline rocks such as the granite, phyllites, schists with limestone embedded which form the core of Zanskar range, which encloses the Dachigam National Park. The area from Khanmoh to Mahadev is mainly composed of calcareous slates, shale and blue limestone (Singh and Kachroo, 1978). The sediment composition of these ranges is of the era of Cambrian to Tertiary period. The crystalline axis of the Himalayan system consists some of the oldest rocks and the northern flank of this crystalline axis consists the fossils of marine origin. The soil depth in Dachigam National Park from lower to the middle reaches is less than 25 cm and falls under the category of shallow Soils.

3.1.1.4 Topography

Dachigam National Park possess Great Himalayan features with steep and rugged mountains separated with deep gorges and valleys. The series of various undulations with different aspect and slope provides a supporting array to different vegetation types. The overall topography of the area is steep mountainous. The Dachigam National Park is divided into two zones on the basis of altitudinal variation – the lower Dachigam and Upper Dachigam. The lower Dachigam comprises of the area, whose altitude range from 1,650 m to 2,000 m and Upper Dachigam comprises the area whose altitude lies between 2,000 m to 4,000 m.

3.1.1.5 Climate

Dachigam National Park experiences a temperate climate with cool summers and chilling cold winters. The area observes a very irregular weather conditions with wide variation in the amount and intensity of precipitation received throughout the year. Snow is the main source of precipitation. The area experiences four distinct seasons *viz.*, winter (December – February), spring (March – May), summer (June – August) and autumn (September – November). The temperature recorded so far shows that Dachigam experiences a mean maximum temperature of 27.3 °C during summer and mean minimum temperature of 2 °C during the winters. The average rainfall recorded in Dachigam is 660 mm although there is no definite rainy season like other parts of the country (Ahamad *et al.*, 2005). The drought is very rare and has been not been recorded past 30 years owing the perennial waters of Dachigam nallah flowing round the year.

3.1.1.6 Vegetation classification

The vegetation of Dachigam National Park typically fall in Himalayan Moist temperate forest, Sub-alpine forest and Alpine forest type as per the new and revised Champion and Seth classification (Champion and Seth, 1968). The vegetation of Dachigam can sub-divided into the following sub-types:-

- Moist temperate deciduous forest
- Temperate grassland and scrub
- Himalayan low level Blue pine forests
- Temperate mixed forests

- Coniferous forests
- Himalayan sub – alpine forests
- Alpine pastures

1. Moist temperate deciduous forests

Riverine forest type is mainly confined along the Dachigam nallah, basically a succession vegetation type whose succession is mainly determined by the local edaphic and climatic conditions. The plant community of this forest include broadleaved species such as *Morus alba*, *Morus nigra*, *Salix alba*, *Salix Babylonia*, *Populus alba*, *Juglunas regia*, *Juglunas nigra*, *Acer caesium*, *Rhus succedanea*, *Robinia pseudoacacia* and *Ulmus wallichinea*. The dominant shrubs of this forest type are *Indigofera heterantha*, *Berberis spp.*, *Viburnum spp.*, etc. the moist temperate deciduous lies in the altitudinal zone of 1650 m to 1900 m and covers near about 30 % of Dachigam National park.

2. Temperate grassland and scrub

The temperate grasslands are the vast stretches of open lands which are most prominent on South – west lying at an altitude between 1,800 m to 2,700 m. The undergrowth of these temperate grasslands and scrubs consists of xerophytic species such as *Indigofera heterantha*, *Rosa webbiana*, *Rubus niveus*, *Rosa burnonii*, *Kocleuria cristata*. These vast open stretches have sparse thickets of broadleaved tree species such as *Parrotiopsis jacquemontiana*, *Prunus armanica*, *Celtis australis*, and *Ulmus spp.*

3. Himalayan low-level Blue pine forests

The Blue pine forests grow on the slopes extending from the north to the north – east aspect starting from the Harwan reservoir up to Draphama. The Himalayan Blue pine (*Pinus wallichiana*) is the dominant conifer of this forest type, which sometimes comes up even open areas and scrubs and form patches. The Blue pine forest extends between the altitudinal zones of 1,800 m to 3,400 m throughout the Dachigam. The Blue pine forms an association with shrubs such as *Parrotiopsis Jacquemontiana*, *Rosa webbiana*, *Prunus ceracifera*, *Creteagus monogyua*, *Berberis lyceum*.

4. Temperate mixed forests

Temperate mixed forests are distributed at the elevations ranging from 1,800 to 2,400 m. It comprises near about 20 percent of the total area of Dachigam. The dominant tree species of this forest type include *Juglans regia*, *Aesculus indica*, *Pardus cornuta*, *Populus ciliata*, *Populus deltoides*, *Rhus succedanea*, and *Fraxinus floribunda*. The dominant shrubs include *Prunus ceracifera*, *Berberis lyceum*, *Rosa webbiana* and *Viburnum spp.* This holds key position regarding the habitat, food of some important animal species of Dachigam National Park such as critically endangered Hangul (*Cervus hanglu hanglu*), Endangered Himalayan Grey Langur (*Semnopithecus ajax*), and Himalayan Black Bear (*Ursus thibetanus*).

5. Coniferous forests

This forest community lies in the upper ranges of Dachigam and varies in the altitude between 2,700 m – 34, 000 m. The coniferous trees are found on scattered slopes except *Abies pindrow*, which is less exposed to sunlight, confined to certain small areas on the both sides of Dachigam nallah. The dominant tree species of the coniferous forest are *Cedrus deodara*, *Pinus wallichiana*, *Taxus wallichiana*, *Abies pindrow*.

6. Himalayan Sub – alpine forest

This forest type is mainly distributed in the upper areas of Dachigam. This forest type is found at elevations above 3,500 m. The dominant tree species of the Himalayan sub – alpine forest are *Betula utilis*, *Rhododendron anthopogon*, *syringa emodi*, *Juniperus recurva*. The dominant shrub species of this forest type include *Fragaria vesca*, *Stachys sericea*, and *Sieversia elata*. The *Betula Utilis* forest is found where the altitudinal zone of *Abies pindrow* ceases. *Betula utilis* at altitude of 3,500 m merges with *Abies pindrow* and form patches with it. Above this altitude, *Betula utilis* form pure patches.

7. Alpine pastures

The alpine pastures are found in upper Dachigam area, which are full of vast grassland with prominent tree cover. The area is devoid of tree cover but full of luxuriant herbaceous grasses and medicinal herbs. These vast alpine pastures are distributed at elevations between 3,600 m to 4,000 m. These vast alpine pastures composed of many mesophytic perineal herbs. The herbs of this area mainly comprise of many Ranunculaceae, Cruciferae, and Compositae family species. These vast alpine meadows and pastures serve as important food reserve during the summer time for critically Endangered Kashmir stag (*Cervus hanglu hanglu*).

3.1.1.7 Flora

The Dachigam National park exhibits a variety of vegetation types mainly characterized the habitat, exposure, slope, aspect, and biotic pressure (Singh and Kachroo, 1978). The low-lying areas of Dachigam exhibit a complex mixture of broadleaved forest comprising of species of *Morus alba*, *Ulmus wallichiana*, *Celtis australis*, and *Juglunas regia* with scattered patches of the plantations of English Oak (*Quercus robur*) and *Robinia pseudoacacia*. The middle areas comprise of the mixed coniferous forests with certain pure patches of *Pinus wallichiana*. There is luxuriant vegetation on the both sides of Dachigam nallah. The riverine vegetation mainly consists of *Salix alba*, *Ulmus wallichiana*, *Populus cilita* and *Juglunas regia*. The upper areas of higher altitudes consists of vegetation comprising mainly of alpine and sub – alpine forest types. These forests are composed of *Betula utilis*, *Rhododendron spp.*, intercepted with luxuriant herbaceous grasses.

3.1.1.8 Fauna

Dachigam National park harbors a great faunal diversity. The fauna include eight large mammalian species, nine small mammalian species, and five reptilian species besides 54 different species of butterflies. Dachigam National Park is home to large number indigenous and migratory birds and exhibits great diversity. There are more than 122 species of birds present within the premises of Dachigam. The habitat of Dachigam is ideal for cold - water fishes and other forms of aquatic life. However, the aquatic biodiversity has not been documented so far for which detailed surveys and studies are required. Although Dachigam National Park is extremely rich in its faunal diversity yet, it has still be unexplored due to bad circumstances prevalent in the valley over last two decades.

3.1.2 STUDY AREA (Wayanad Wildlife Sanctuary)

3.1.2.1 Area, extent and location

Wayanad was chosen as the second study as a part comparative feeding study between the two endemic langur species Tufted Grey Langur (*Semnopithecus priam*) and Himalayan grey langur (*Semnopithecus ajax*). Wayanad constitutes a major portion of the much - acclaimed Nilgiri Biosphere Reserve falling under the domain of North Wayanad division, South Wayanad division and Wayanad Wildlife sanctuary. The location of Wayanad holds a key ecological position as it lies at the tri – junction of Bandipur Tiger Reserve in the south, Mudumalai Tiger Reserve in the South East and the Rajiv Gandhi National Park in the North-East. Wayanad lies between 11° 20'

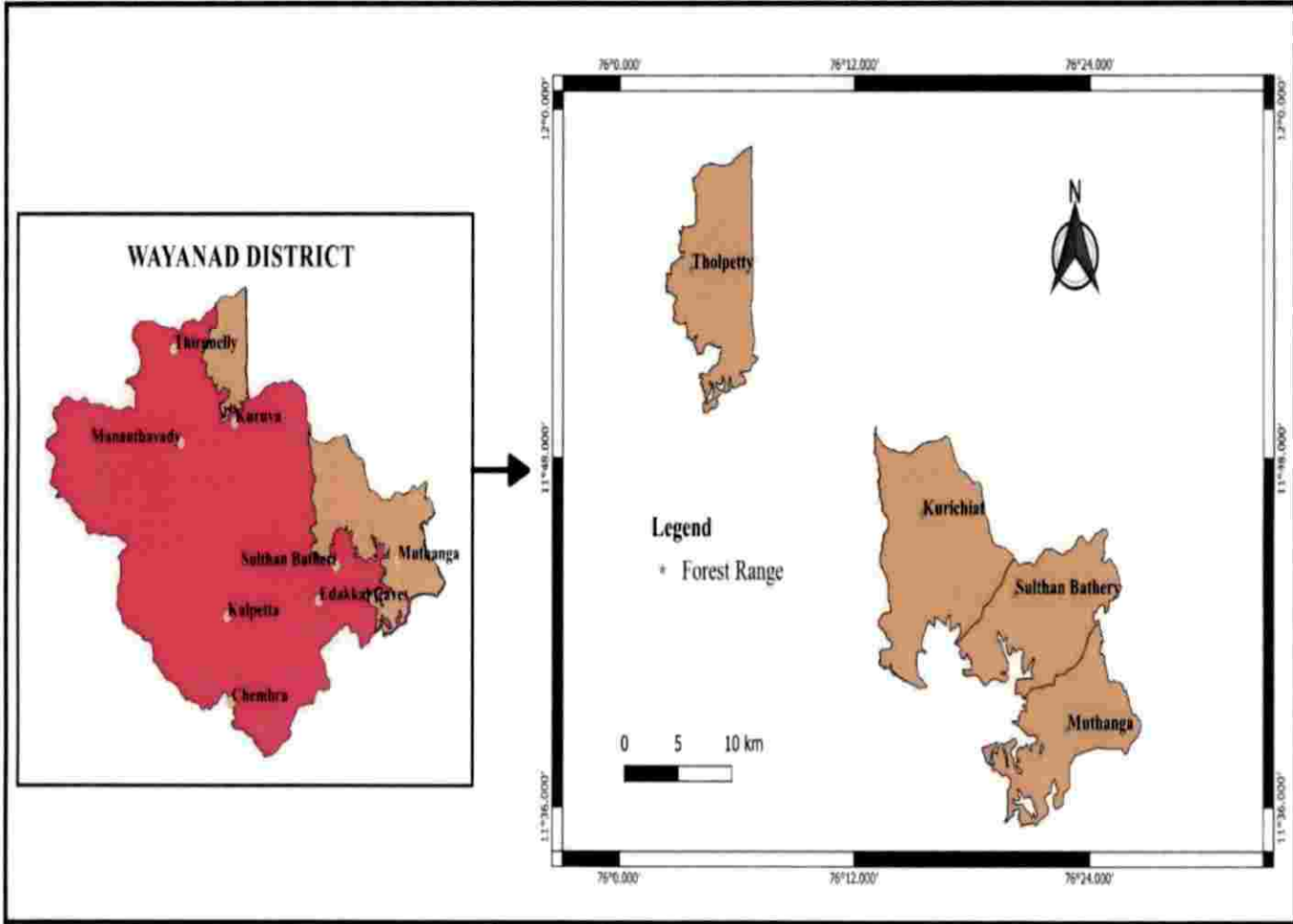


Figure 2. Location map of the Wayanad Wildlife Sanctuary

N and 12°7' and latitude and 75° 38' E and 76° 36' E longitude. The total area of Wayanad is 520.78 km² of, which Wayanad wildlife sanctuary comprise of 344.44 Km². The presence of swamps locally known, as *Vayals* are the prominent feature of Wayanad wildlife sanctuary, consequently deriving its name from such swamps. During the earlier times, there was prominence of shifting cultivation in and around the Wayanad wildlife sanctuary. Coffee was the first plantation crop introduced in 1828. Other crops grown include paddy grown in the swamps.

3.1.2.2 Climate

Wayanad wildlife sanctuary receives major portion of its precipitation in the form of rain. The annual rainfall received varies from 1200 – 1700 mm and huge amount of this rainfall is received during the south – west monsoon in the months of June to September. The mean atmospheric temperature in southern ranges varies with monthly maximum of 31° C in March 24° C in July and monthly minimum of 19° C in May and 14° C in December. The relative humidity varies from 60.4 % - 87.6 %.

3.1.2.3 Flora

Nearly about two third of the Wayanad wildlife sanctuary is covered by the plantations such as Eucalyptus, Teak, pepper and other soft wood species, which are largely intercepted by bamboos. There is long belt of deciduous forests, which run through bordering areas of adjacent states of Tamil Nadu and Karnataka.

3.1.2.4 Vegetation

The vegetation of Wayanad wildlife sanctuary can be broadly classified into the following Categories as per latest available forest classification (Champion and Seth, 1968):-

1. Southern moist mixed deciduous forest (3B / C2)

The most area of the Wayanad wildlife sanctuary is covered by the Southern moist mixed deciduous forest. These forests are largely intercepted by seasonally formed swamps or depressions (locally known as *Vayals*). These swamps are luxuriant in grasses but are generally devoid of tree cover. During the wet season, the canopy cover is moderate (50 – 60 %) while during the dry season when the trees shed their leaves the canopy cover fairly reduces to 10 – 20 %. The Bamboo brakes (*Bambusa arundinacea*) are fairly spread all over the area. The upper canopy

comprises of *Terminalia bellirica*, *Terminalia paniculata*, *Terminalia tomentosa*, *Tectona grandis*, *Adina cardifolia*, *Pterocarpus marsupium*. The prominent climbers of this forest type include *Butea parviflora*, *Caesalpinia spp.* and *Calycopteris floribunda*.

2. Southern dry mixed deciduous forests (5A / C3)

In this forest type, the swamps or *Vayals* are comparatively fewer than other areas and dominated by tall grasses such as *Thameda spp.* and *Pennisetum hohenackeri*. The dominant trees include *Shoera roxburgii*, *Anogeisis latifolia*, *Terminalia alata*, *Terminalia chebula*, *Pterocarpus marsupium*, *Gmelia orborea*, *Dalbergia latifolia*, *Diospyros montana*, *Bahunia racemosa*. The ground cover include certain grass species like *Thameda cymbaria*, *Thameda trianda*, and *Cymbopogon flexusus*. The canopy cover is less as much as 10 – 20 percent during the drier periods. The Distribution of bamboo brakes is comparatively less than the Southern moist mixed deciduous forests.

3. Plantations

The plantation consists the considerable part of Wayanad wildlife sanctuary and cover an area of 163 km². The major plantations of Wayanad wildlife sanctuary include Eucalyptus, Teak, and pepper besides other softwoods. The plantations are infested with *Lantana camara* and tall grasses such as *Thameda cymbaria*, *Thameda trianda* and *Cymbopogon flexuosus*.

3.2 METHODS

3.2.1 Site selection

The study was conducted from 7 August 2018 to 12 April 2019. The observations were recorded monthly during the span of time and pooled into two seasons *viz.*, summer (April – October) and winter (November – March). The animals surveyed by line transect method using direct observation method. A detailed reconnaissance survey was conducted in both the study areas to finalize the transects.

3.2.2 Food and feeding habits

The information regarding the food items and feeding habits, their composition and the variation was collected through foraging observation. The “Focal animal sampling” (Altman, 1974) method was employed for studying the food and feeding habits of *Semnopithecus ajax* and

Semnopithecus priam. The activities performed by the animals while sighting them were observed and recorded. In the method of focal animal sampling one individual in the group was followed and the observations based on the time spent on the various daily activities such as feeding, food items taken, part of plant fed were recorded. The langurs are usually folivorous but also found to be feeding on other items including buds, flowers, bark, seeds and fruits. The following feeding observations were taken during the course of study period:-

- a. Leaf feeding:- The leaf feeding included parts of leaves taken, whether any preference shown towards young or old leaves.
- b. Bark and twigs:- Included feeding on the bark of trees and big branches after debarking. The tender twigs and buds of certain tree species.
- c. Fruits:- Included feeding on fruits and nuts
- d. Seed feeding: - Included feeding on seeds of certain tree species.
- e. Flowers: - Included feeding on the any part of flower.

3.2.3 Social behavior and organization

The instantaneous scan sampling (Altman, 1974) was used to study the social behavior and organization of the animals. The daily activities of the animals were mainly classified into feeding, resting, moving, calling, mating, drinking and grooming. All these events in a troop were recorded at predetermined time interval. The percentage duration, percentage frequency and mean duration, percentage duration were calculated to see the time budgeting activity and how the animal allots time to its activities on daily basis during the different seasons. The data on each element of behavior of the animal was pooled to evaluate total time budget activity.

3.2.4 Population distribution and density estimation

The population estimation of the animal was done using the line transect method. Line transect method is most widely used method to estimate the wildlife population. The line transect is shown graphically in Figure 3.

H3

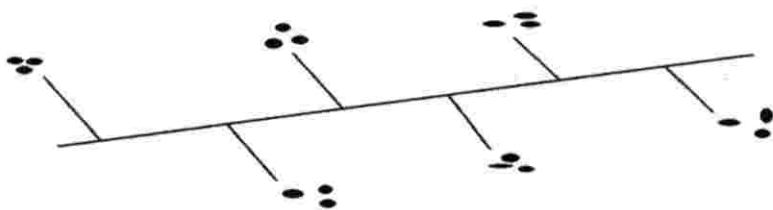


Figure 3. The schematic view of Line transect method

Only one transect is shown for illustration. The census zone is whole of the rectangle. The observer moves along the transect and measures the distance from where the animal was seen. It may be noted that the observer may miss several animals present in a particular habitat. The detection probability of animals decreases as the animals move far away transect. The Line transect method is further detailed in Figure 4.

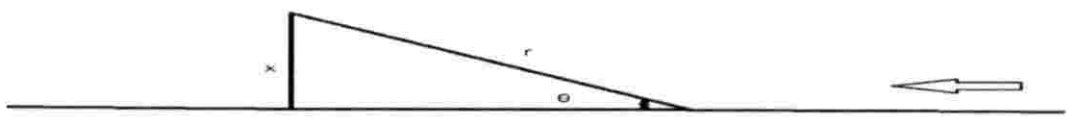


Figure 4. Illustration of Line transect method

When an animal is detected along a transect the following parameters are recorded:-

- a. Sighting distance (r)
- b. Sighting angle (θ)
- c. Sighting distance (x)

The perpendicular distance can be calculated using formula

$$x = r \sin \theta$$

All the transects were traversed on foot. Information on relative abundance of Himalayan grey langur through direct observations.

3.2.5 VEGETATION ANALYSIS, COMPOSITION AND DIVERSITY AT DACHIGAM NATIONAL PARK

3.2.5.1 Period of study

The vegetation enumeration at Dachigam National Park was carried out from August 2018 to March 2019.

3.2.5.2 Quadrant selection

The vegetation enumeration was done in various habitats and forest types within the Dachigam National Park. The quadrants were selected randomly in the various habitats of the Himalayan grey. Each quadrant consisting of 10 m x 10 m was taken. A total of 70, 100 m² quadrants were enumerated for the vegetation sampling.

3.2.5.3 Recording of observations and parameters

In each quadrant, all the tree species above 10 cm GBH (Girth at Breast height) and 1 m height were identified and recorded. The GBH and height were measure using the measuring tape and vortex laser hypsometer respectively. The vegetation of the Dachigam Nation Park were classified into either of the four broad vegetation types.

3.3 Data analysis

3.3.1 Food and feeding

Analysis of variance was performed to check variations in different feeding parameters such as feeding height, part of plant fed, time of feeding, species of tree on which animal is feeding and other positional parameters.

3.3.2 Social behavior and organization

The time activity of *Semnopithecus ajax* was prepared based on percentage of time spent on different daily activities such as feeding, grooming, mating and other daily activities. The percentage duration, percentage frequency and mean duration for different activities across the different seasons to check the seasonal variation. Mean duration was calculated using formula;

$$\text{Mean duration} = \frac{\text{Total duration in one activity}}{\text{Frequency of occurrence of that activity}}$$

3.3.3 Population estimation

Population estimation was done using the software DISTANCE version 6.0 (Thomas *et al.*, 2010) and extrapolating to whole Dachigam National park. The average monthly encounter rate was calculated.

Analysis was run on the Half – normal and Uniform model. A combination of the percentage CV and confidence interval was considered to select the model. The half – normal model was then chosen for the data analysis using the software DISTANCE.

3.3.4 VEGETATION ANALYSIS

The quantitative analysis of the sampled vegetation was done to obtain the frequency, density, basal area and their relative values and Important Value Index (Curtis and Macintosh, 1950).

$$\text{Relative Density (RD)} = \frac{\text{Number of individuals of the species}}{\text{Number of individuals of all species}} \times 100$$

$$\text{Percentage frequency} = \frac{\text{Number of quadrants of occurrence}}{\text{Total number of quadrants studied}} \times 100$$

$$\text{Relative frequency (RF)} = \frac{\text{Percentage frequency of individual species}}{\text{Sum percentage frequency of all species}} \times 100$$

$$\text{Basal area} = \frac{\text{Girth at Breast Height (GBH)}^2}{4}$$

$$\text{Relative Basal area (RBA)} = \frac{\text{Basal area of the species}}{\text{Basal area of all species}} \times 100$$

$$\text{Important Value Index (IVI)} = \text{RD} + \text{RF} + \text{RBA}$$

The trees also classified into the girth classes with an interval of 10 cm and the girth class distribution curves were plotted to assess the stability of the habitats.

RESULTS

4.1 FOOD AND FEEDING HABITS OF HIMALAYAN GREY LANGUR AND TUFTED GREY LANGUR

4.1.1 FOOD AND FEEDING HABITS OF HIMALAYAN GREY LANGUR

The regular observations were made during two seasons *viz.*, summer (May – October) and winter (November – April) to understand the feeding ecology of the Himalayan Grey Langur. The duration of feeding, the plant species fed, plant part fed and the feeding height were recorded.

4.1.1.1 FOOD SELECTION OF HIMALAYAN GREY LANGUR

The Himalayan Grey Langur showed a typical preference towards a particular food item during the two different seasons. These preferential feeding habits were most prominent during the summer season. Although, Himalayan Grey Langur is folivorous mainly feeding on the leaves yet showed a great preference towards fruits especially walnut, oaks, and horse chestnut during the summer season. While selecting food, the Himalayan Grey Langur used effectively the forelimbs and the mouth for breaking the fruits as well as plucking leaves (Plate 1). While the breaking of fruits from tree tops particularly walnut, horse chestnut and oak there was a great division of labor. The adult individuals of troop climb the tree top while sub - adult and juvenile individuals collect food items on the ground. This association has the additional benefit of increased surveillance both above and below the canopy. While jumping from branch to branch in search of food the Himalayan Grey Langur used firmly the forelimbs and bend branches towards them and pluck leaves and fruits with their sharp teeth. The fruits having hard shells such as horse chestnut, oak and walnut were dropped on the ground. They gnaw epicarp of fruit, break the fruit with their sharp canines (Plate 2), and extract seed to be fed. During feeding, the Himalayan Grey Langur used forelimbs, mouth, and canines effectively. While feeding on leaves the Himalayan Grey Langur preferred to remain on tree branches while feeding on fruits and nuts, it dropped the food items on the ground and then break it on the ground to feed on.

4.1.1.2 FOOD COMPOSITION OF HIMALAYAN GREY LANGUR

A total of 2097 minutes of feeding observation was recorded during the course of the study period. The Himalayan Grey Langur was found to be feeding on 34 plant species belonging to 21

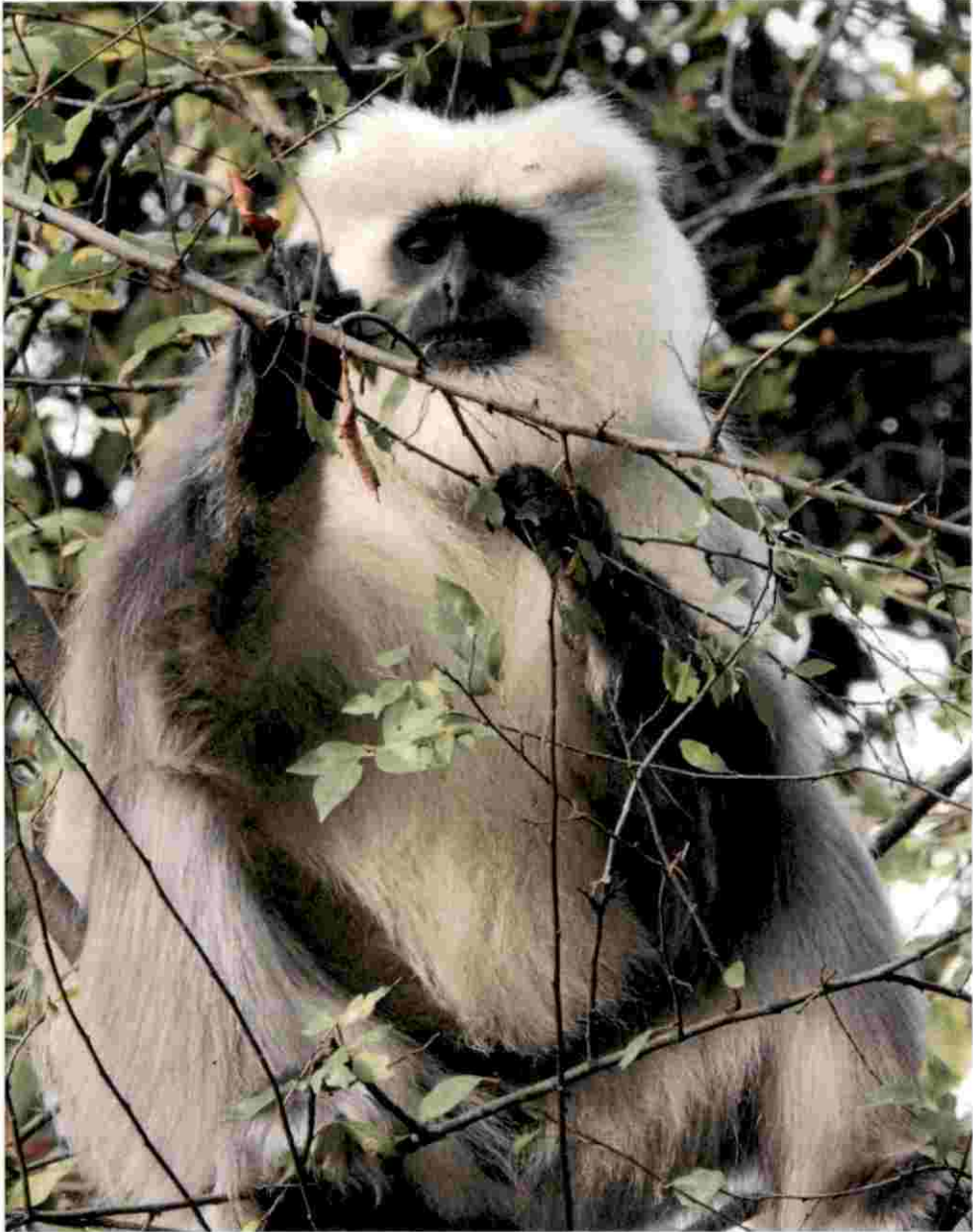


Plate 1. Himalayan Grey Langur effectively using forelimbs for feeding at Dachigam National Park

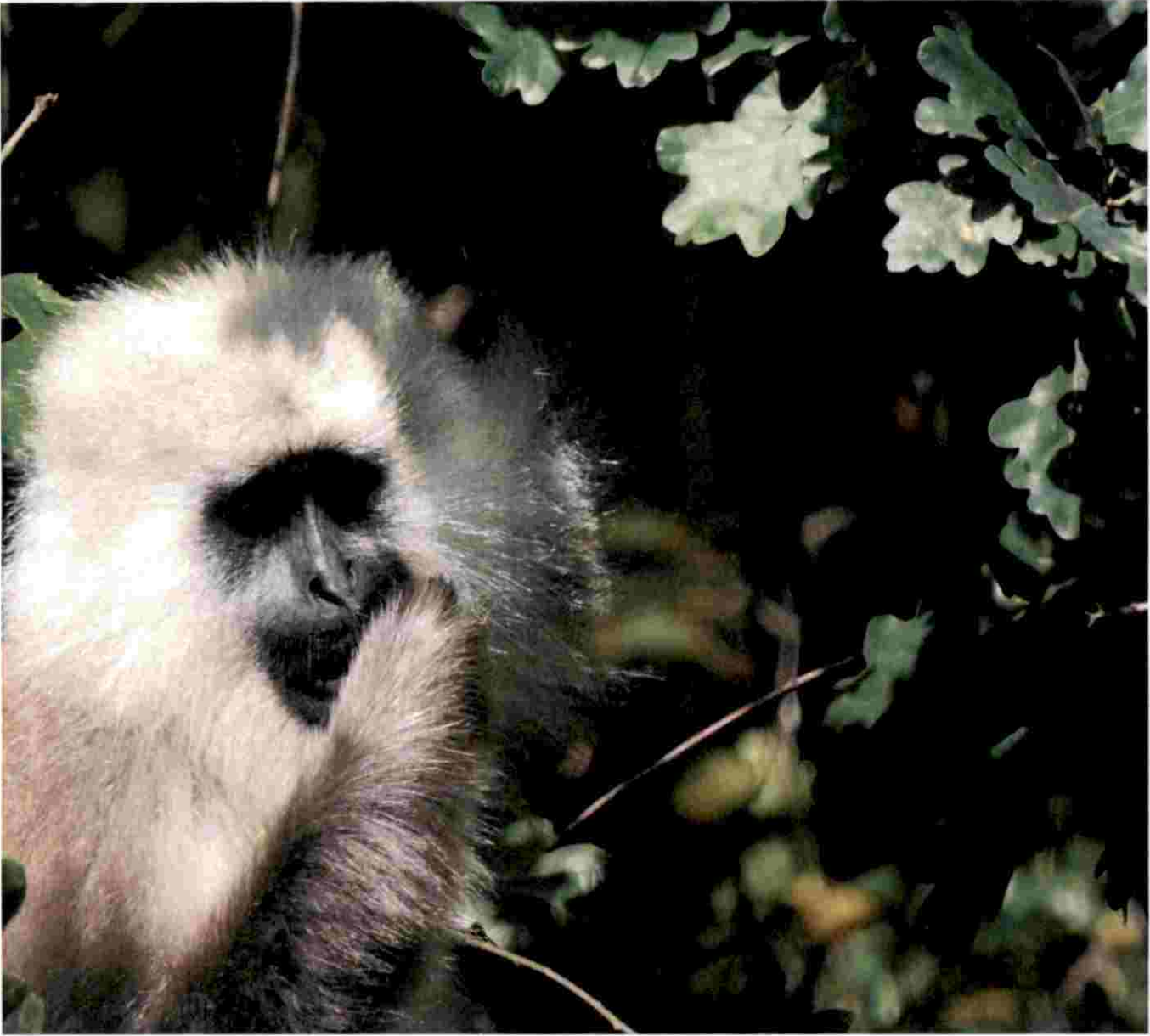


Plate 2. The Himalayan Grey Langur using canines effectively to break oak seeds at Dachigam National Park

different families at Dachigam National Park. The 34 plant species include 22 tree species, five shrubs, four grass species, and three climber species. Besides feeding on all these plant species, the Himalayan Grey Langur spent considerable time in searching insects near streams and springs and fondly feeding on them to maintain ionic balance in their body. This insectivory was mostly prevalent during summer season (May – October). The Himalayan Grey Langur was also observed licking salt bricks put artificially for Hangul (*Cervus hanglu hanglu*) near the waterholes. The Himalayan Grey Langur was also seen licking soil beneath roots, buildings and other structures at Dachigam National Park for maintaining its ionic balance in the body.

The overall maximum duration of feeding was observed on *Rosa webbiana* (9.54 %), followed by *Populus deltoides* (8.11 %), *Salix alba* (7.63 %), *Hedera nepalensis* (7.63 %), *Aesculus indica* (6.91 %), *Sorghum halepense* (6.68 %), *Pinus wallichiana* (4.11 %), *Quercus robur* (4.11%), *Morus alba* (4.29 %) and *Juglnas regia* (4.15 %) (Figure 5).

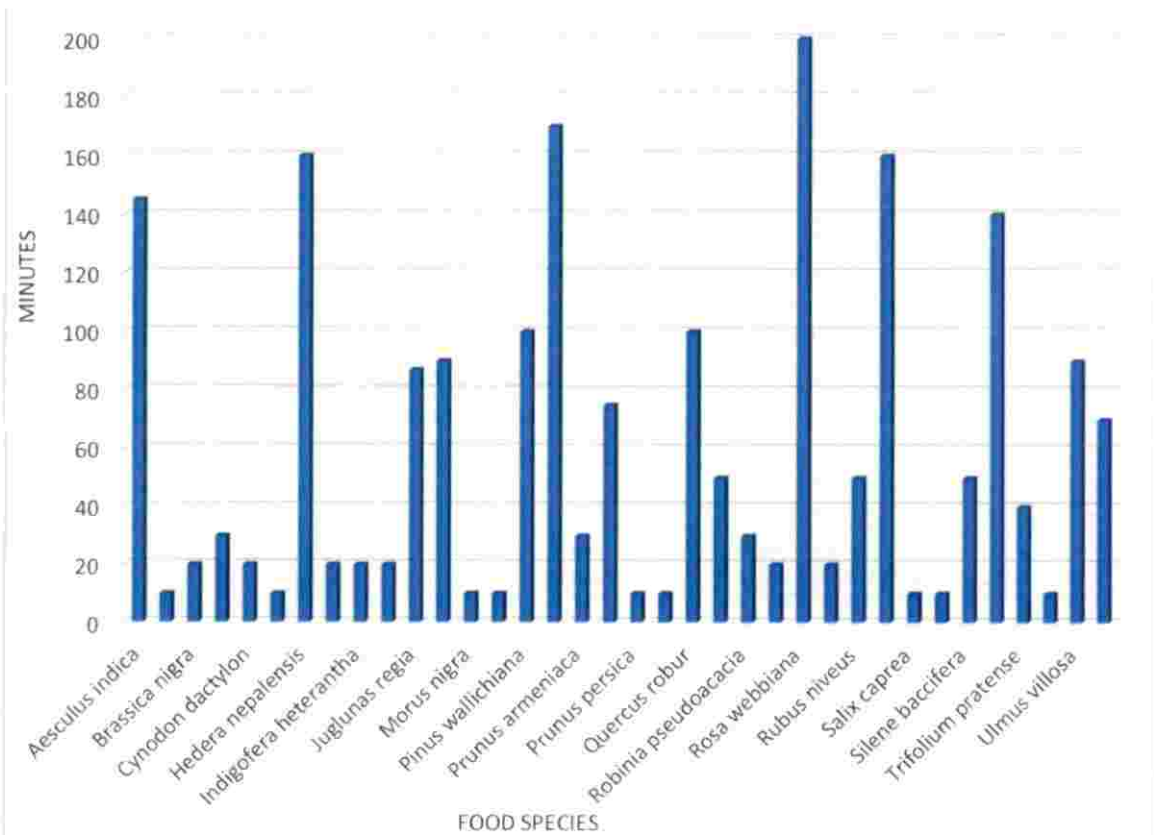


Figure 5. The overall time spent by Himalayan Grey Langur on feeding various plant species at Dachigam National Park

The Himalayan Grey Langur in Dachigam National Park was found feeding on different plant parts including leaves, fruits, bark, buds, twigs, seeds besides insects and soil licking for the mineral nutrients. The Himalayan Grey Langur found to be feeding on *Populus deltoides*, *Salix alba*, and *Ulmus wallichiana* in all seasons while other plant species were fed upon in one or two seasons or a particular season. The leaves of *Populus deltoides*, *Salix alba*, and *Ulmus wallichiana* were fed during summer season, buds twigs in the winter season and young twigs and bark during the spring season. Out of 21 families, Rosaceae consisting of many evergreen and deciduous shrubs was preferred family followed by Salicaceae (Table 1).

4.1.1.3 PERCENTAGE CONTRIBUTION OF DIFFERENT FOOD ITEMS IN DIET OF HIMLAYAN GREY LANGUR

The percentage contribution of different food articles such as leaves, fruits, bark, twigs, and seeds were analyzed based on the duration of feeding on a particular food item and number of times animal fed on particular food item during the whole study period. The feeding duration whole during the study period was summed up and it was found that a total of 2097 minutes were spent in overall feeding. Within this overall duration of feeding incidences, in the majority of feeding incidence, the Himalayan Grey Langur was found feeding on the single food item. In certain other cases, Himalayan Grey Langur was found to be feeding on more than one food item. The Himalayan Grey Langur spent maximum time on leaves (29.09 %), fruits (22.75 %) and seeds (10.49 %) (Figure 5). The Himalayan Grey Langur was found to be feeding on multiple food items within one incidence of feeding. The Himalayan Grey Langur was found feeding simultaneously on bark and twigs, buds and twigs and other combinations. The multiple incidences of feeding were counted in aggregation. A total of 205 incidences of feeding were observed during the study period. Out of 205 feeding incidences, 61 incidences were of leaf feeding followed by fruits with 43 incidences, seeds with 22 incidences, buds with 16 incidences, bark, and twigs with 10 incidences (Figure 6).

4.1.1.4 AVERAGE HEIGHT OF FEEDING OF HIMALAYAN GREY LANGUR

The average height of feeding for various food articles was analyzed based on the height at which a particular food item was fed. During the study period, the overall average height of feeding observed was 5.68 m. The overall average height was observed maximum in case of

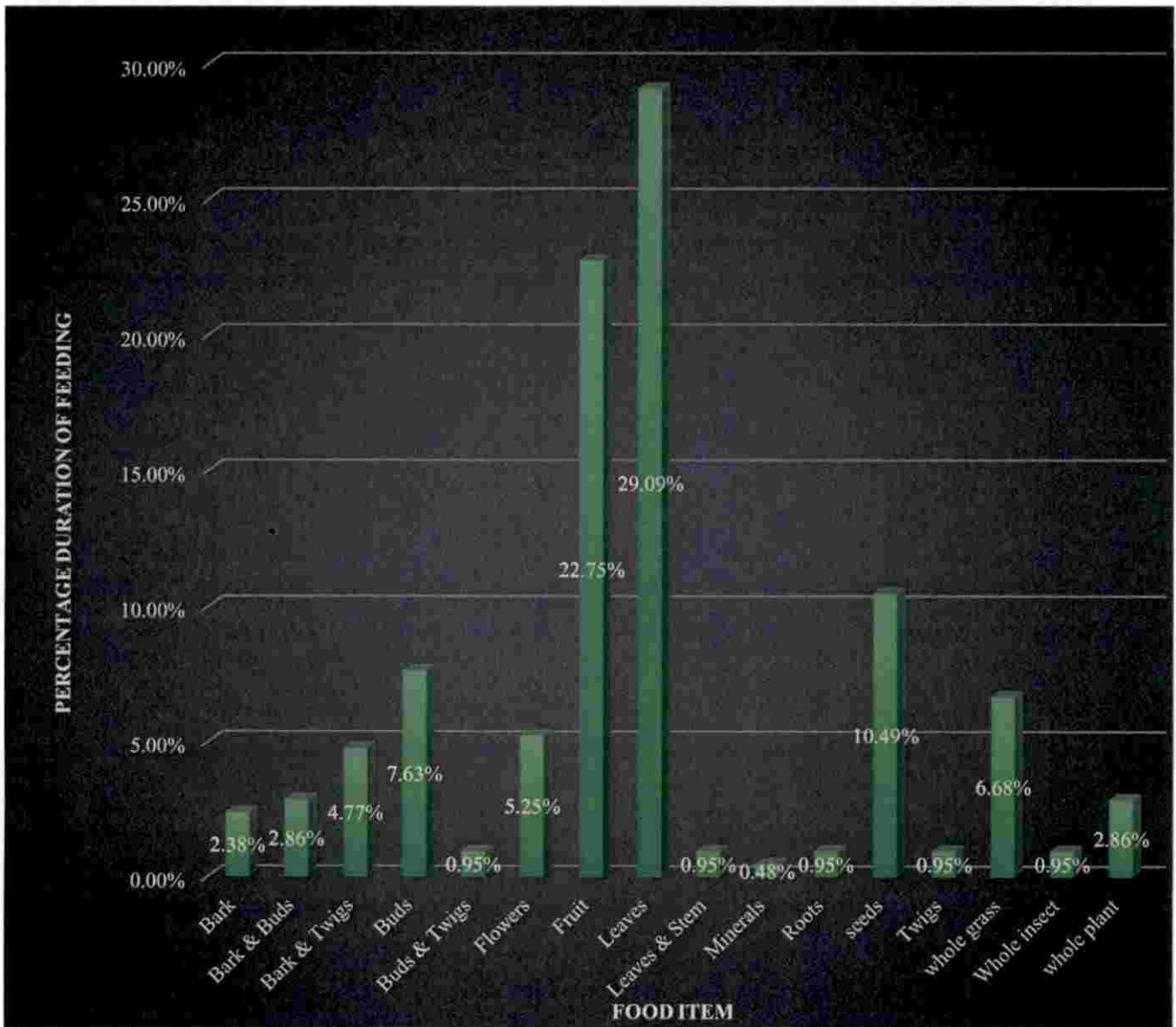


Figure 6. The percentage duration of time spent on various food items by Himalayan Grey Langur at Dachigam National Park

Aesculus indica (11 m) and *Pinus wallichiana* (11 m), followed by *Ulmus villosa* (9.8 m) and *Ulmus wallichiana* (9.7 m) (Figure 7).

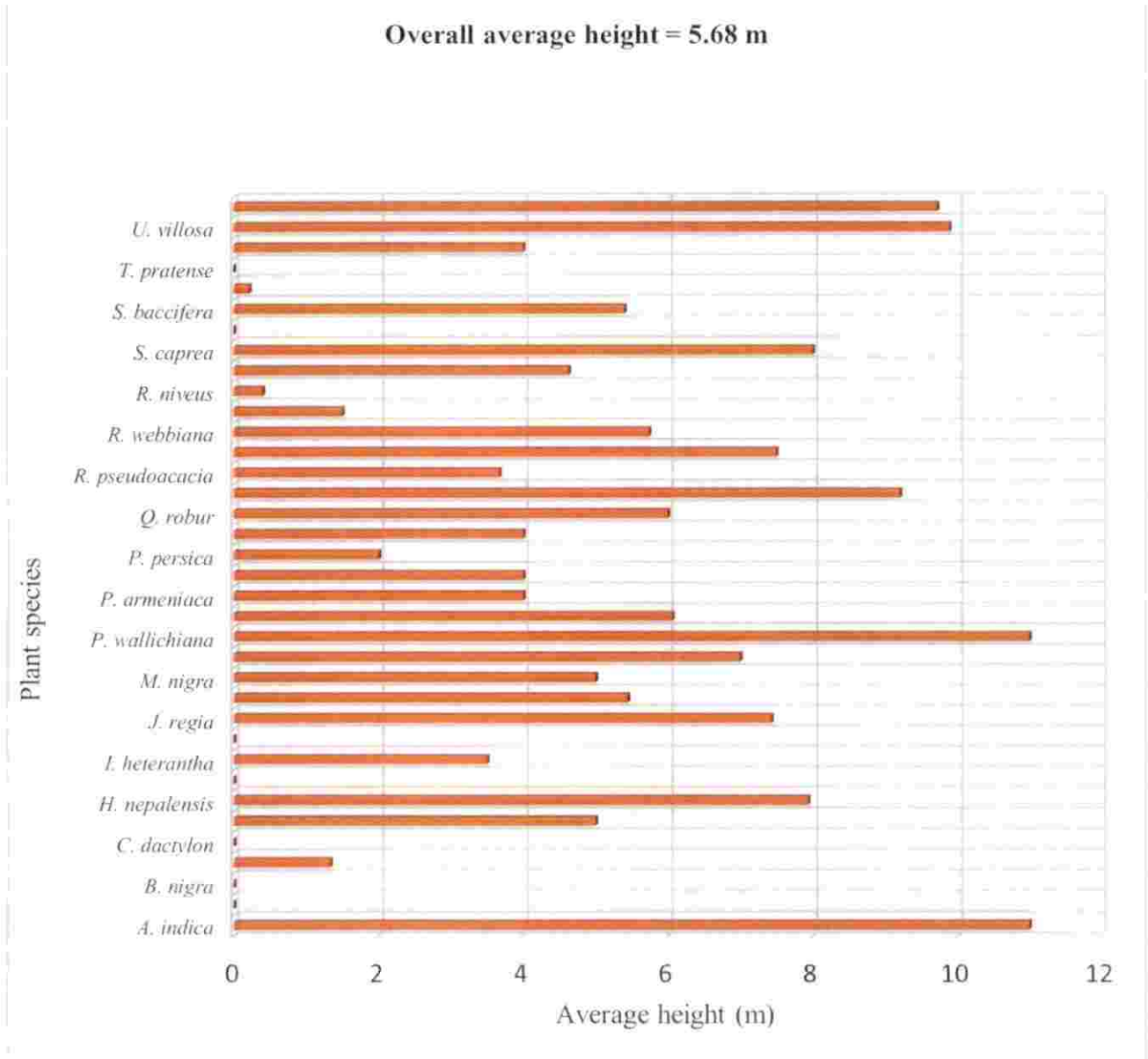


Figure 7. The average height of feeding of the Himalayan Grey Langur at Dachigam National Park

4.1.1.4 SEASONAL VARIATION IN HIMALAYAN GREY LANGUR FOOD AND FEEDING

The study period was divided into two seasons *viz.*, summer (May – October) and winter (November – April). The feeding observations were divided across these two

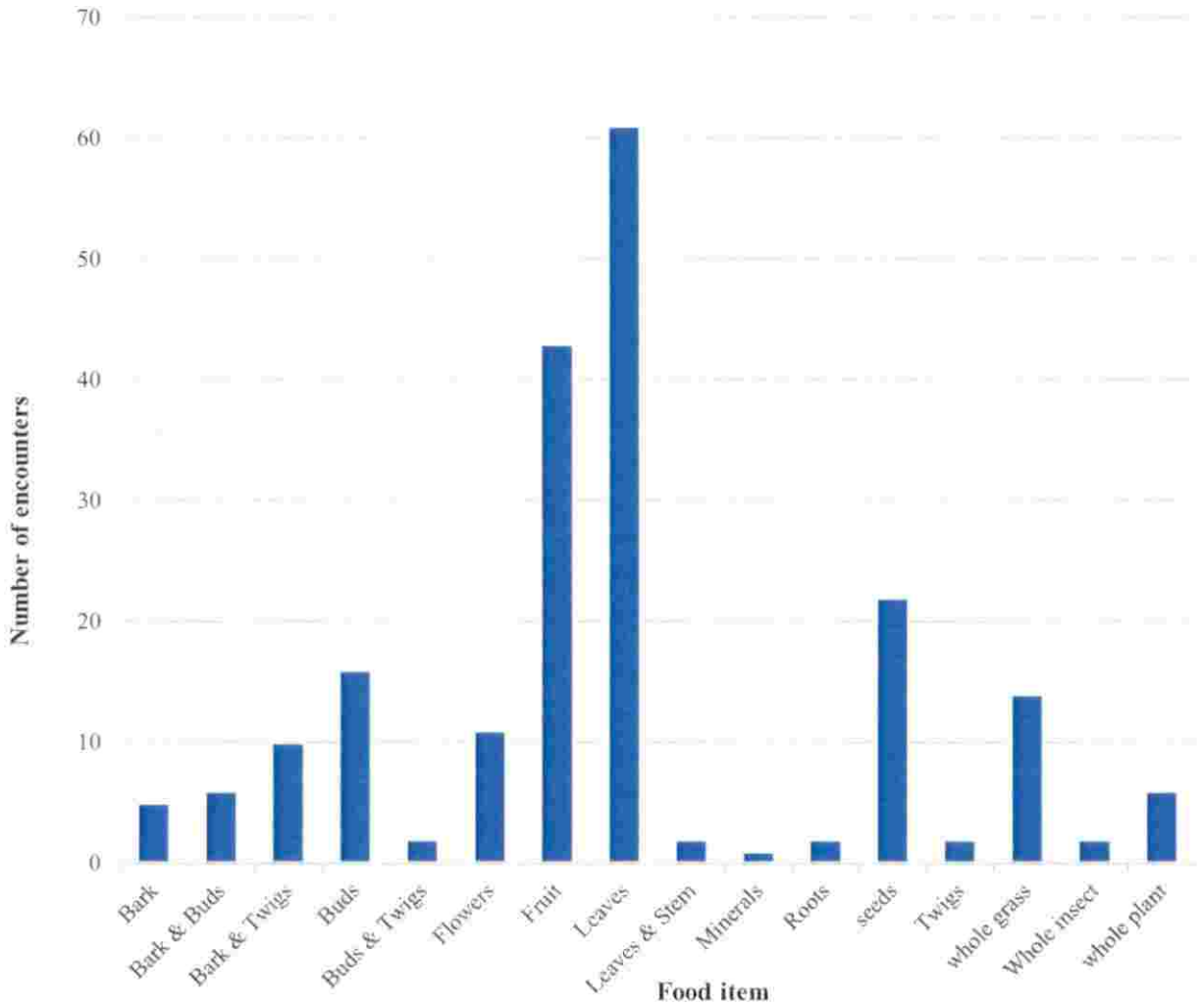


Figure 8. The feeding incidences of various feeding items of Himalayan Grey Langur at Dachigam National Park

Table 1. List of plant species on which Himalayan Grey Langur feeds their family, common name, season of feeding, time duration, and percentage duration

Sl. No	Scientific name	Common name	Family	Part eaten	Season	Time duration (minutes)	Percentage duration of feeding
1.	<i>Rosa webbiana</i>	Wild rose	Rosaceae	Leaves, fruits	Winter, summer	200	9.54
2.	<i>Populus deltoides</i>	Poplar	Salicaceae	Leaves, roots, twigs, bark	Summer, winter	170	8.11
3.	<i>Hedera nepalensis</i>	Himalyan Ivy	Araliaceae	Leaves, flowers	Summer, winter	160	7.63
4.	<i>Salix alba</i>	English willow	Salicaceae	Leaves, buds, bark, twigs	Winter, summer	160	7.63
5.	<i>Aesculus indica</i>	Horse chestnut	Sapindaceae	Fruit	Summer, winter	145	6.91
6.	<i>Sorghum halepense</i>	Johnson grass	Poaceae	Whole grass	Summer, winter	140	6.68
7.	<i>Pinus wallichiana</i>	Blue pine	Pinaceae	Seeds	Winter	100	4.77
8.	<i>Quercus robur</i>	English Oak	Fagaceae	Fruit	Summer, winter	100	4.77
9.	<i>Morus alba</i>	Mulberry	Moraceae	Leaves	Summer	90	4.29
10.	<i>Ulmus villosa</i>	Elm	Ulmaceae	Leaves, buds	winter	90	4.29
11.	<i>Juglans regia</i>	Walnut	Juglandaceae	Fruit	Summer	87	4.15
12.	<i>Prunus ceracifera</i>	Cherry plum	Rosaceae	Leaves	Summer	75	3.58
13.	<i>Ulmus wallichiana</i>	Himalayan Elm	Ulmaceae	Leaves, buds	Winter	70	3.34
14.	<i>Rhus succedanae</i>	Wax tree	Anacardiaceae	Seeds	Winter	50	2.38
15.	<i>Rubus niveus</i>	Hill raspberry	Rosaceae	Leaves, fruits	winter	50	2.38
16.	<i>Silene baccifera</i>	Catchfly	Caryophyllaceae	leaves	Winter	50	2.38

17.	<i>Trifolium pratense</i>	Red clover	Papilionaceae	Wholes grass	Summer	40	1.91
18.	<i>Cydonia oblonga</i>	Quinces	Rosaceae	Fruit	Summer	30	1.43
19.	<i>Prunus armanica</i>	Apricot	Rosaceae	Leaves	Summer	30	1.43
20.	<i>Robinia pseudoacacia</i>	Black locust	Fabaceae	Seeds	Winter	30	1.43
21.	<i>Brassica nigra</i>	Mustard	Brassicaceae	Whole plant	Winter	20	0.95
22.	<i>Cynodon dactylon</i>	Dhoob grass	Poaceae	Whole grass	Winter	20	0.95
23.	<i>Hydrocotyl sp.</i>	Waterwort	Araliaceae	Whole plant	Summer	20	0.95
24.	<i>Indigofera heterantha</i>	Indigo	Fabaceae	Leaves	Winter	20	0.95
25.	<i>Rosa indica</i>	Rose	Rosaceae	leaves	Winter	20	0.95
26.	<i>Rubus fruticosus</i>	Wild raspberry	Rosaceae	Leaves, fruits	Winter	20	0.95
27.	<i>Berberis lyceum</i>	Barberry	Berberidaceae	Leaves	Winter	10	0.48
28.	<i>Fraxinus hookeri</i>	Ash	Oleaceae	Buds, Twigs	Winter	10	0.48
29.	<i>Morus nigra</i>	Black Mulberry	Moraceae	Leaves	Summer	10	0.48
30.	<i>Prunus persica</i>	Peach	Rosaceae	Fruit, leaves	Summer, winter	10	0.48
31.	<i>Parrotiopsis jacquemontiana</i>	Witch hazel	Hamamelidaceae	Leaves	Summer, winter	10	0.48
32.	<i>Prunus sp.</i>		Rosaceae	Leaves	Summer, winter	10	0.48
33.	<i>Salix caprea</i>	Goat willow	Salicaceae	leaves	Summer	10	0.48
34.	<i>Ulmus glabra</i>	Wych Elm	Ulmaceae	Buds, bark	Winter	10	0.48

these two seasons and the analysis was done. Three types of analysis was done to check the seasonal variation based on number of incidences of feeding on different food articles, plant species preferred during a particular season, duration of feeding in particular season and the feeding height at which the animal feeds during the particular season.

Overall average feeding height of the Himalayan Grey Langur

During the study period, the Himalayan Grey Langur was observed feeding on 34 plant species at different heights. The animal was observed feeding both on the ground as well as above the ground on the trees. The overall average height of feeding was calculated based on the food article taken at a particular height of the plant. The overall average feeding height during the study period was found to be 5.68 m. The overall maximum feeding height during the study period was observed in case of *Aesculus indica* (11 m), *Pinus wallichiana* (11 m), followed *Ulmus villosa* (9.8 m), *Ulmus wallichiana* (9.7 m), *Rhus succedanae* (9.2 m), *Hedera nepalensis* (7.9 m), *Juglans regia regia* (7.4 m), *Parrotiopsis jacquemontiana* (7 m) and *Populus deltoides* (6.05 m) (Figure. 9).

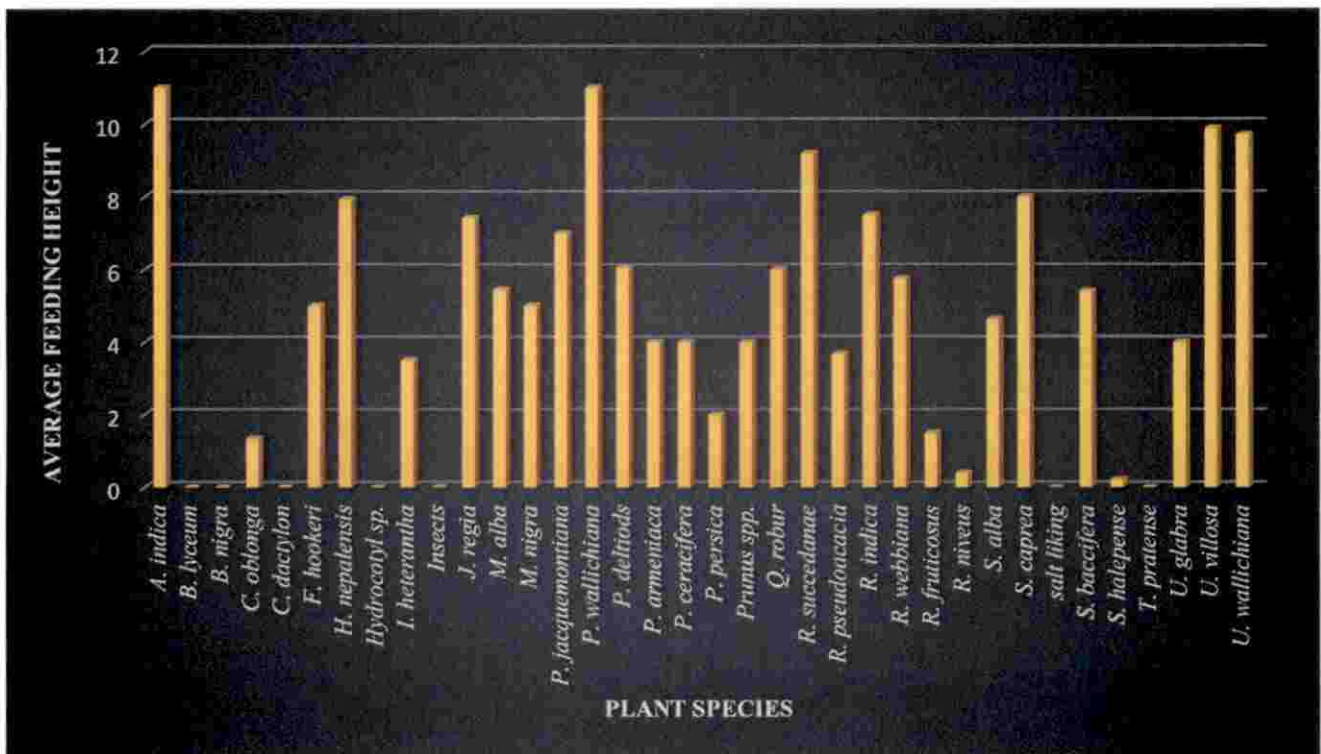


Figure 9. The average feeding height of Himalayan Grey Langur of various plant species at DNP

During the study period, the diet of Himalayan Grey Langur comprised of fruits, leaves, buds, bark, flowers, twigs and seeds. The average height for each food item was calculated based on the height at which a particular food item was consumed. During the study period the average feeding height was maximum in case of buds (9.68 m), followed by flowers (8.90 m), bark and buds (8.83 m), bark and twigs (8.4 m), fruits (7.6 m) and seeds (7.5 m). The other feeding items such as insects, roots, and grasses were fed on the ground (Figure 10).

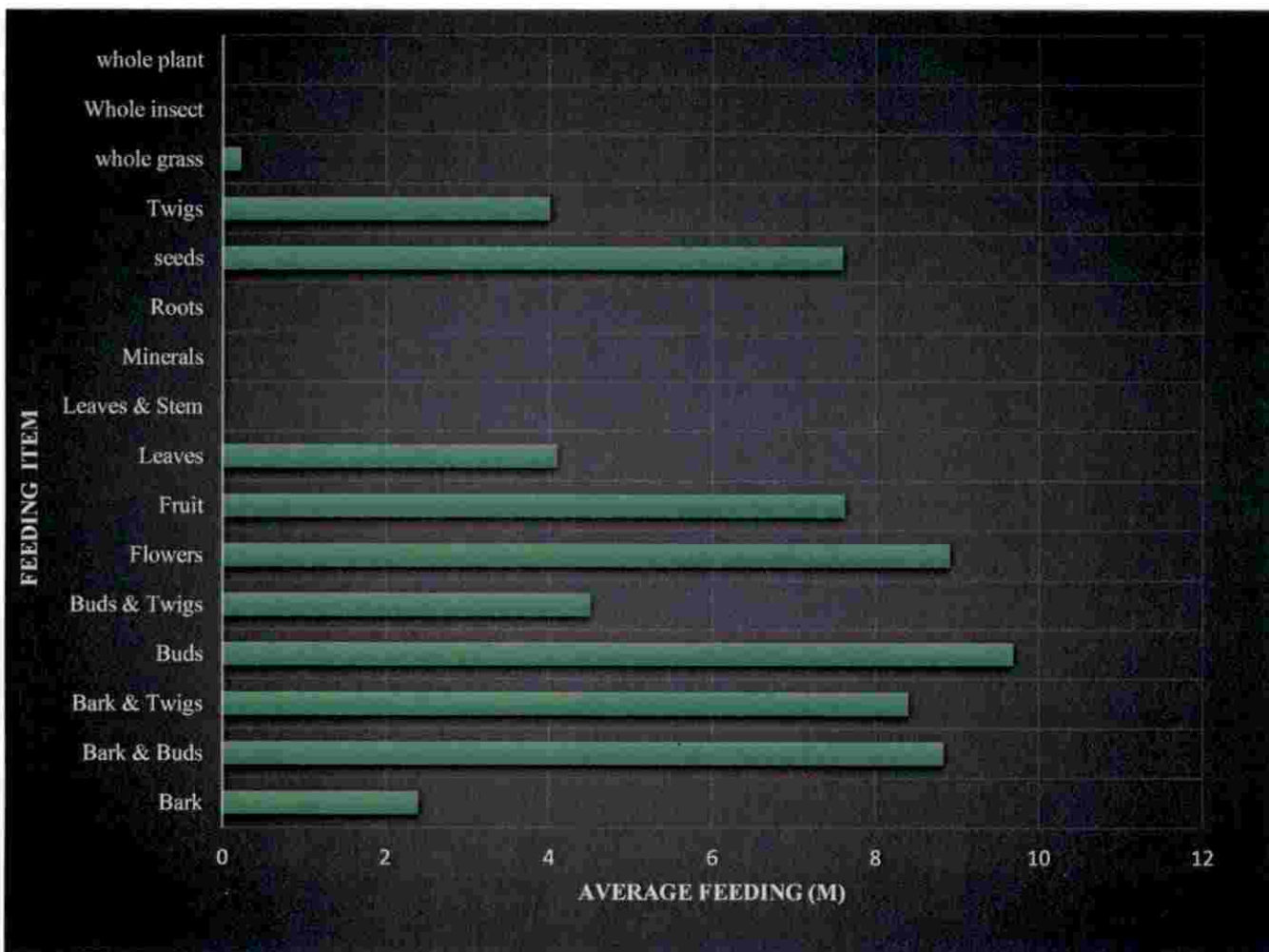


Figure 10. The average feeding height of various food items fed by the Himalayan Grey Langur at Dachigam National Park

4.1.1.4.1 FEEDING OF HIMALAYAN GREY LANGUR DURING SUMMER SEASON

During the summer season (May – October) a total of 687 minutes of feeding observation was recorded. The Himalayan Grey Langur was found feeding on 16 plant species belonging to 12 different families, which include 12 tree species, three grass species, and one shrub species. During summer season the maximum duration of feeding was recorded in case of *Aesculus indica* (19.65 %), followed by *Juglans regia* (12.66 %), *Sorghum halepense* (11.64 %), *Morus alba* (10.19 %), *Populus deltoides* (8.73%), *Prunus armeniaca* (4.37%) and *Trifolium pratense* (4.37%) (Table 2). Besides feeding on plant species, the Himalayan Grey Langur spent considerable, time in searching insects and feeding on them (Plate 3). This insectivory was most prevalent during summer season and was not observed during the winter season. The Himalayan Grey Langur was observed licking bricks put artificially near waterholes for Hangul (*Cervus hanglu hanglu*) during summer season (Figure 6). The Himalayan Grey Langur during summer season was observed feeding on fruits, leaves, seeds, and grasses. Besides these feeding items, the Himalayan Grey Langur fed on insects during this season. The animal was found licking salt bricks near waterholes put artificially to maintain its ionic balance in the body. The percentage duration of different feeding items was calculated based time duration animal spent feeding on a particular food item and number of feeding incidences on particular feeding item during the summer season. A total of 64 feeding incidences were observed during summer season. The maximum feeding incidences were observed in case of fruits followed by leaves. Out of 64 feeding incidences during the summer season, 24 incidences were of fruit feeding, 23 incidences of leaf feeding, six incidences in which animal consumed whole plant, two incidences each of insectivory and root feeding (Plate 4) while as there was single incident each of salt licking and seed feeding (Figure 11).

Table 2. The plant species fed during summer, their family, part fed, time duration and percentage duration of feeding

Sl. No	Scientific name	Common name	Family	Part fed	Time duration(minutes)	Percentage duration of feeding
1.	<i>Aesculus indica</i>	Horse chestnut	Sapindaceae	Fruit	135	19.65
2.	<i>Juglans regia regia</i>	Walnut	Juglandaceae	Fruit	87	12.66
3.	<i>Sorghum halepense</i>	Johnson grass	Poaceae	Whole grass	80	11.64
4.	<i>Morus alba</i>	Mulberry	Moraceae	Leaves	70	10.19
5.	<i>Populus deltoides</i>	Poplar	Salicaceae		60	8.73
6.	<i>Quercus robur</i>	Oak	Fagaceae	Fruits	60	8.73
7.	<i>Prunus armeniaca</i>	Apricot	Rosaceae	Leaves	30	4.37
8.	<i>Trifolium pratense</i>	Red clover	Papilionaceae	Leaves	30	4.37
9.	<i>Hydrocotyl sp.</i>	Waterwort	Araliaceae	Whole plant	20	2.91
10.	<i>Salix alba</i>	Willow	Salicaceae	Leaves	20	2.91
11.	Insects			Whole insect	20	2.91
12.	<i>Prunus ceracifera</i>	Cherry plum	Rosaceae	Fruit	15	2.18
13.	<i>Morus nigra</i>	Mulberry	Moraceae	Leaves	10	1.46
14.	<i>Parrotiopsis jacquemontiana</i>	Witch hazel	Hamamelidaceae	Leaves	10	1.46
15.	<i>Prunus sp.</i>	Cherry plum	Rosaceae	Leaves	10	1.46
16.	<i>Rhus succedanae</i>	Wax tree	Anacardiaceae	seeds	10	1.46
17.	<i>Ulmus glabra</i>	Wych elm	Ulmaceae	Leaves	10	1.46
18.	Salt licking			Minerals	10	1.46



Plate 3. Himalayan Grey Langur searching for and feeding on insects near a small stream at Dachigam National Park

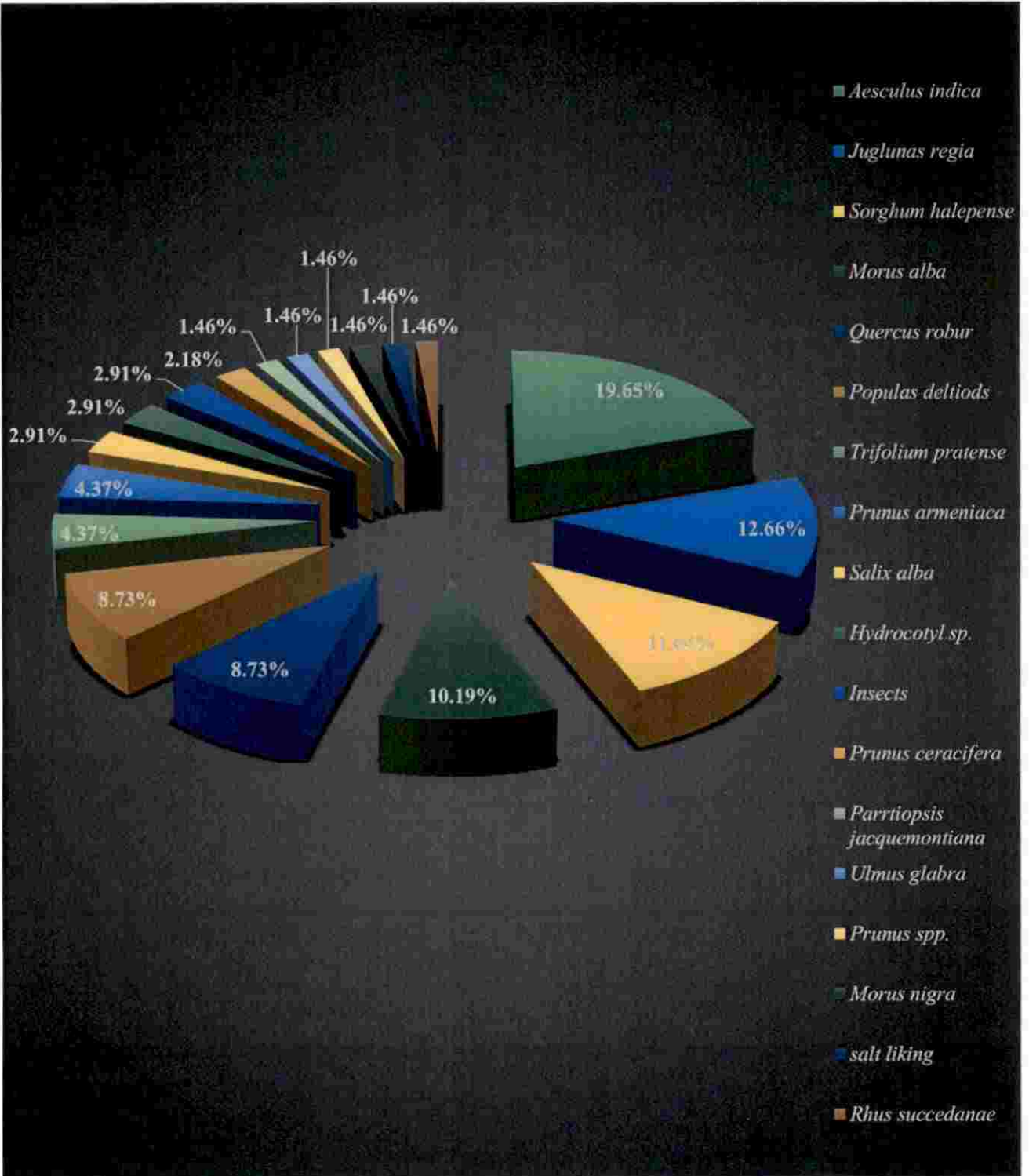


Figure 11. The percentage duration of time spent on feeding different plant species by Himalayan Grey Langur at Dachigam National Park

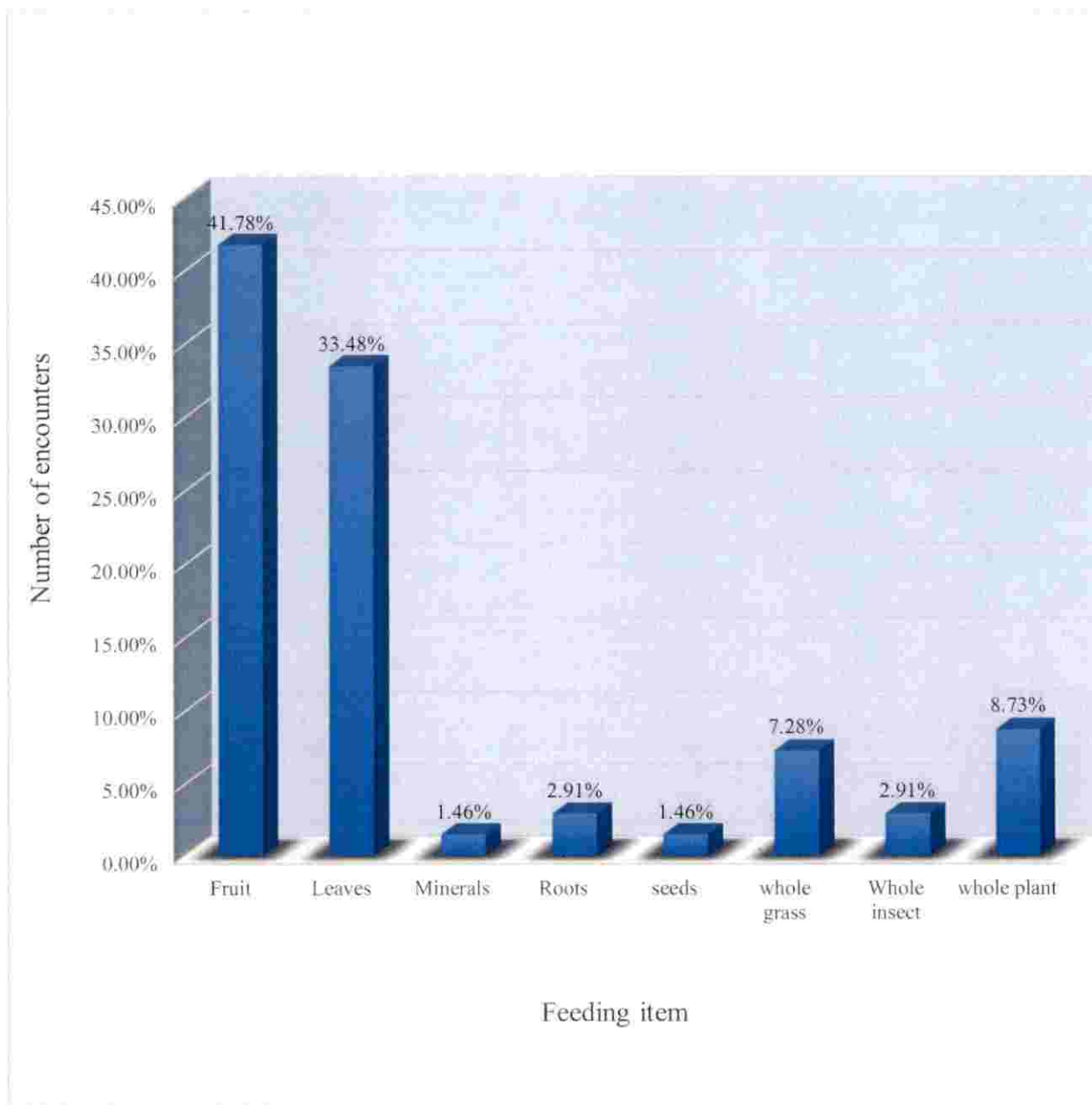


Figure 12. The percentage number of feeding incidences of various feeding item during summer season by Himalayan Grey Langur at Dachigam National Park

During summer season, the Himalyan grey langur showed a great preference towards fruits rather than leaves. The animal showed this preference when actually leaves were present in

abundance during summer season. The fruits include that of *Aesculus indica*, *Juglans regia*, *Prunus armeniaca* and *Prunus ceracifera*. The percentage duration of time spent on different food items during the summer season was analyzed based on duration of time spent by the Himalayan Grey Langur in feeding on different food items. During the summer season, the Himalayan Grey Langur spend maximum duration of time feeding on fruits (41.78 %), followed by leaves (33.48 %), whole plant (8.73 %), grasses (7.28 %), roots (2.91 %), insects (2.91 %), salts (1.46 %) and Seeds (1.46 %) (Figure 13).

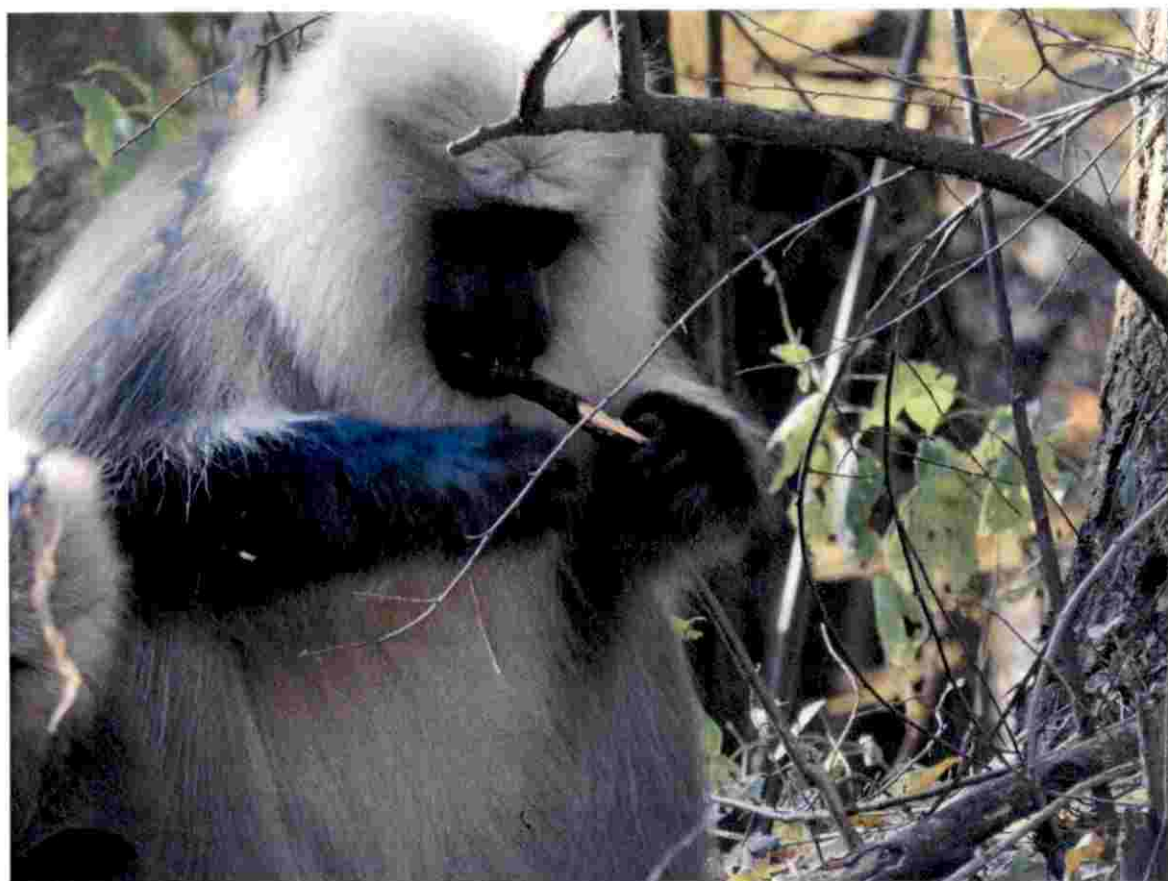


Plate 4. The Himalayan Grey Langur feeding on the roots of *Populus deltoides* at Dachigam National Park

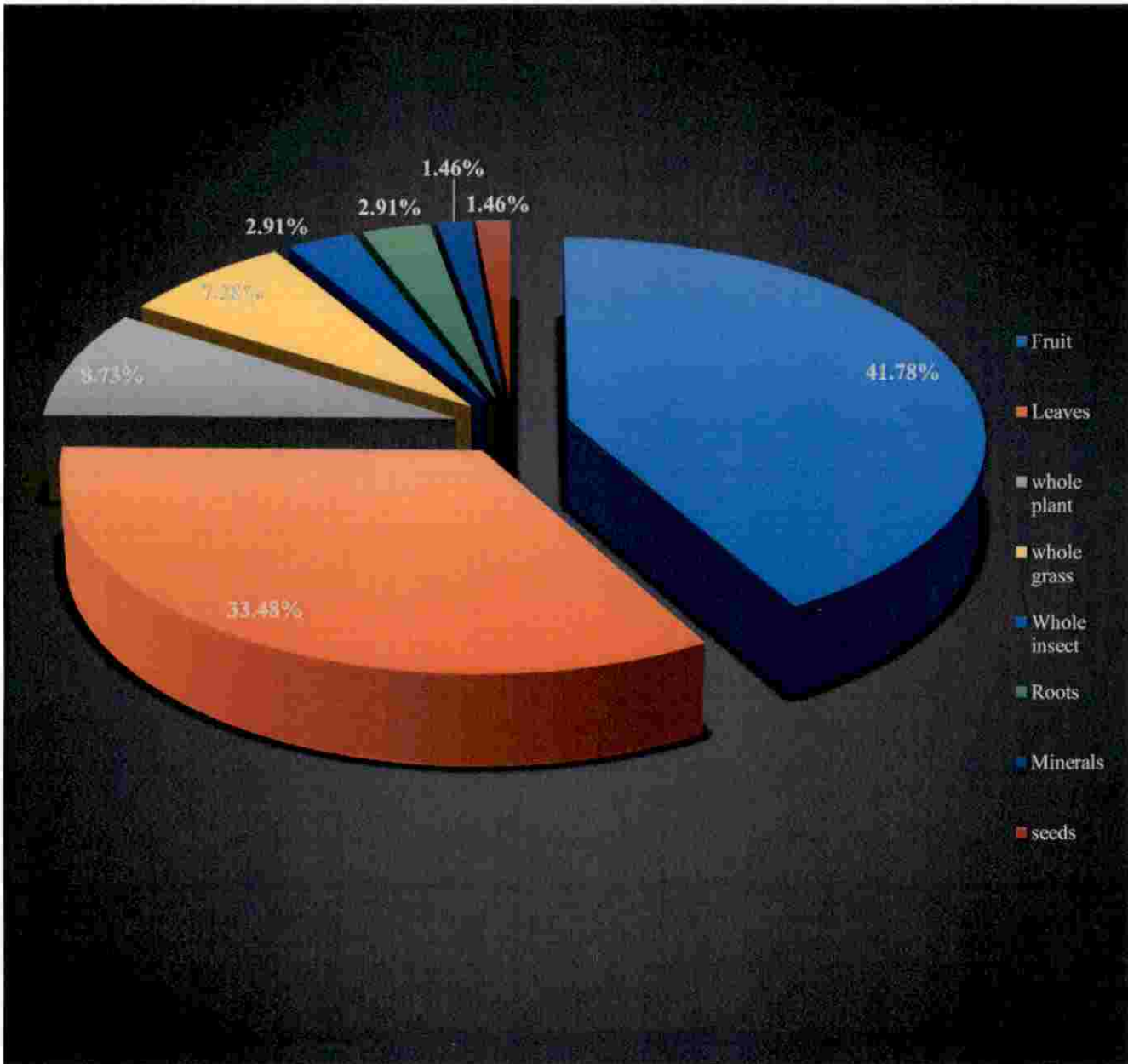


Figure 13. The percentage duration of time spent by the Himalayan Grey Langur in feeding different food items during the summer season

During the summer season, the Himalayan Grey Langur fed on different feeding items at different heights of trees as well as on the ground. During the study period in most of cases, the animal fed on leaves both on the trees as well as on the ground. The fruits were occasionally dropped on the ground to be fed on. The grasses were mostly fed on the ground and in some rare case; the animal took the grass on the tree to be fed on. During the summer season, the average height of feeding was found out to be 5.11 m. During the summer season, the average maximum height was highest for *Rhus succedanae* (12 m), followed by *Aesculus indica* (11.5), *Quercus robur* (10 m), *Juglans regia* (7.42 m), *Parrotiopsis jacquemontiana* (7 m), *Morus alba* (5.42 m), *Morus nigra* (5 m), *Prunus ceracifera* (4.5 m), *Salix alba* (4.5 m) and *Prunus armeniaca* (4 m) (Figure 14).

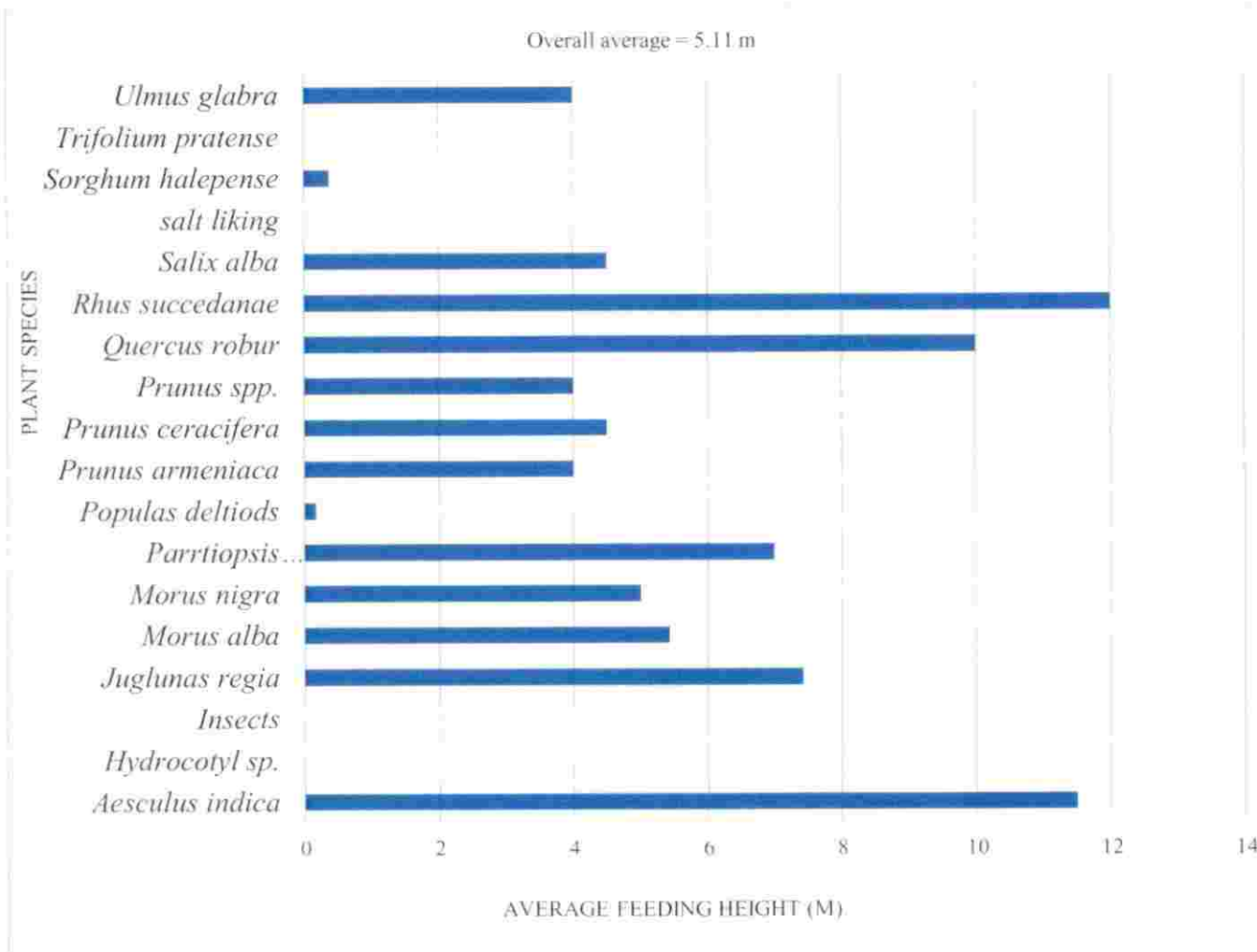


Figure 14. The average feeding height various plant species during the summer season

During the study period, the Himalayan Grey Langur was observed feeding on fruits, leaves, insects, and grasses. The average height of feeding of each food item was analyzed based on the height at which the animal consumed food article. During the summer season, the average height of each food article consumed by the animal was calculated. The average maximum feeding height was maximum in case of seeds (12 m), followed by fruits (9.66 m), leaves (3.6 m) and grasses (0.6 m) (Figure 15).

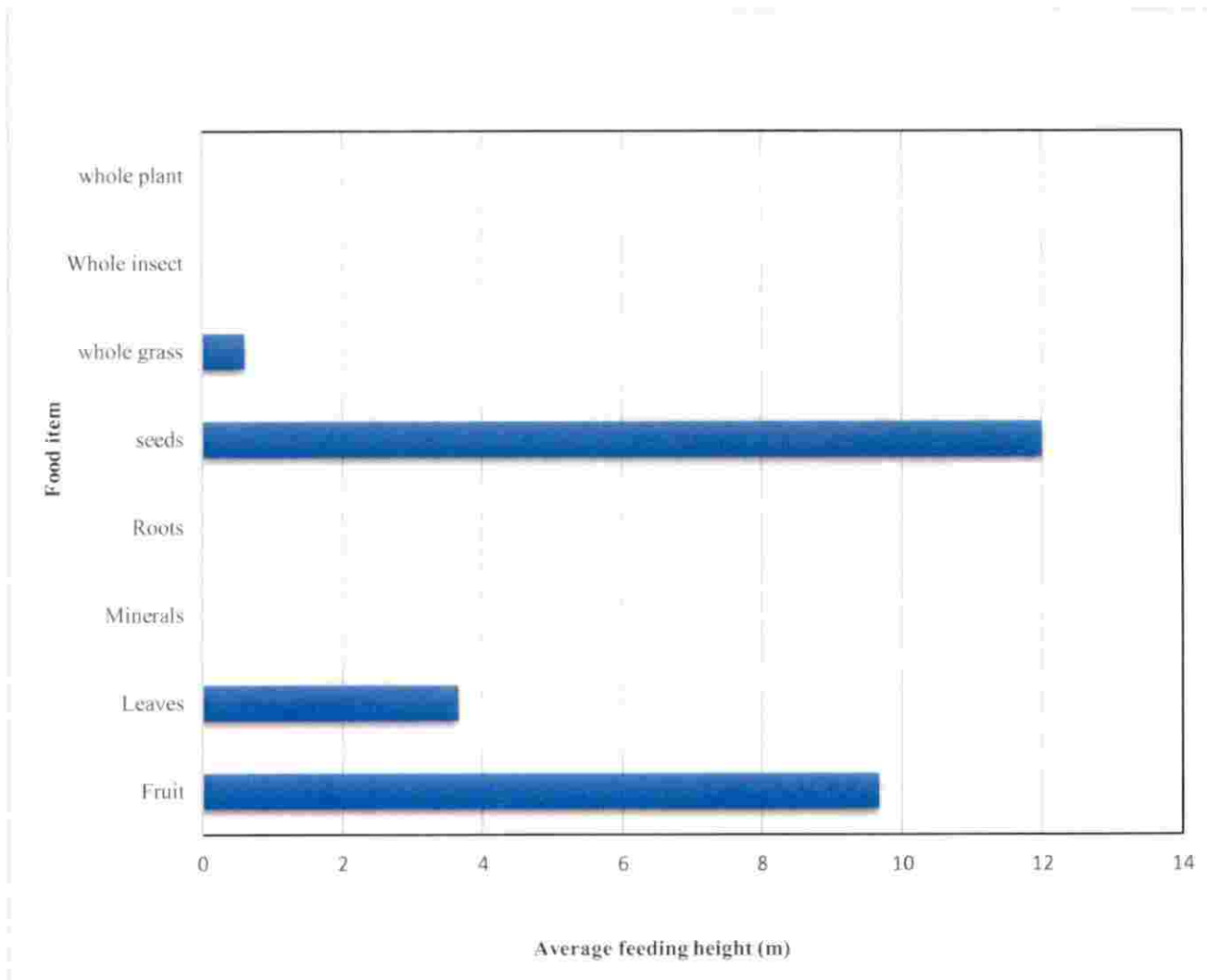


Figure 15. The average feeding height of Himalayan Grey Langur of different feeding items during the summer season

Habitat utilization by the Himalayan Grey Langur during the summer season

During the summer season, habitat utilization by the Himalayan Grey Langur was calculated based on the food availability and food consumption in that habitat. During the summer season, three main food habitats were identified *viz.*, mixed broadleaved, Oak patch and grasslands. The mixed broadleaved habitat was observed to provide maximum food materials and was most utilized habitat. The mixed broad leaved habitat provided maximum food material (80.06 %), followed by Oak patches (11.73 %) and grasslands (8.73 %) (Figure 16).

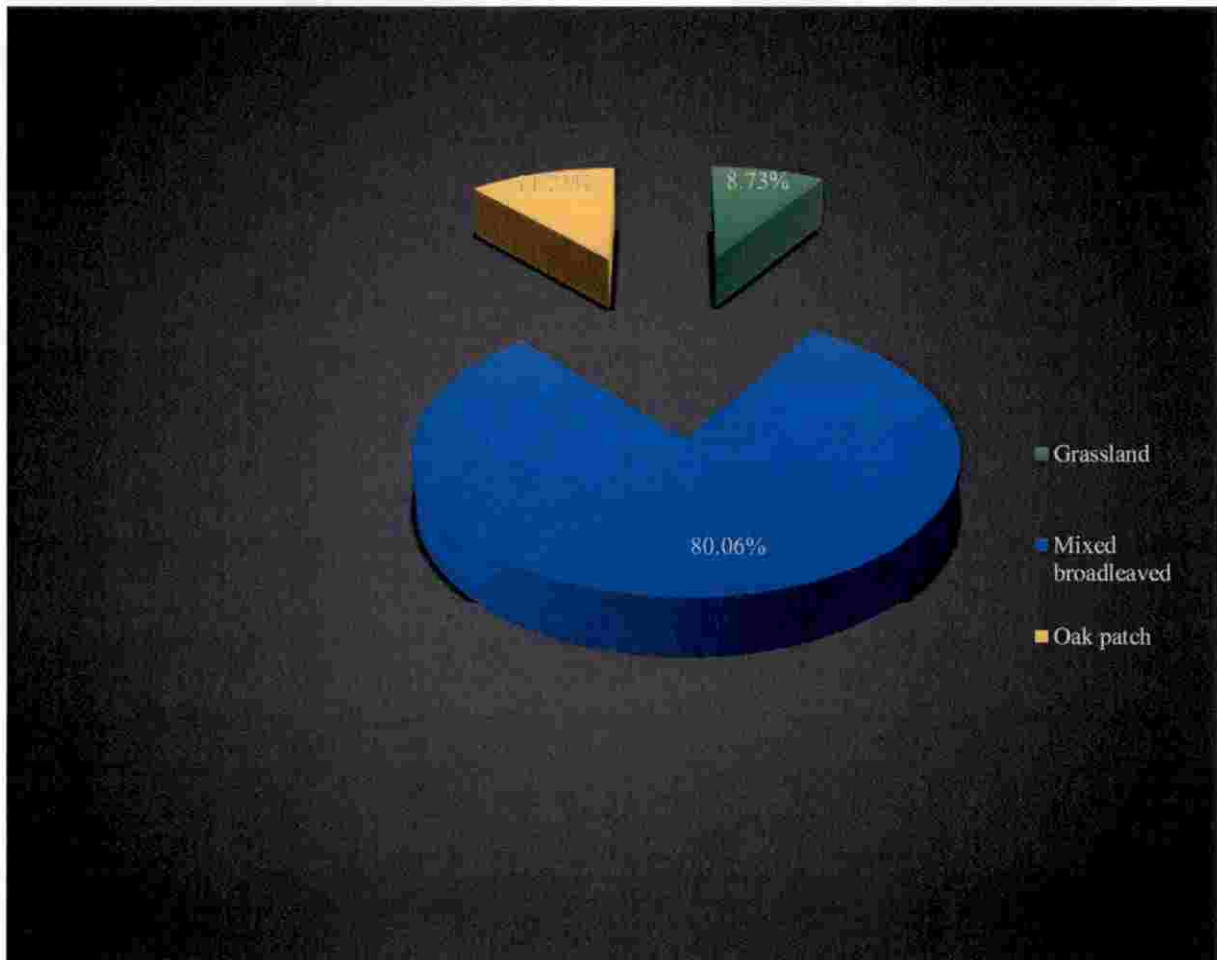


Figure 16. The percentage utilization of various feeding habitats during the summer season

4. 1. 1. 4. 2 FEEDING OF HIMALAYAN GREY LANGUR DURING WINTER SEASON

During the winter season (November – April), a total of 1410 minutes of feeding observation was recorded. The Himalayan Grey Langur was observed feeding on 27 plant species belonging to 16 different families which include 15 tree species, six shrub species, four grass species, and two climber species. The maximum duration of time in feeding was observed in case of Rosaceae family (490 minutes). During the winter season, the percentage duration of time spent feeding on different plant species was calculated based on percentage of time spent feeding on the particular plant species. During the winter season, the maximum duration of time was recorded in case of *Rosa webbiana* (14.18 %), followed by *Hedera nepalensis* (11.35 %), *Salix alba* (9.93 %), *Populus deltoides* (7.80 %), *Ulmus villosa* (7.80 %), *Pinus wallichiana* (7.09 %), *Ulmus wallichiana* (4.96 %), *Sorghum halepense* (4.26 %) (Plate 5), *Silene baccifera* (3.55 %), *Rubus niveus* (3.55 %) and *Cydonia oblonga* (2.13 %). The preferred species during the winter season included *Rosa webbiana*, *Hedera nepalensis*, *Salix alba* and *Populus deltoides* (Table 3).

During the winter season, the Himalayan Grey Langur was observed feeding on various food items such as leaves, seeds, buds, bark, grasses, fruits and twigs. The percentage duration of time spent on feeding various food articles during the winter season was calculated based on the time duration animal spent feeding a particular food item. During the winter season, a total of 141 feeding incidences were observed. The maximum duration of feeding was observed in case of leaves while least feeding incidences were observed when the animal was feeding on twigs alone. Out of 141 feeding incidences, 38 incidences were of leaf feeding, 21 incidences of leaf feeding, 19 incidences of seed feeding, 16 incidences of bud feeding, 11 incidences of flower feeding, 10 incidences in which bark and twigs were fed together, nine incidences of grass feeding, six incidences were bark and buds were fed together and two incidences were twigs were fed alone (Figure 17).

The percentage duration of different feeding articles was calculated based on time duration animal spent feeding on a particular food item during the winter season, the Himalayan Grey Langur fed on various food items such as leaves, fruits, barks, buds, twigs, seed, and grasses.



Plate 5. The Himalyan grey langur feeding on *Sorghum halepense* at Dachigam National Park

Table 3. The list of plant species, their family, part fed, time duration of feeding and percentage duration of feeding during winter season

Sl. No.	Scientific name	Local name	Family	Part eaten	Time duration(minutes)	Percentage duration of feeding
1.	<i>Rosa webbiana</i>	Wild rose	Rosaceae	Leaves, fruit	200	14.18
2.	<i>Hedera nepalensis</i>	Himalayan Ivy	Araliaceae	Leaves, flowers	160	11.35
3.	<i>Salix alba</i>	Willow	Salicaceae	Leaves, bark, buds, twigs	140	9.93
4.	<i>Populus deltoides</i>	Poplar	Salicaceae	Bark, twigs, buds	110	7.80
5.	<i>Pinus wallichiana</i>	Blue pine	Pinaceae	Seeds	100	7.09
6.	<i>Ulmus villosa</i>	Wych elm	Ulmaceae	Buds, bark	90	6.38
7.	<i>Ulmus wallichiana</i>	Himalayan elm	Ulmaceae	Buds	70	4.96
8.	<i>Prunus ceracifera</i>	Cherry plum	Rosaceae	Leaves	60	4.26
9.	<i>Sorghum halepense</i>	Johnson grass	Poaceae	Whole grass	60	4.26
10.	<i>Rubus niveus</i>	wild berry	Rosaceae	Leaves	50	3.55
11.	<i>Silene baccifera</i>	Catchfly	Caryophyllaceae	Leaves	50	3.55
12.	<i>Quercus robur</i>	Oak	Fagaceae	Seeds	40	2.84
13.	<i>Rhus succedanae</i>	Wax tree	Anacardiaceae	Seeds	40	2.84
14.	<i>Cydonia oblonga</i>	Quince	Rosaceae	Fruit	30	2.13
15.	<i>Robinia pseudoacacia</i>	Black locust	Fabaceae	Seeds	30	2.13
16.	<i>Brassica nigra</i>	Mustard	Brassicaceae	Leaves, stem	20	1.42
17.	<i>Cynodon dactylon</i>	Dhoob grass	Poaceae	Whole grass	20	1.42
18.	<i>Indigofera heterantha</i>	Indigo	Fabaceae	Leaves	20	1.42
19.	<i>Morus alba</i>	Mulberry	Moraceae	Leaves	20	1.42
20.	<i>Rosa indica</i>	Rose	Rosaceae	Fruit	20	1.42
21.	<i>Rubus fruticosus</i>	Hill raspberry	Rosaceae	Leaves	20	1.42
22.	<i>Aesculus indica</i>	Horse chestnut	Sapindaceae	Fruit	10	0.71
23.	<i>Berberis lyceum</i>	Barberry	Berberidaceae	Leaves	10	0.71
24.	<i>Fraxinus hookeri</i>	Ash	Oleaceae	Buds, twigs	10	0.71
25.	<i>Prunus persica</i>	Peach	Rosaceae	Leaves	10	0.71
26.	<i>Salix caprea</i>	Goat willow	Salicaceae	Leaves	10	0.71
27.	<i>Trifolium pratense</i>	Red clover	Papilionaceae	Whole grass	10	0.71

During winter season, the Himalayan Grey Langur spent maximum duration of time feeding on

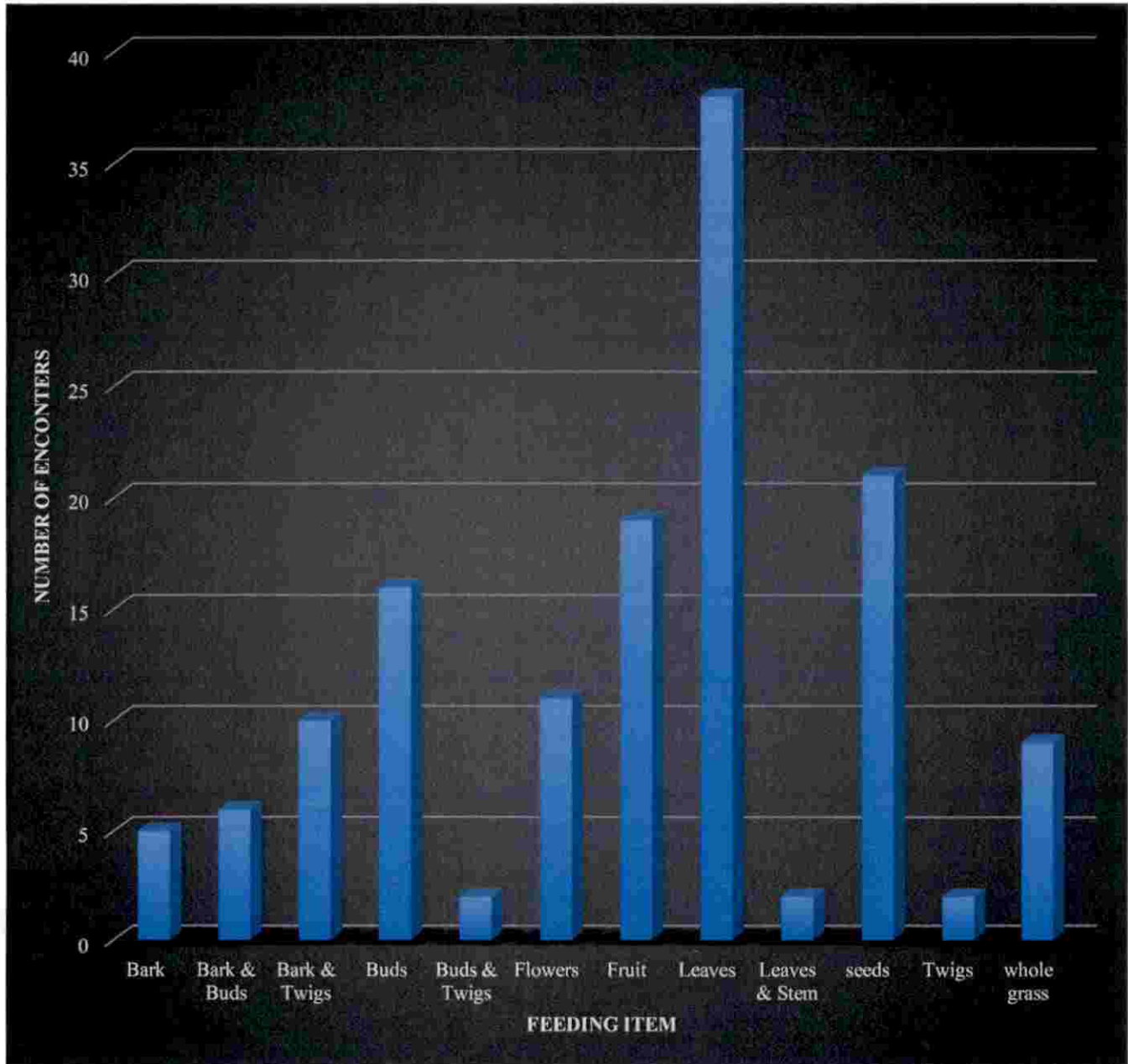


Figure 17. The number of feeding encounters for each food item by Himalayan Grey Langur during the winter season

leaves (27 %), followed by seeds (15%), fruits (13 %), buds (11 %), flowers (8 %), bark and twigs (7 %), grasses (6 %), bark (4 %), bark, buds together (2 %), and twigs (1 %) (Figure 18). Thus, during the winter season, the most preferred feeding item for Himalayan Grey Langur were leaves while as twigs were the least preferred food items.

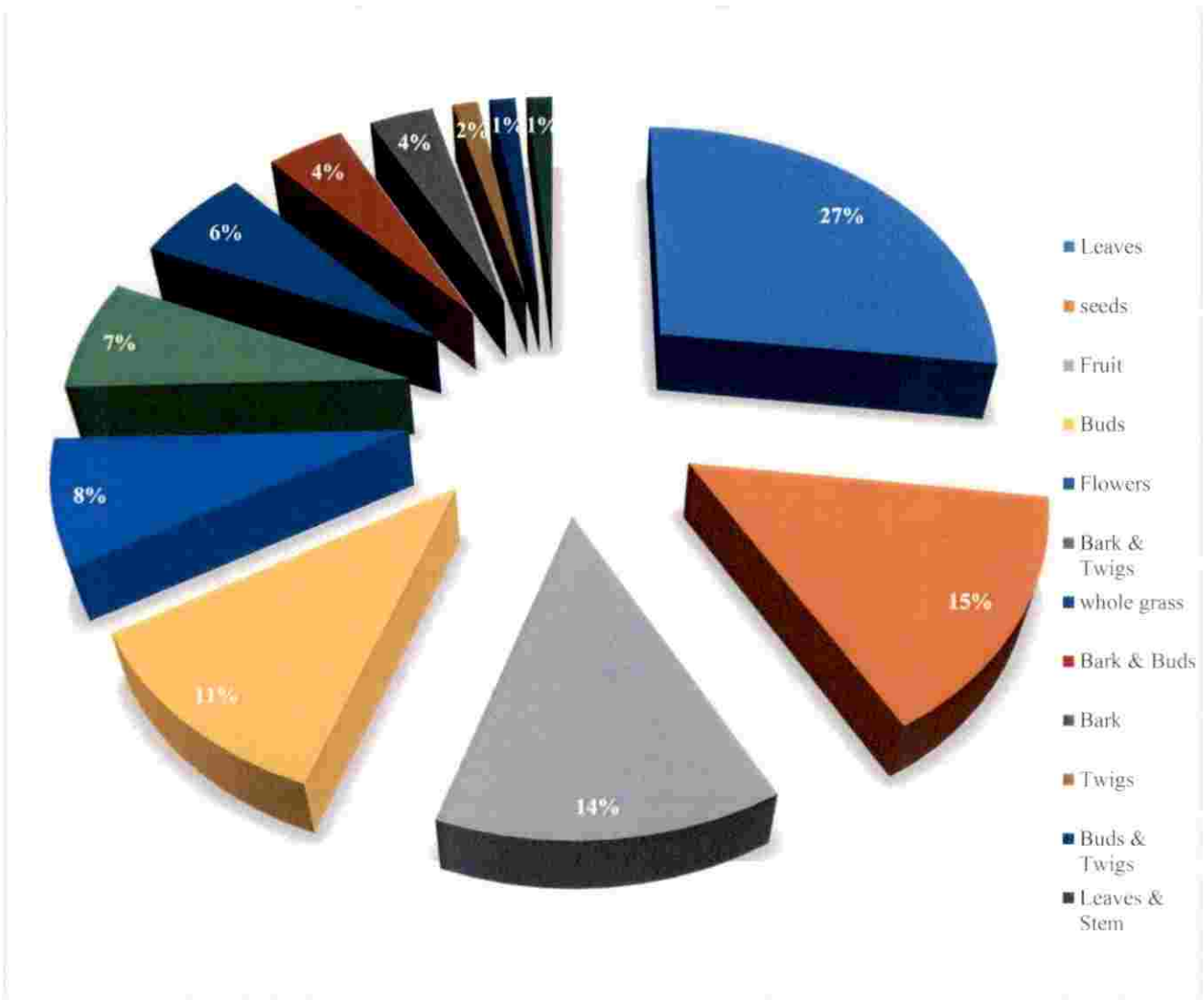


Figure 18. The percentage contribution of various feeding items in the diet of Himalayan Grey Langur during the winter season

During the winter season, the Himalayan Grey Langur was observed feeding on leaves, flowers, seeds, fruits and grasses at various heights of trees. The average height of each food article was calculated based on the height at which the animal was observed consuming the particular food article. During the winter season, the animal was found feeding both on the ground on fallen leaves and other food items as well as above ground. During the study period, the overall average feeding height at which the fed various food articles during the winter season was observed to be 5.9 m. During the winter season, the average maximum feeding height was observed in case of *Pinus wallichiana* (11 m), followed by *Ulmus villosa* (9.88 m), *Ulmus wallichiana* (9.7 m), *Populus deltoides* (9.2 m), *Rhus succedanae* (8.5 m), *Salix caprea* (8 m), *Hedera nepalensis* (7.9 m), *Aesculus indica* (6 m), *Rosa webbiana* (5.73 m), *Silene baccifera* (5.4 m), and *Salix alba* (4.6 m) (Figure 19).

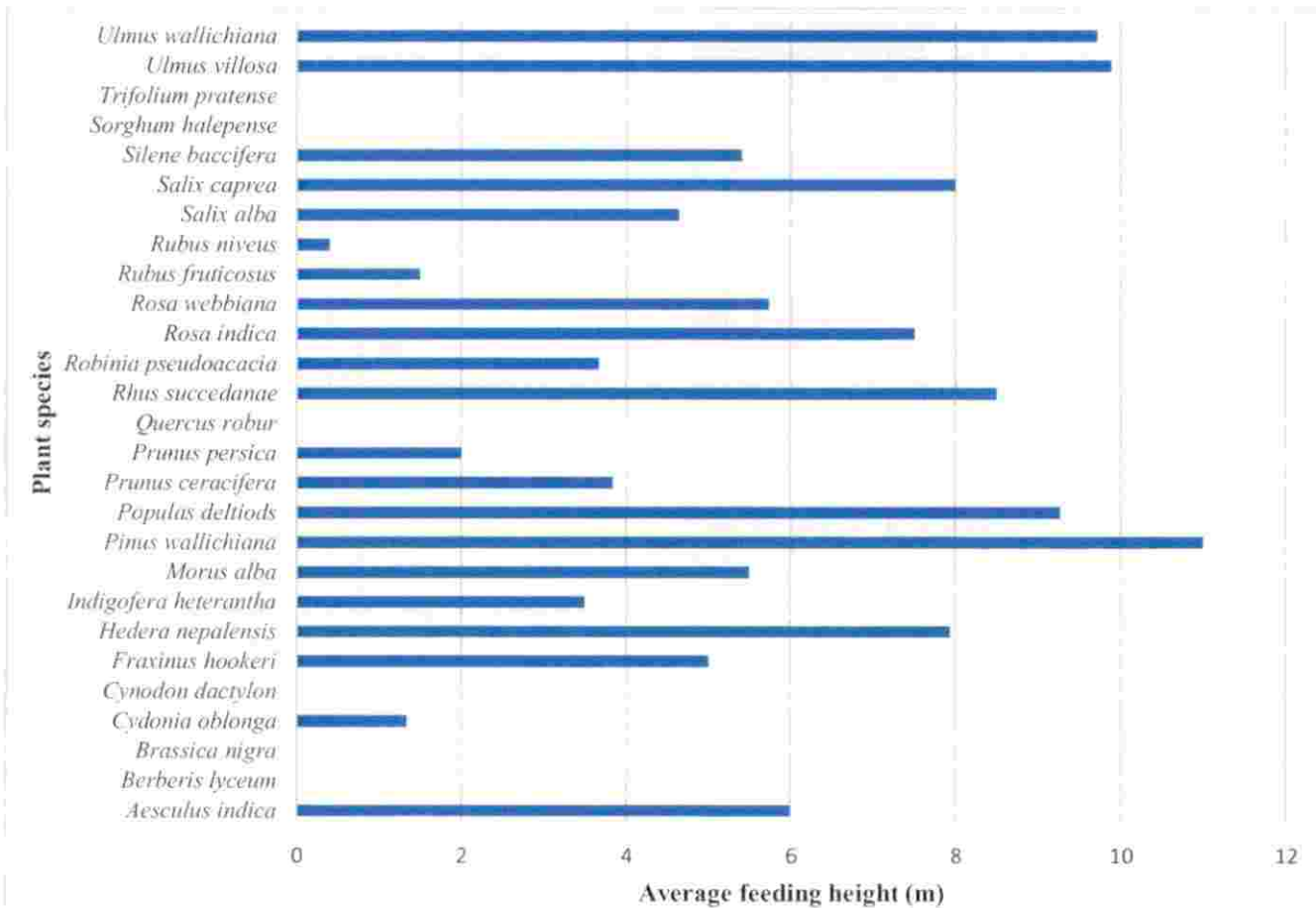


Figure 19. The average height of feeding for various plant species during the winter season

Thus, during the winter season, the average maximum feeding height was highest in case of *Pinus wallichiana* while certain other species were fed on the ground.

During the winter season, the average height for each food article was calculated based on the height at which the animal was observed feeding a particular food item. During the winter season, the average feeding height for different food items was observed to be 5.91 m. The average maximum feeding height was found to be maximum in case of buds (9.68 m), followed by flowers (8.99 m), bark and buds (8.83 m), bark and twigs (8.4 m), twigs (4.5 m), leaves (4.3 m), bark (2.4 m) and grasses were fed on the ground (Figure 20).

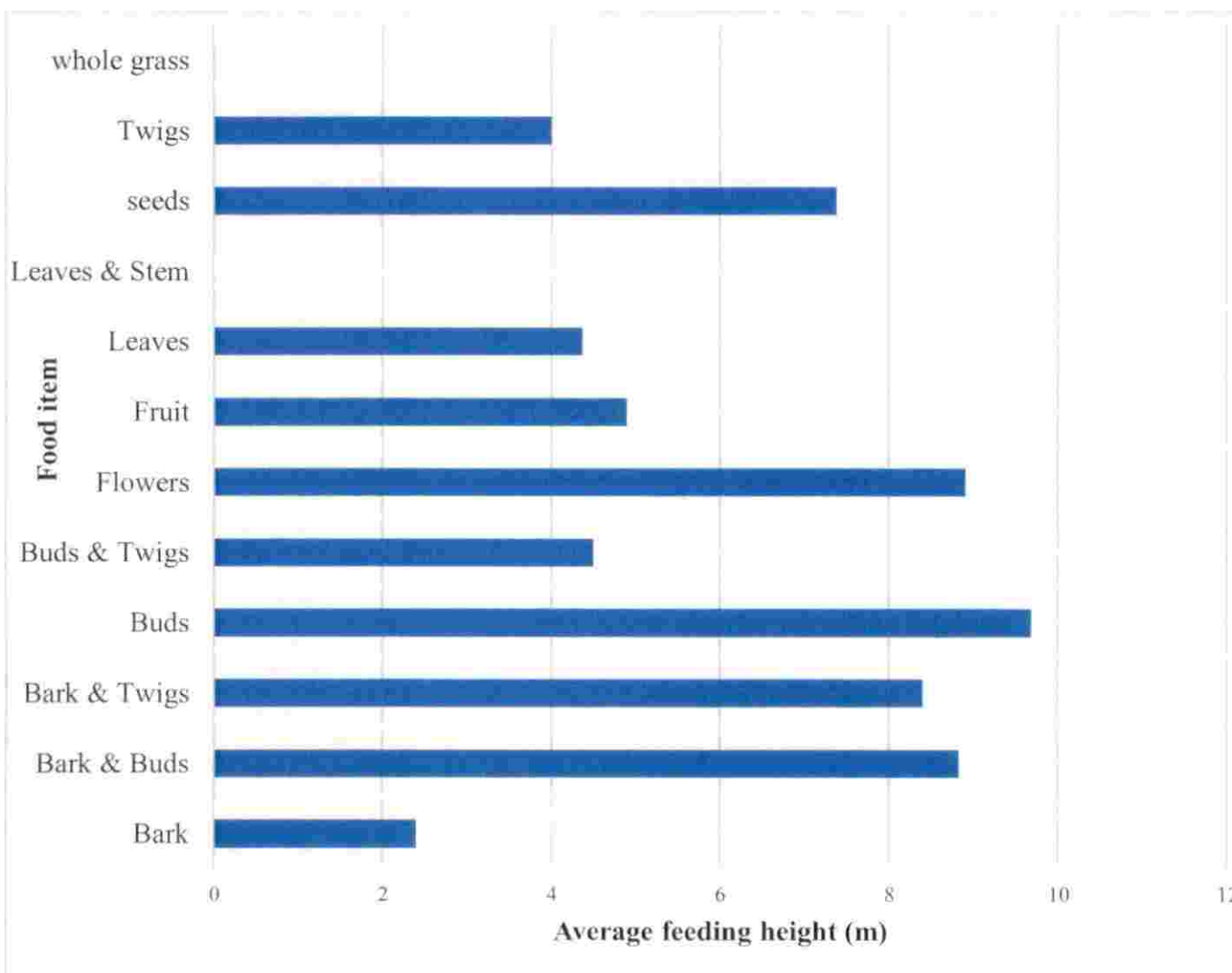


Figure 20. The average feeding height of various feeding articles during the winter season

Thus, during winter season the buds were fed at maximum height while as the grasses were fed at the ground level.

Habitat utilization by Himalayan Grey Langur during the winter season

During the winter season, four feeding habitats were identified during the study period viz., Broadleaved, Coniferous, Mixed coniferous and Riverine. The winter survival of the Himalayan Grey Langur during the harsh climatic conditions of extreme cold and snow depends upon the food availability in these feeding habitats. During the winter season, the Himalayan Grey Langur was observed to be making maximum use of broadleaved habitat while as coniferous habitat was least utilized. The maximum feeding species were contributed by the broadleaved habitat (69.50 %), followed by the mixed coniferous habitat (19.15 %), Riverine habitat (8.51 %) and coniferous (2.84 %) (Figure 21).

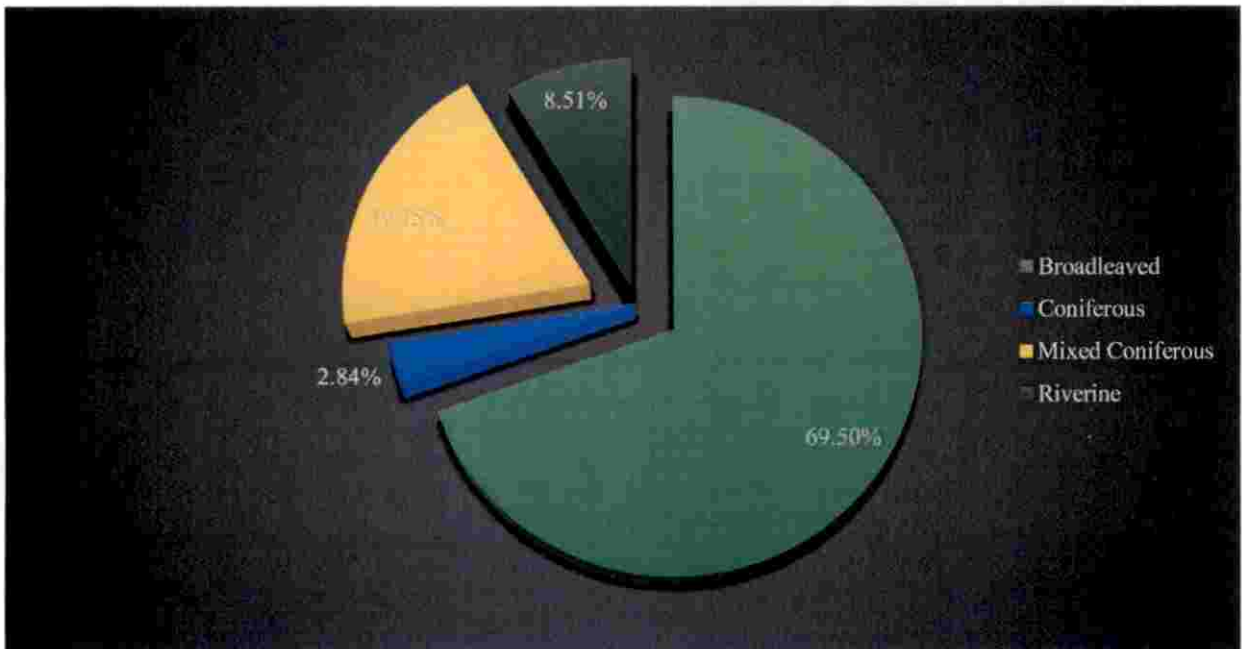


Figure 21. The Percentage utilization of different feeding habitats during the winter season by the Himalayan Grey Langur

Thus, during the winter season, the Himalayan grey preferred the broadleaved habitat while, as the coniferous habitat was least preferred.

4.1.2 FEEDING ECOLOGY OF TUFTED GREY LANGUR AT WAYANAD WILDLIFE SANCTUARY

The Wayanad Wildlife sanctuary was chosen to be the second study area to study the comparative feeding ecology of two endemic species of langurs. In the Wayanad wildlife sanctuary Muthanga range was selected as extensive study area and the observation were recorded.

During the study period, the Tufted Grey Langur was observed to be feeding on 12 tree species belonging to the seven different families (Table 4).

Table 4. The plant species fed, their family, part fed, time of feeding and percentage duration of feeding by Tufted Grey Langur at Wayanad Wildlife Sanctuary

Sl.No	Plant species	Family	Part fed	Time of feeding (minutes)	Percentage duration of time
1.	<i>Anogeissus latifolia</i>	Combretaceae	Leaves, twigs	100	18.87
2.	<i>Samanea saman</i>	Fabaceae	Leaves	100	18.87
3.	<i>Dalbergia lanceolaria</i>	Fabaceae	Leaves, twigs	50	9.43
4.	<i>Grewia tiliifolia</i>	Malvaceae	Leaves, fruit	50	9.43
5.	<i>Terminaliala bellarica</i>	Combretaceae	Leaves, fruit	40	7.55
6.	<i>Gmelia arborea</i>	Lamiaceae	Fruit, leaves	30	5.66
7.	<i>Hydnocarpus pentandra</i>	Achariaceae	Leaves, twigs	30	5.66
8.	<i>Melia dubia</i>	Meliaceae	Fruit	30	5.66

9.	<i>Pongamia pinnata</i>	Fabaceae	Leaves	30	5.66
10.	<i>Tectona grandis</i>	Lamiaceae	Leaves	30	5.66
11.	<i>Dalbergia latifolia</i>	Fabaceae	Leaves	20	3.77
12.	<i>Muntingia calabura</i>	Muntingiaceae	Leaves	20	3.77

The leaves comprised of main chunk of food followed by twigs and fruits.

Among the tree species maximum feeding was observed in case of *Anogeissus latifolia* and *Samanea saman* (18 %), followed by *Gmelia tillifolia* (10%), *Dalbergia lanceolaria* and *Terminalia bellarica* (8%) and *Pongamia pennata* (6 %) (Figure 22).

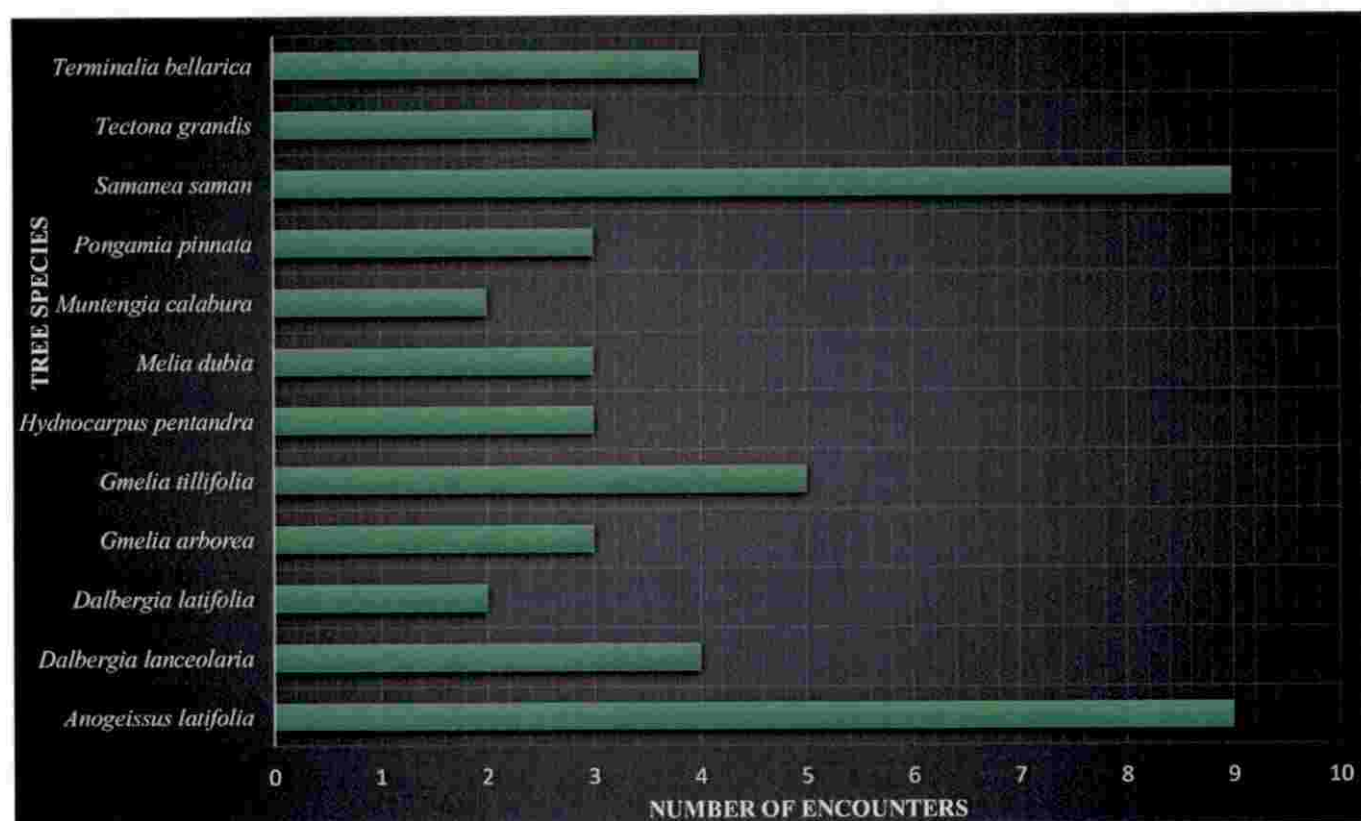


Figure 22. The number of encounters for each tree species by Tufted Grey Langur at Wayanad Wildlife Sanctuary

Food composition of Tufted Grey Langur at Wayanad Wildlife sanctuary

During the study period, a total of 530 minutes of feeding observation was recorded. The diet of the Tufted Grey Langur composed mainly of leaves, fruits and twigs. Although the leaves constituted the major portion of the diet yet the Tufted Grey Langur was observed feeding on fruits and twigs as well. The diet constituted majority portion of leaves with 60.38 % of the total diet followed by twigs (20.75 %) and fruits (18.87 %) (Figure 23).

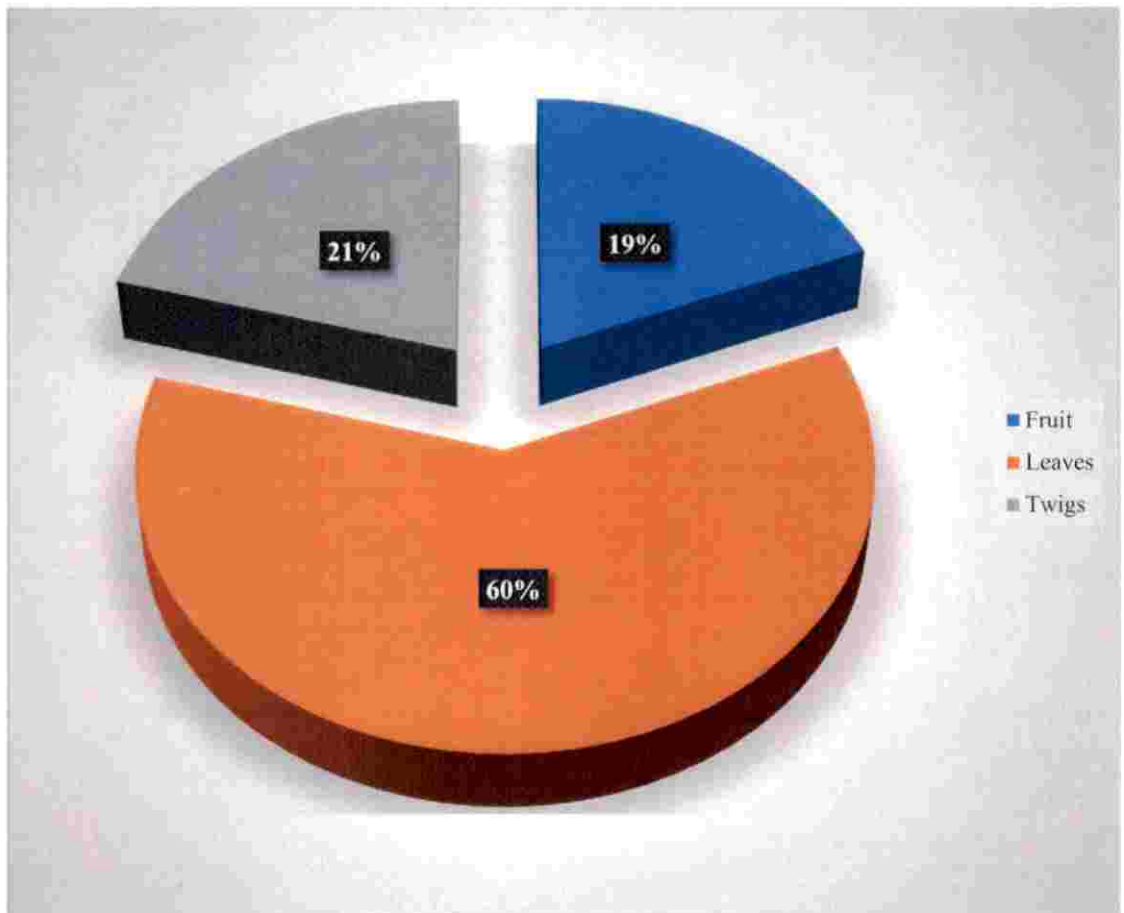


Figure 23. The contribution of various food items in the diet of Tufted Grey Langur at Wayanad Wildlife Sanctuary

During the study period, a total of 50 feeding incidences were observed. The maximum frequency of incidences was recorded in case of leaves (30), followed by twigs and fruits with ten each (Figure 24).

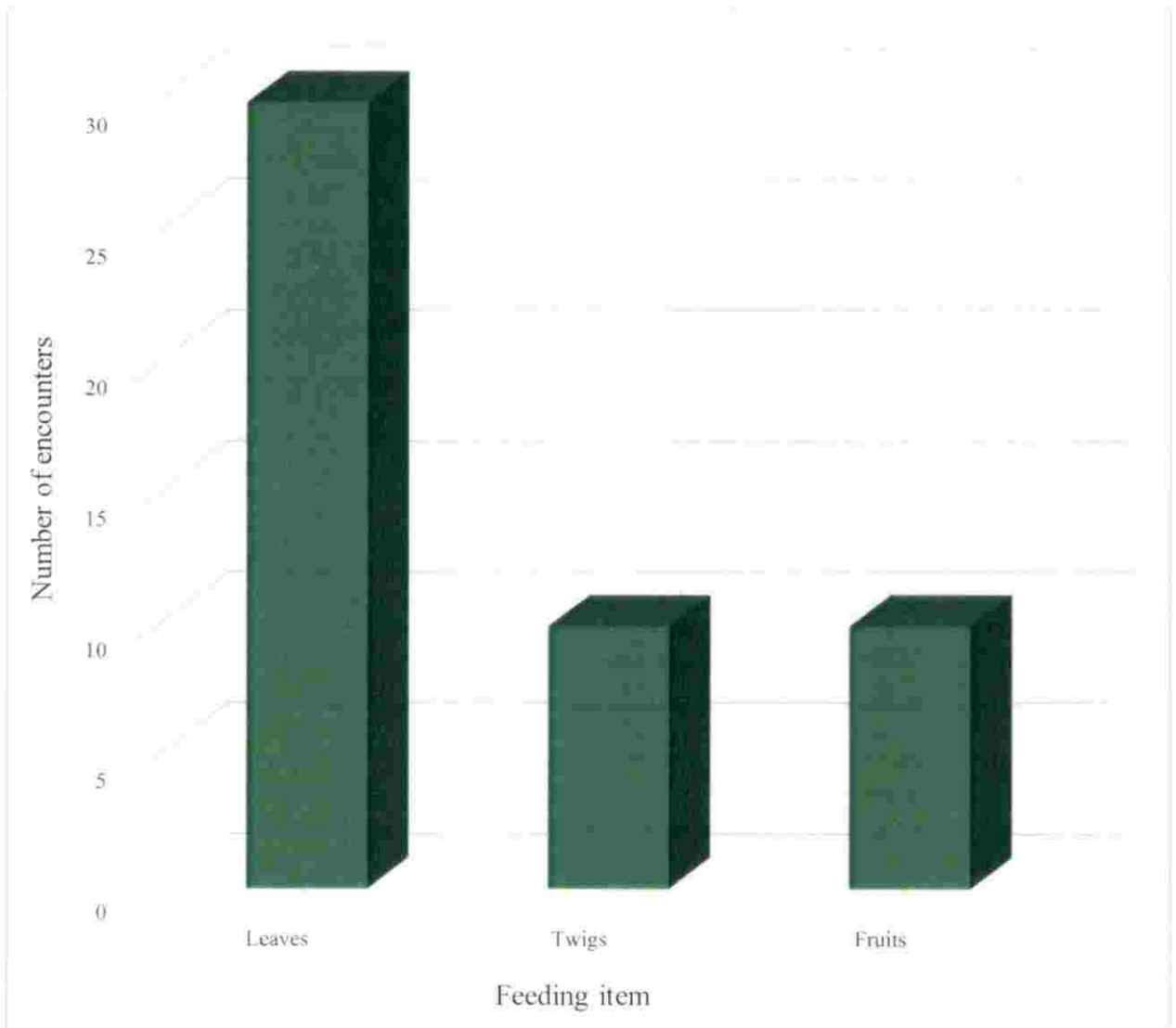


Figure 24. The number of encounters for each feeding item by Tufted Grey Langur at Wayanad Wildlife Sanctuary

Time duration of feeding of Tufted Grey Langur at Wayanad Wildlife Sanctuary

During the study period, a total of 530 minutes of feeding observation was recorded. The Tufted Grey Langur was observed to be feeding on 12 tree species. Among all the tree species the maximum duration of time was spent feeding on *Anogeissus latifolia* and *Samanea saman* (18.87 %), followed by *Dalbergia lanceolaria* and *Gmelia tillifolia* (9.43 %), *Terminalia bellarica* (7.55 %) (Figure 25). Thus, during the current study period, *Anogeissus latifolia* and *Samanea saman* were most preferred food trees for the Tufted Grey Langur at Wayanad wildlife sanctuary.

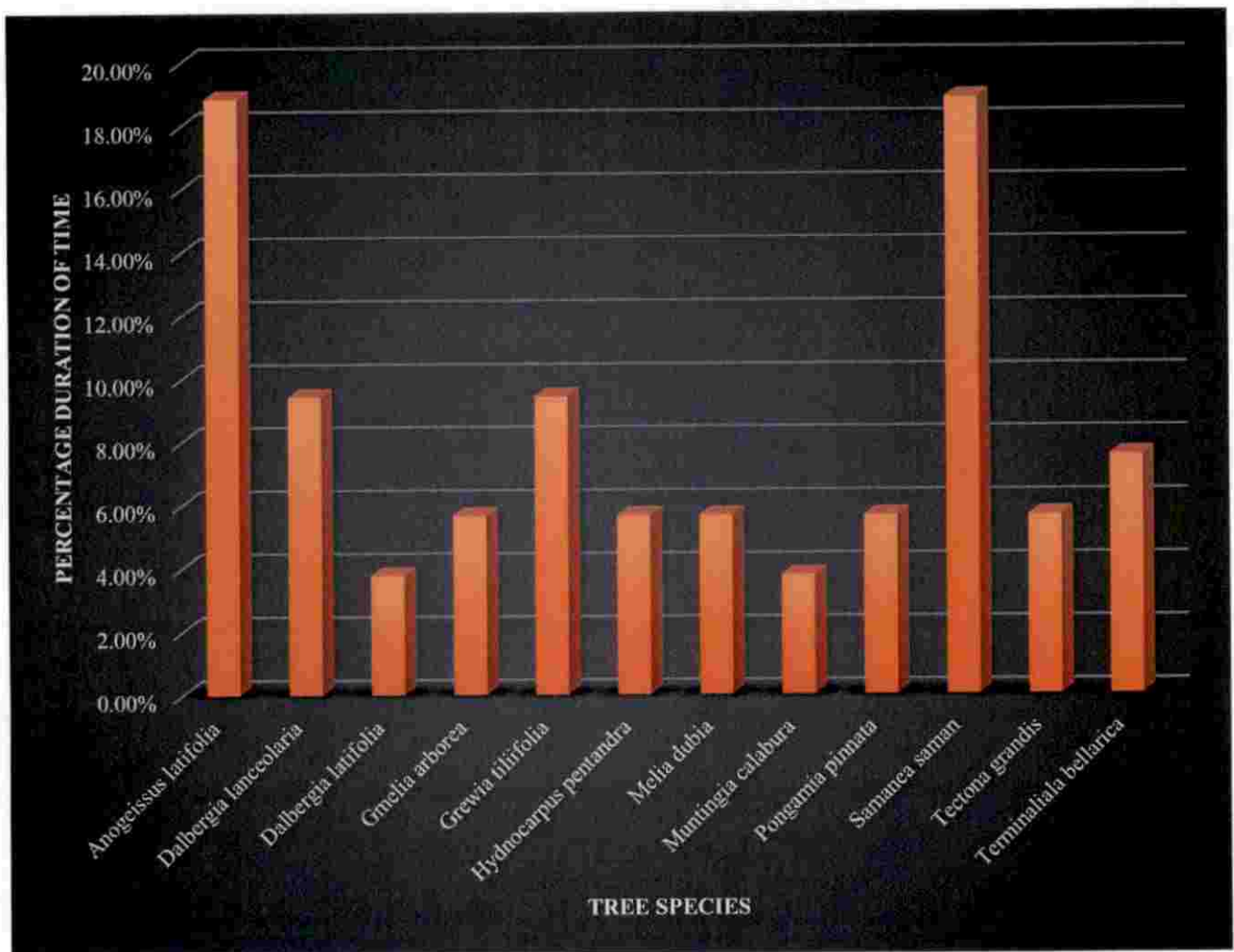


Figure 25. The percentage duration of time spent feeding on each tree species by Tufted Grey Langur at Wayanad wildlife sanctuary

During the study period, the maximum duration of time was spent feeding on leaves (60.38 %), followed by twigs (20.75 %) and fruits (18.87 %). Thus, leaves were most favorite and Preferred food for the Tufted Grey Langur at Wayanad wildlife sanctuary during the current study period (Figure 26).

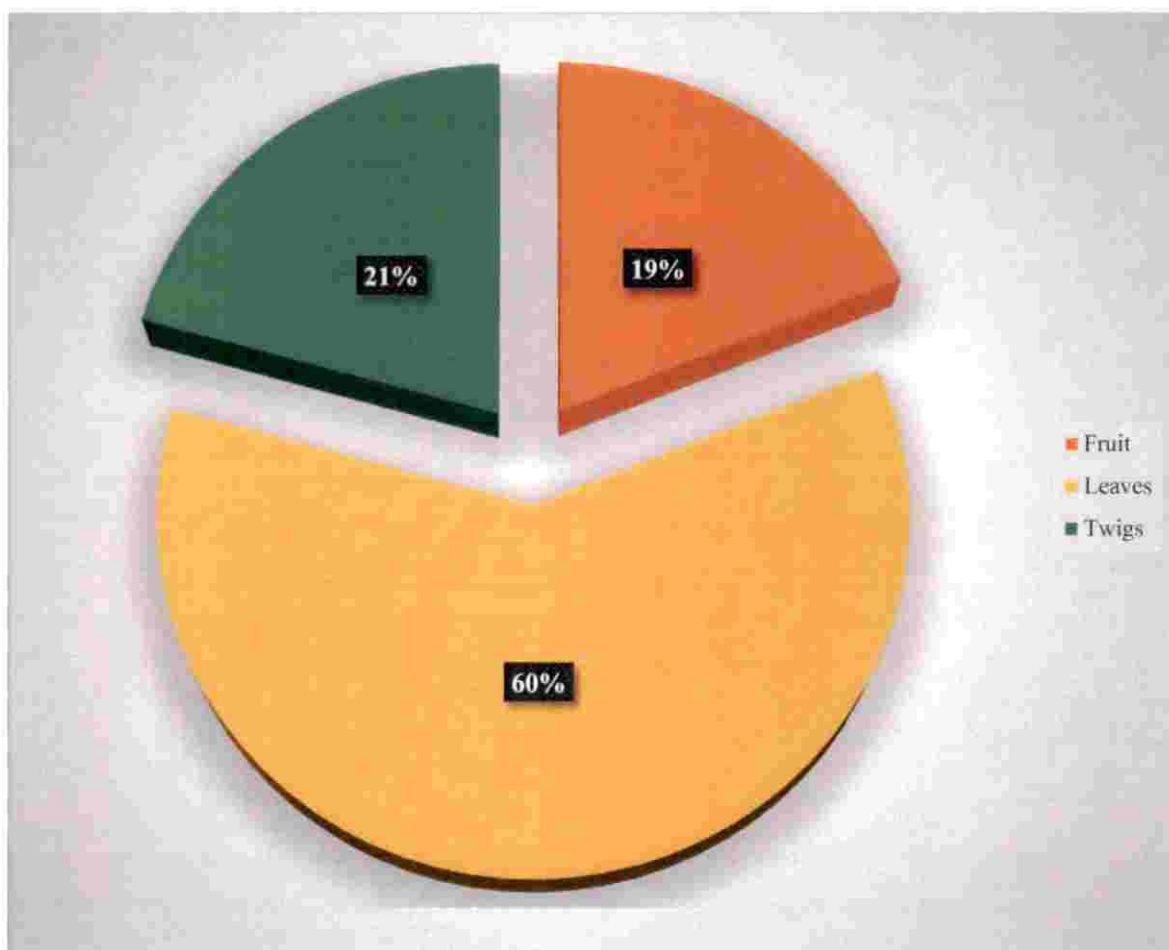


Figure 26. The percentage duration of time spent on feeding on each food article by the Tufted Grey Langur at Wayanad wildlife sanctuary

Average height of feeding of Tufted Grey Langur at Wayanad wildlife sanctuary

During the study period, the overall average height of feeding was observed to be 8.88 m. The maximum average height was observed in case of *Hydnocarpus pentandra* (12 m), followed by *Terminalia bellarica* (10.5 m), *Gmelia arborea* (10.3 m) and *Dalbergia latifolia* (9 m) (figure. 27).

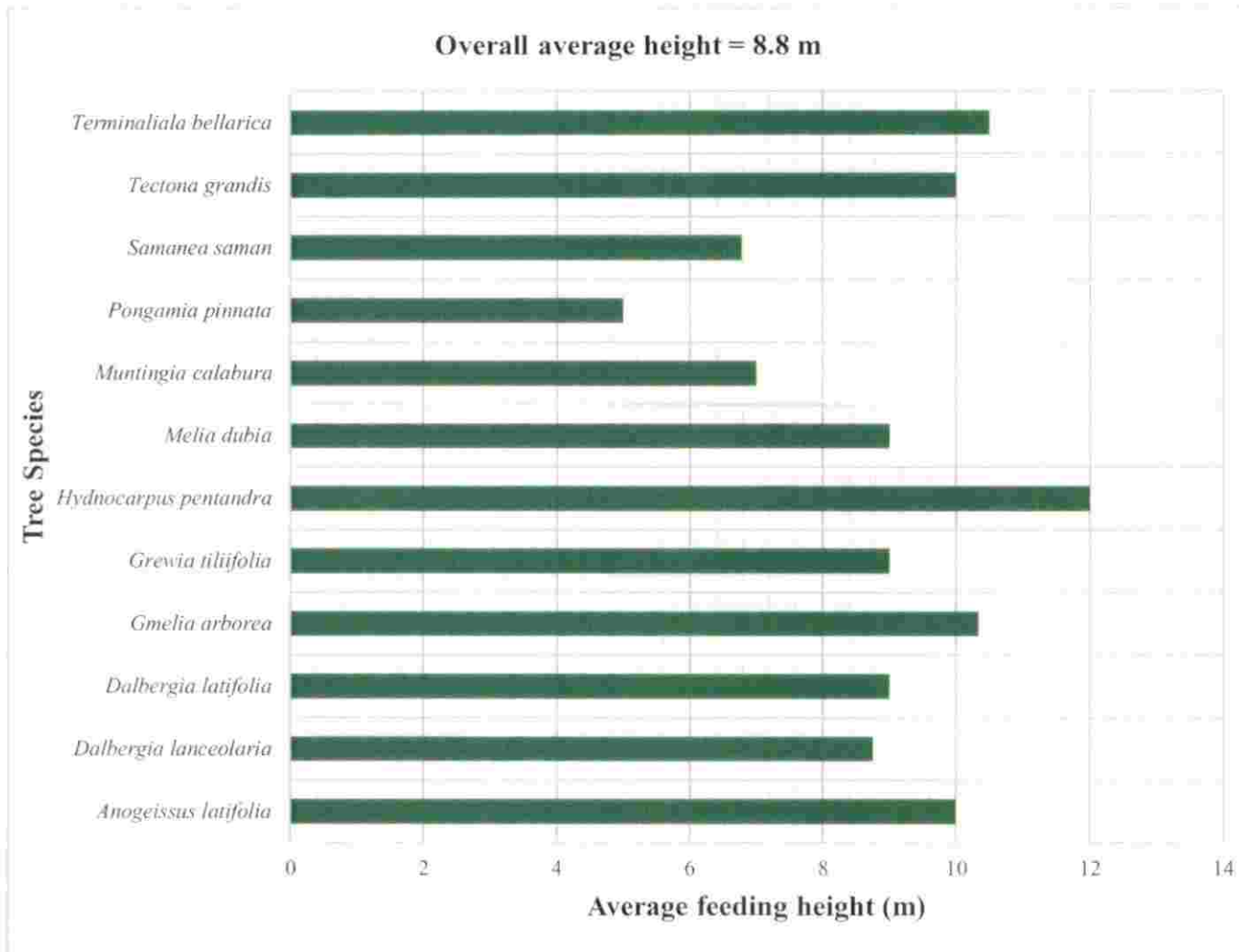


Figure 27. The average height of feeding of various trees species at Wayanad wildlife sanctuary

During the study period, the average height of feeding for fruits was maximum (10 m), followed by twigs (9.2 m) and leaves (8.4 m) (Figure 28).

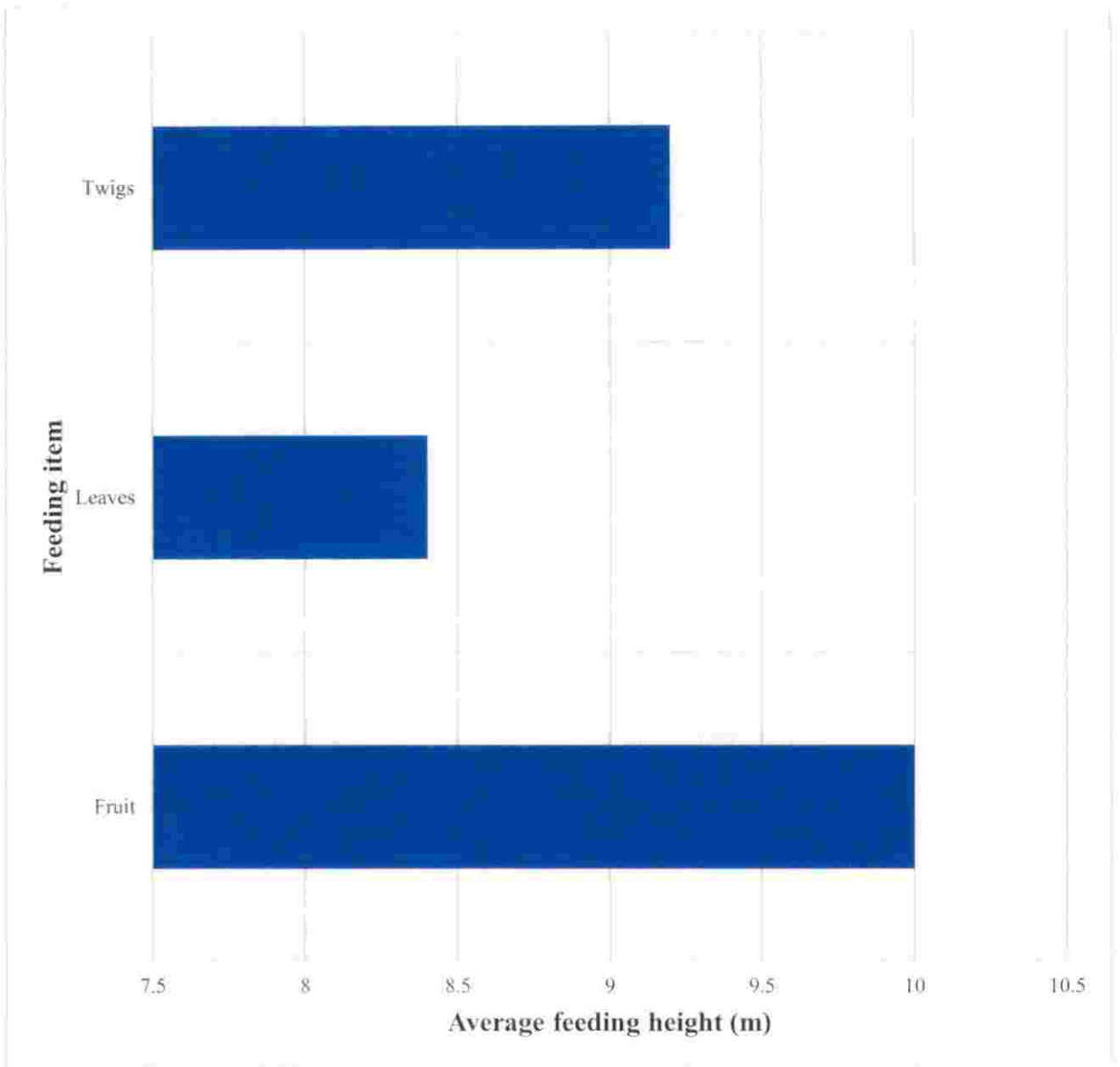


Figure 28. The average feeding height of various food articles at Wayanad wildlife sanctuary

4.2 SOCIAL BEHAVIOR AND ORGANIZATION OF THE HIMALAYAN GREY

LANGUR

The focal animal sampling was followed to find out the time budget activity of the Himalayan Grey Langur. While following the focal animal sampling, scanning of focal individual langur, selected based on certain prominent and unique morphological characters was done. One individual langur was selected in the troop and followed and different activities such as feeding, moving, resting, grooming and calling were recorded. Data collected during the study period was pooled to analyze distribution of activities during the different seasons (summer and winter). The frequency, total duration, percentage duration and mean duration for each activity during the different seasons were calculated. The frequency of the specific act refers to the number of times the occurrence of that particular activity recorded during the observation period. The total duration of a single activity refers to the time spent on that particular activity during the whole observation period.

The Instantaneous scan sampling method was followed for recording the social organization observations with the predetermined set time limit. The scanning of individual langur was carried out for its movement activities, sub grouping and interaction with other members of the troop.

The time budget activity, mean duration and percentage duration of the Himalayan grey langur at Dachigam National Park

During the study period, total of 5420 minutes of observation regarding various activities Grooming, feeding, resting, moving and calling were recorded. The Himalayan Grey Langur spent maximum time in feeding 2243 minutes, followed by moving 1091 minutes, resting 886 minutes, grooming 7790 minutes while as 410 minutes of calling were also recorded (Figure 29).

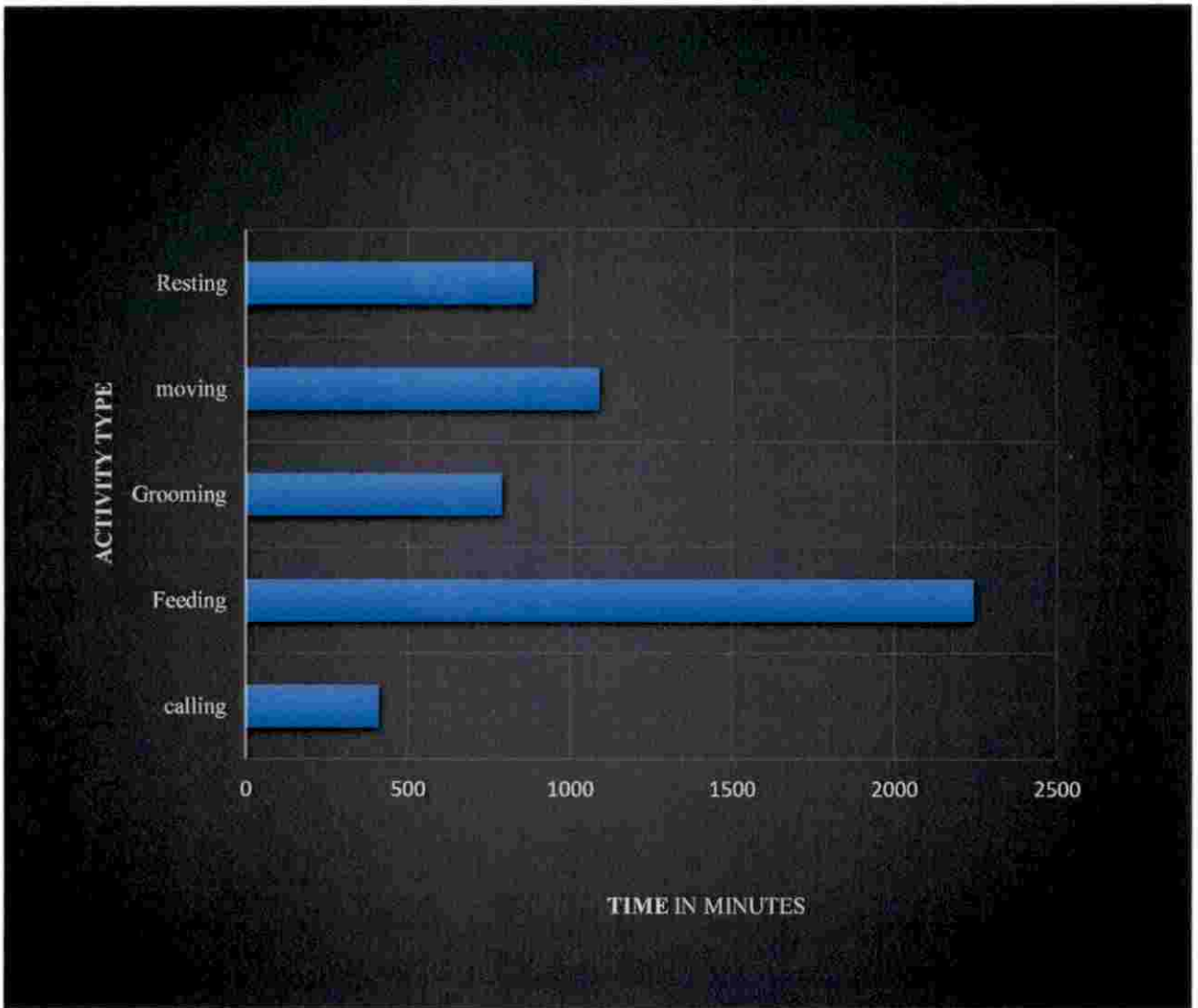


Figure 29. The time duration of various activities performed by the Himalayan Grey Langur at Dachigam National Park

The activity time budget of the Himalayan Grey Langur

Based on the duration of time spent on the various activities the percentage contribution of different activities to the total duration of time was calculated. The primary activity performed by the Himalayan Grey Langur at Dachigam National Park was feeding which accounted 41 percent of the total time budget of activities, which was followed by moving (21 %), resting (16 %), grooming (15 %) while as 8 percent of the total time budget was utilized in calling (Figure 30).

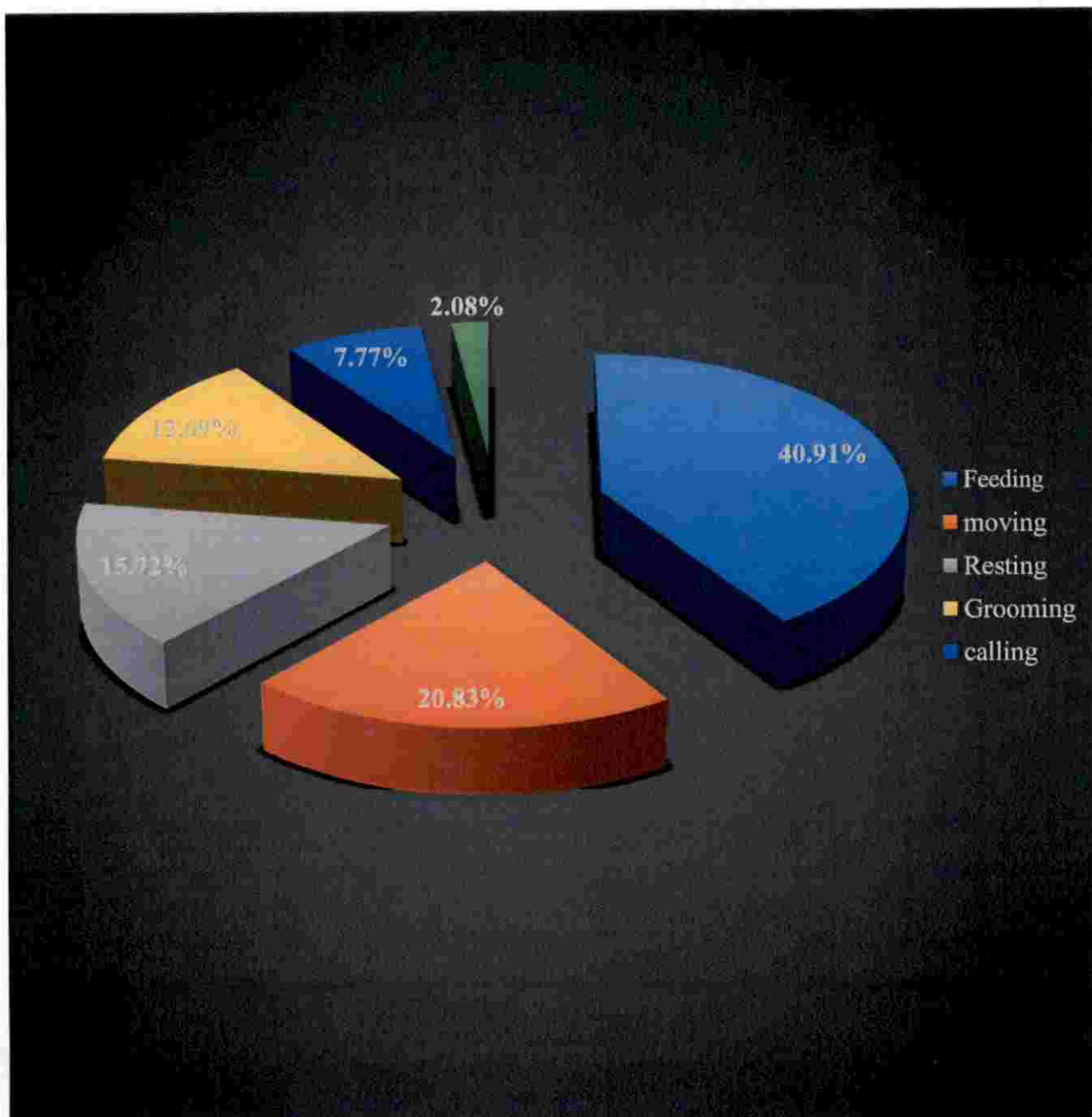


Figure 30. The Activity time budget of the Himalayan Grey Langur at Dachigam National Park

Mean duration of activities of the Himalayan Grey Langur

The mean duration of the time was calculated by dividing the duration of a particular activity by the number of occurrence of that activity. In this case resting accounted for the maximum mean duration with 10.67 minutes, followed by feeding (10.38 minutes), grooming (10.12 minutes) and moving (9.91 minutes). In this case, the mean duration of calling was more than that of moving (Figure 31).

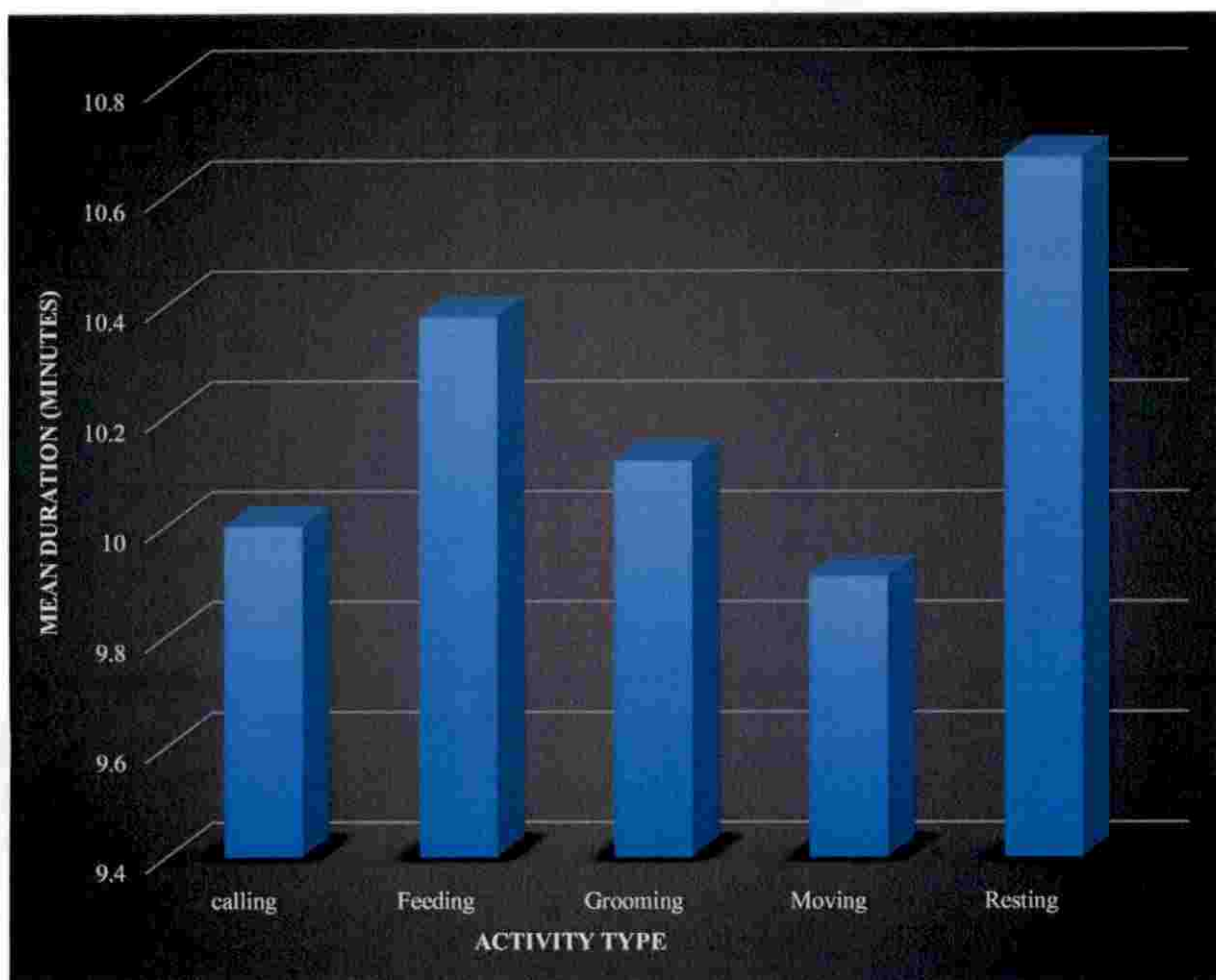


Figure 31. The mean duration of activities of the Himalayan Grey Langur at Dachigam National Park

Percentage frequency of various activities of the Himalayan Grey Langur

The frequency of specific act refers to the number of occurrence of that particular activity during the whole observation period. The percentage frequency of various activities of the Himalayan Grey Langur during the study period was calculated. The trends of various activities performed by the Himalayan Grey Langur shows that the animal dedicates maximum percentage of time frequency in feeding accounting for 40.91 percent, followed by moving (20.83 %), resting (15.73 %), grooming (14.77 %) while as 7.7 percent of percentage frequency of time was allotted for calling (Figure 32).

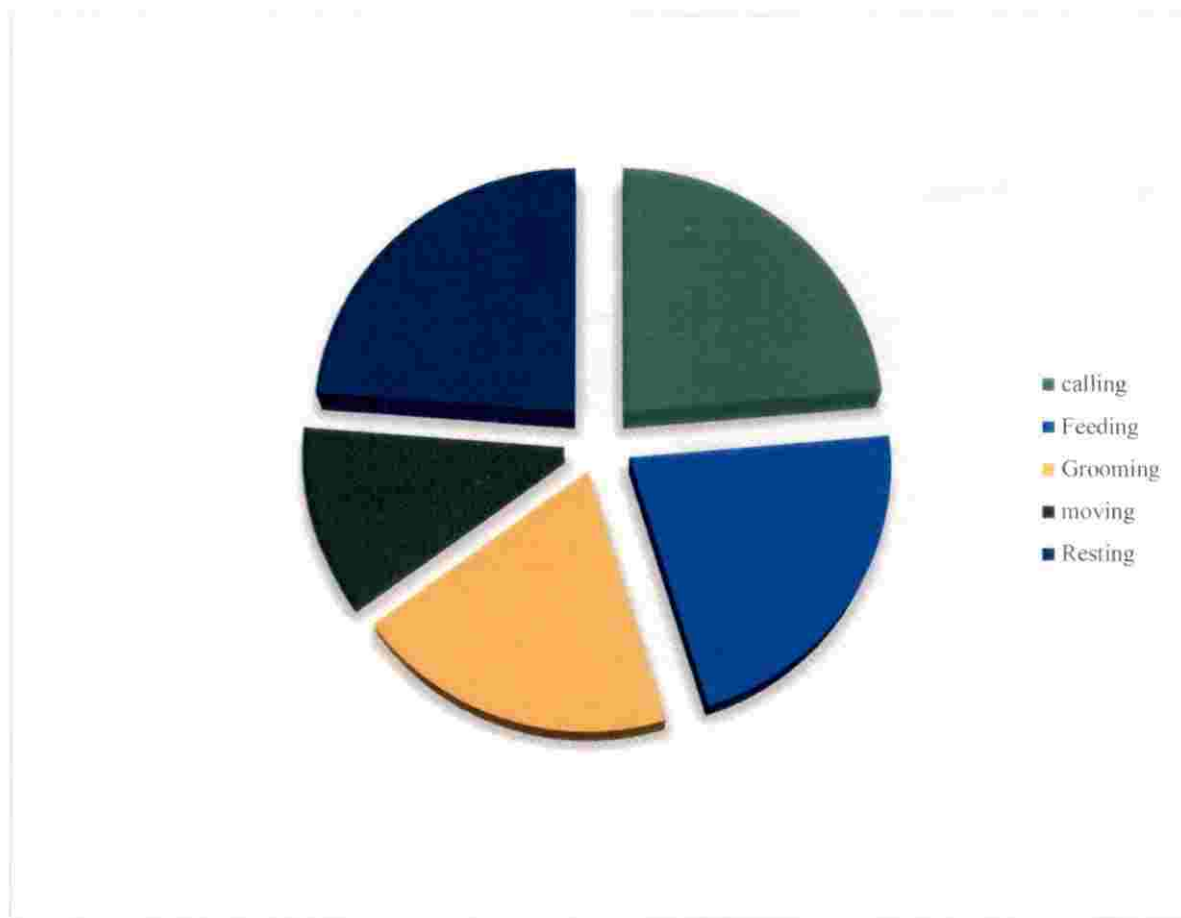


Figure 32. The percentage frequency of activities by the Himalayan Grey Langur

Thus, the Himalayan grey spent maximum time in feeding followed by resting, grooming and calling.

Average height of various activities performed by the Himalayan Grey Langur

The average height of various activities performed by the Himalayan Grey Langur was calculated. The average height was calculated based on the height at which the animal performed a particular social activity. During the study period, the overall average height was found out to be 4.9 m. The average maximum height was observed in case of resting (5.96 m), followed by calling (5.92 m), feeding (5.4 m), grooming (4.91 m) and moving (2.86 m) (Figure 33).

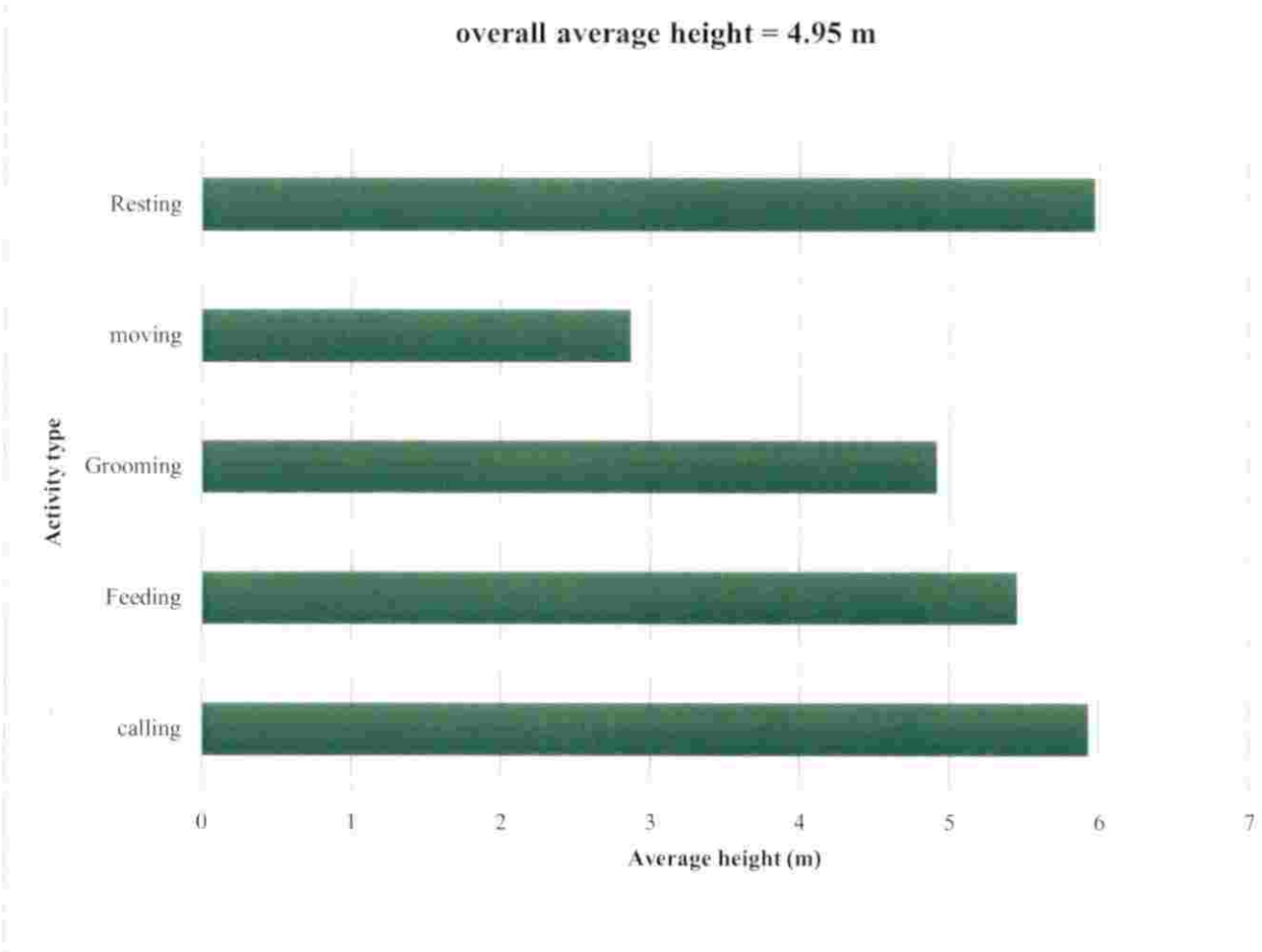


Figure 33. the average height of various activities performed by the Himalayan Grey Langur at Dachigam National Park

Thus, during the study period, the Himalayan Grey Langur rested at maximum height while moved at the lowest height.

Social organization of the Himalayan Grey Langur

During the study period, the social organization was observed in the Himalayan Grey Langur using instantaneous scan sampling technique. During the study period, two types of social groups were observed at Dachigam National Park *viz.*, multi-male multi-female or bisexual troop and the all-male troop. The bisexual troops comprised of many individuals of adult, sub-adult and juvenile of both the sexes. The male all-band comprised very less number of individuals and during this study, as much as two individuals were seen in such troops. The multi-male multi-female troops were much organized having proper and strong association than the all-male band. There was prominent hierarchy observed among the bisexual troop, which was clearly missing, in the all-male troop. The males of all ages were present in the bisexual troop. Usually an alpha adult male would lead the troop. The leader is chosen by defeating its opponents. During the study period, it was observed that when other strong male individual defeated the leader alpha male the later either joined the all-male troop or became solitary.

1. *Grooming*

During the study period, the animal spent considerable time in grooming activities in both the seasons. During the study period, the Himalayan Grey Langur allotted 14.77 percent of the time budget activity to the grooming. The grooming behavior of the animal consisted both auto – grooming / self – grooming (Plate 6A) as well as allogrooming (Plate 6B). During the study period, the allo – grooming was observed between female-female, female – male, adult individual groomed by sub – adult individual. In general, a high ranked individual was groomed by low ranked individual.

2. *Feeding*

During the study period, the Himalayan Grey Langur spent maximum time on feeding. The feeding behavior was observed when the animal made first contact with any of the food article.

Feeding session was considered terminated when the focal animal either stopped feeding or moved away from the feeding item. The related activities such as soil licking, licking the building walls (Plate 7A.) and drinking (Plate 7B.) were included as the feeding sessions. During the study period, the animal spent as much as 40.91 percent of time budget activity in feeding.

3. *Moving*

The moving behavior included all locomotion activities such as running, leaping and jumping from the arboreal support, walking and climbing. During the study period, the Himalayan Grey Langur spent 20.83 percent of time budget activity on moving.

4. *Communication*

The alpha individual of the troop by the call “Whoops” started the daily routine of activities for the Himalayan Grey Langur troop. The communication system and calling behavior was well developed among the troops of Himalayan Grey Langur at Dachigam National Park. During the study period, the Himalayan Grey Langur spent 7.7 percent of the total time budget activity on calling. During the study period, three types of calls were observed through which the Himalayan Grey Langur communicate with each other *viz.*, connecting call, breeding call and danger call. The connecting call was used when the troop members moved from one place to another so that no individual is left behind the troop. The adult individuals of the opposite sex to woo each other for breeding activities mostly used breeding call. The danger call was used to send a sense of invasion or danger across the troop.

4.2.1 SEASONAL VARIATION IN TIME ACTIVITY BUDGETING OF THE HIMALAYAN GREY LANGUR ACROSS DIFFERENT SEASONS

The seasonal variation in the time budgeting activity was calculated across different seasons *viz.*, summer season (May – October) and winter season (November – April). The percentage duration, mean duration and percentage frequency of various activities across these two seasons were observed and used for seasonal comparison.



Plate. 6A. an adult female self – grooming with infants in the laps at Dachigam National Park



Plate. 6B. allogrooming between adult and juvenile female at Dachigam National Park

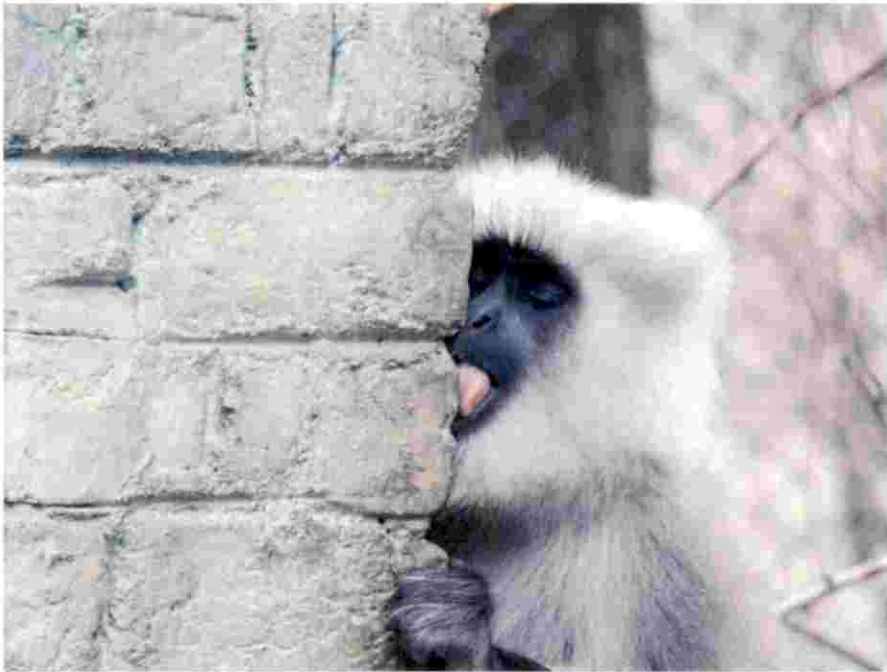


Plate.7A the Himalayan grey licking the gate wall at Dachigam National Park

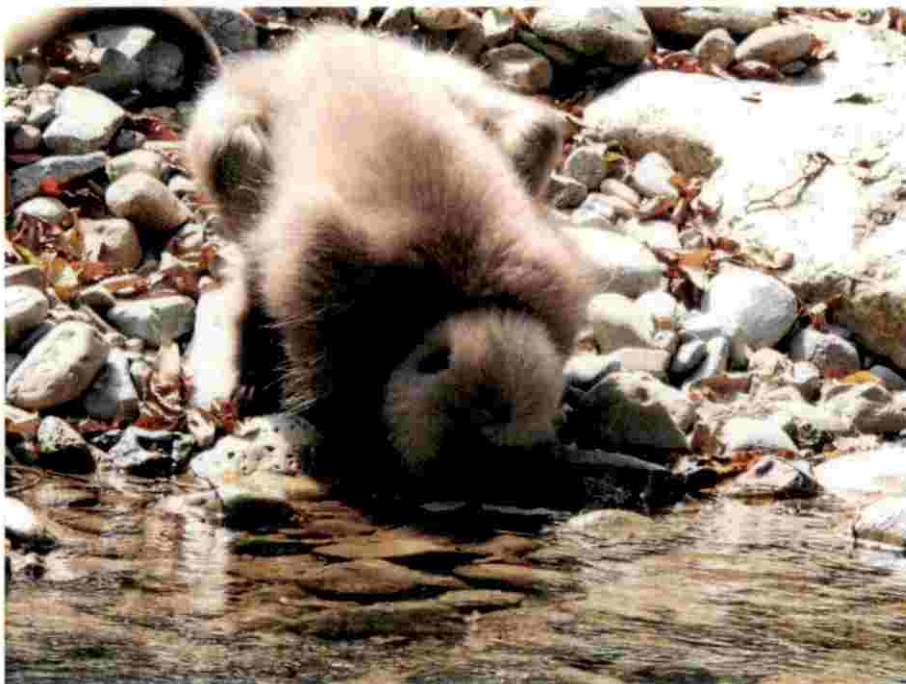


Plate 7B. The Himalayan Grey Langur drinking water from Dachigam nallah at Dachigam National Park

Percentage duration of various activities of the Himalayan Grey Langur across different seasons

The percentage duration of activities performed by the Himalayan Grey Langur was calculated separately across the two seasons.

4.2.1 TIME BUDGET ACTIVITY DURING SUMMER SEASON

Percentage duration of time budget activities during the summer season

During the summer season (May – October), the activity budgeting had observations for duration of 1770 minutes. The main activity performed by the Himalayan Grey Langur was feeding (43.67 %), followed by moving (21.53 %), resting (18.98 %), grooming (14.69 %) while as calling during summer season accounted only for 1.13 percent (Figure 34).

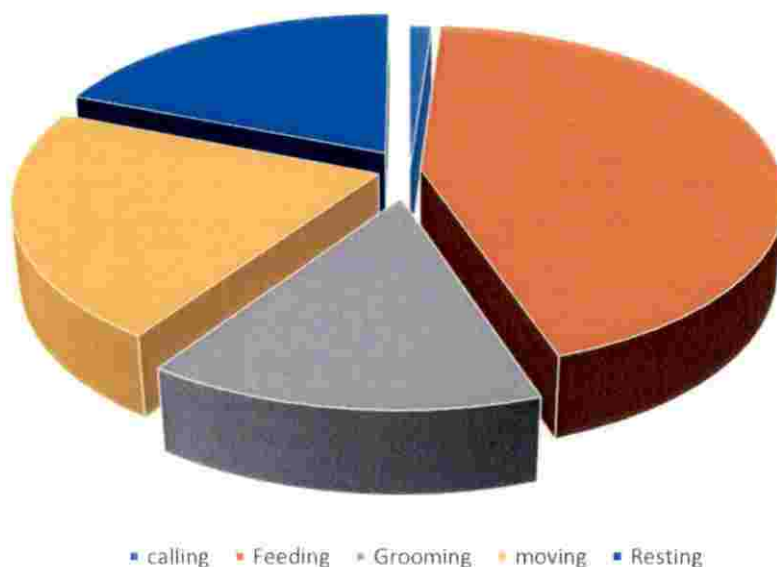


Figure 34. The percentage duration of time spent by Himalayan Grey Langur on various activities during the summer season

Percentage frequency of various event during the summer season

During the summer season, a total of 163 incidences of various activities were observed. During the summer season, the percentage frequency of various events was calculated based on the number of times the animal performed a particular activity. During the summer season, the

percentage frequency of feeding was highest (42.33 %), followed by moving (23.93 %), resting (17.18 %), grooming (15.34 %), while as calling accounted only 1.23 percent (Figure 35).

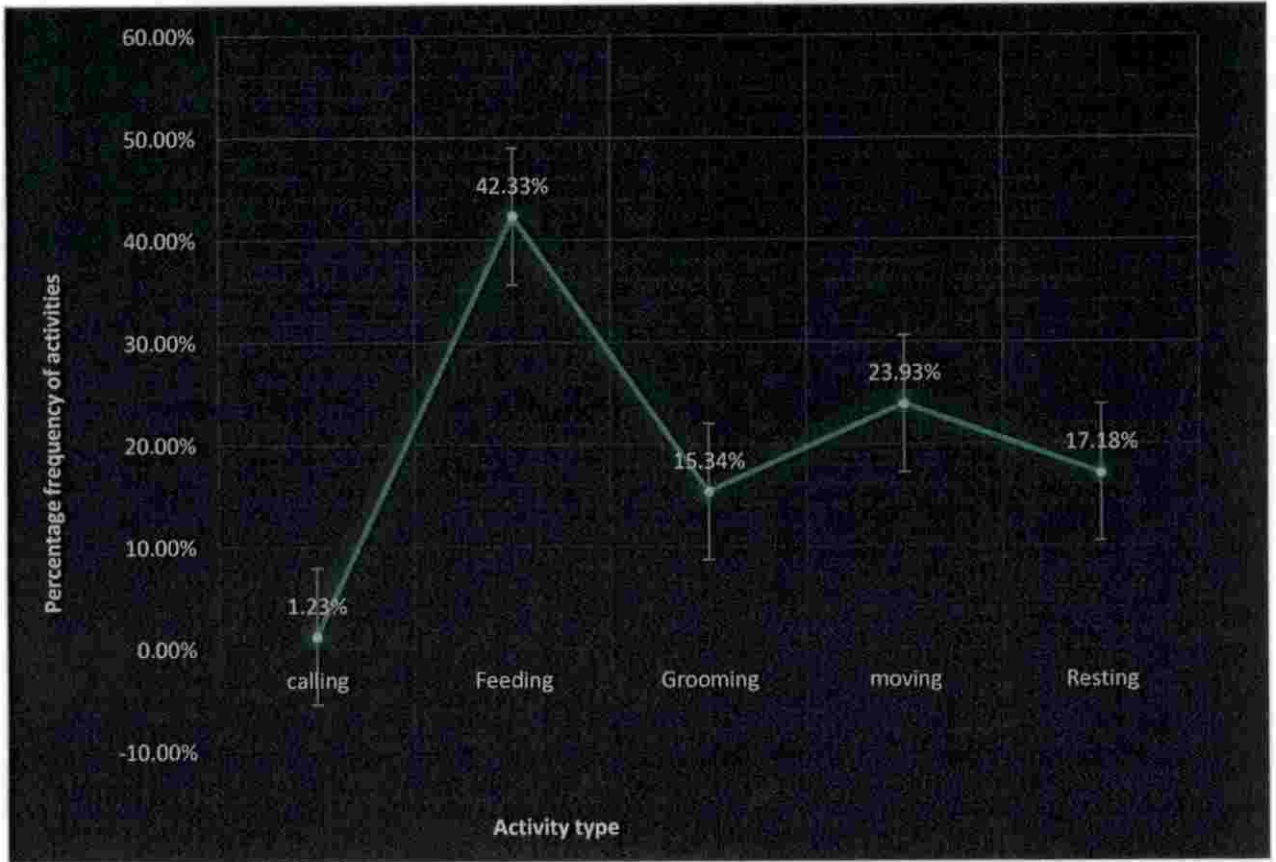


Figure 35. The percentage frequency of various activities of Himalayan Grey Langur during the summer season

The average height of various activities during the summer season

During the summer season, the Himalayan Grey Langur performed various activities at different heights of trees. The average height of each activity performed during the summer season was calculated based on the height at which a particular activity was executed. The overall average

height of various activities during the summer season was observed to be 4.94 m. The average height was observed to be maximum in case of calling (7.5 m), followed by resting (7.3 m), grooming (4.9 m), feeding (4.7 m) and moving (3.3 m) (Figure 36).

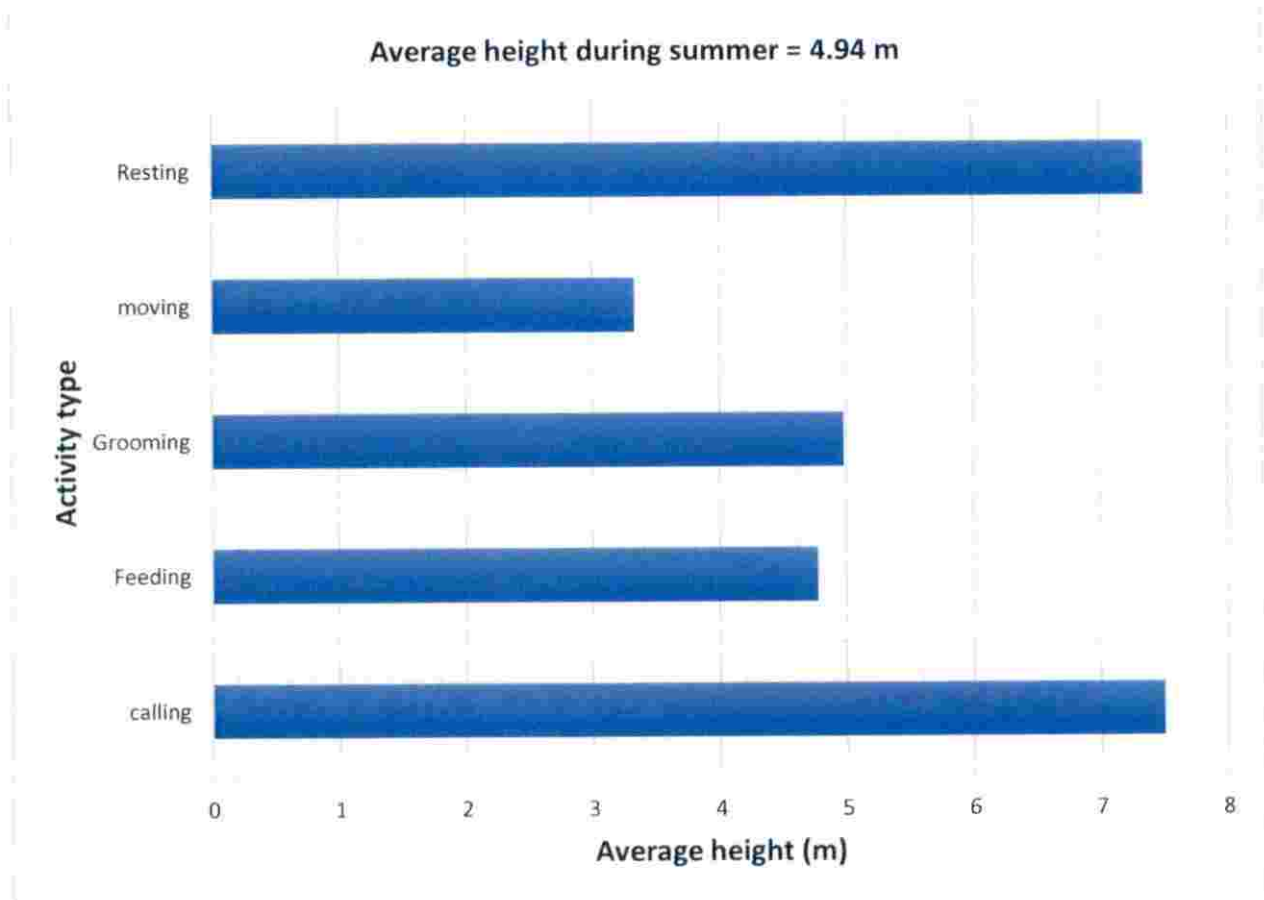


Figure 36. the average height of various activities performed by the Himalayan Grey Langur during the summer season

Mean duration of activities of the Himalayan Grey Langur during the summer season

During the summer season, the mean duration was calculated by dividing the total duration of a particular activity by the number of occurrence of that activity. During the summer season,

the maximum mean duration of time was observed in case of feeding (30.92 minutes), followed by resting (12 minutes), grooming (10.4 minutes), calling (10 minutes) and moving (9.6 minutes) (Table 5).

Table 5. The mean duration of various activities performed by the Himalayan Grey Langur during the summer season

Sl. No	Activity	Total time duration (minutes)	Frequency of occurrence	Mean duration (minutes)
1.	Feeding	773	69	30.92
2.	Moving	381	39	9.6
3.	Resting	336	28	12
4.	Grooming	260	25	10.4
5.	calling	20	2	10

Thus, during the summer season, the duration for moving was more than that of calling (Figure 37).

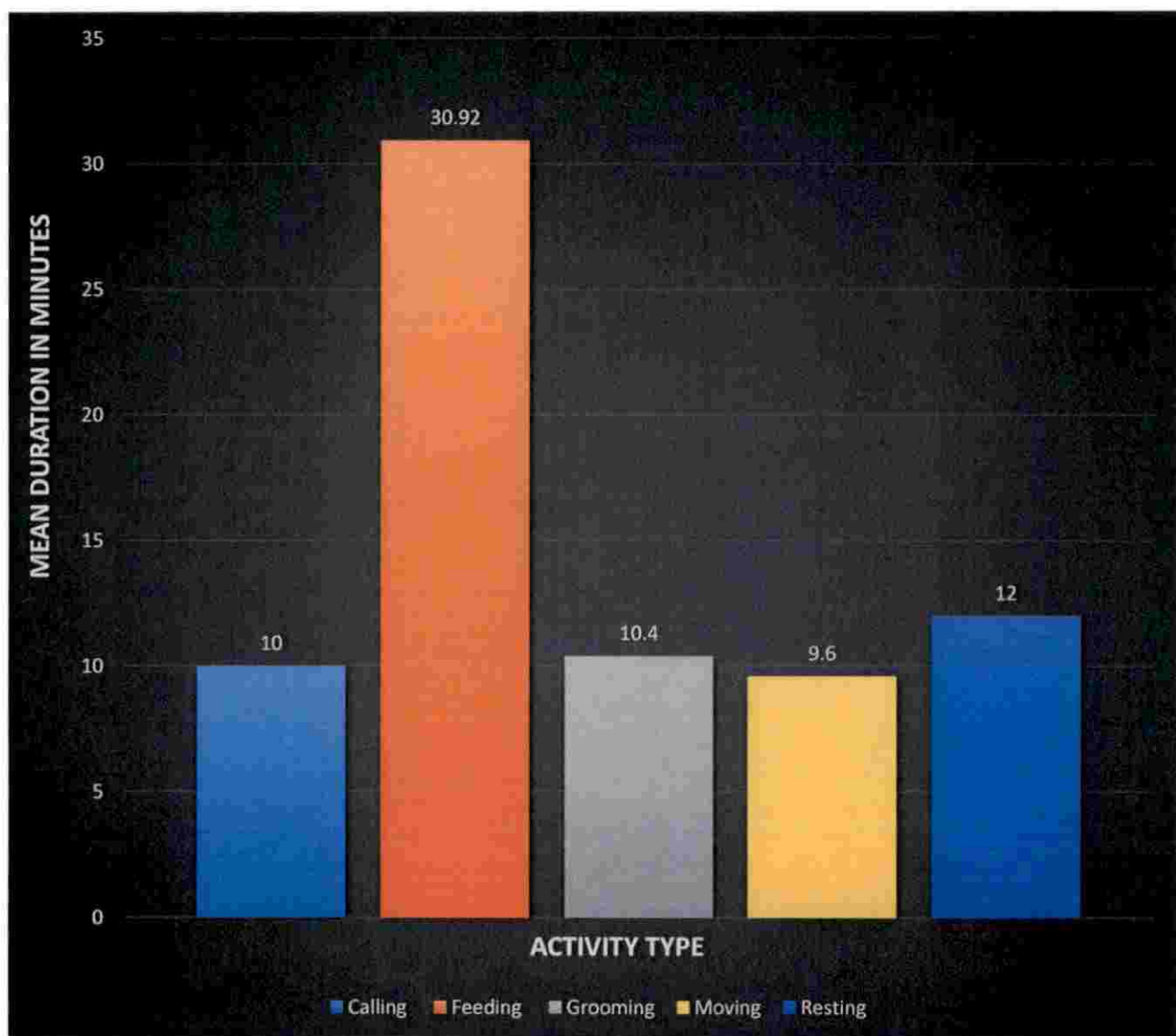


Figure 37. The mean duration of activities performed by the Himalayan Grey Langur during the summer season

4.2.2 TIME BUDGET ACTIVITY DURING WINTER SEASON

Percentage of time budget activity of the Himalayan Grey Langur during the winter season

During the winter season, a total of 3650 minutes of observation were recorded for various activities performed by the Himalayan Grey Langur. The main activities performed by the Himalayan Grey Langur during the winter season includes feeding (40.27 %), moving (19.45 %), resting (15.07 %), grooming (14.52 %) and calling (10.68 %) (Figure 38).

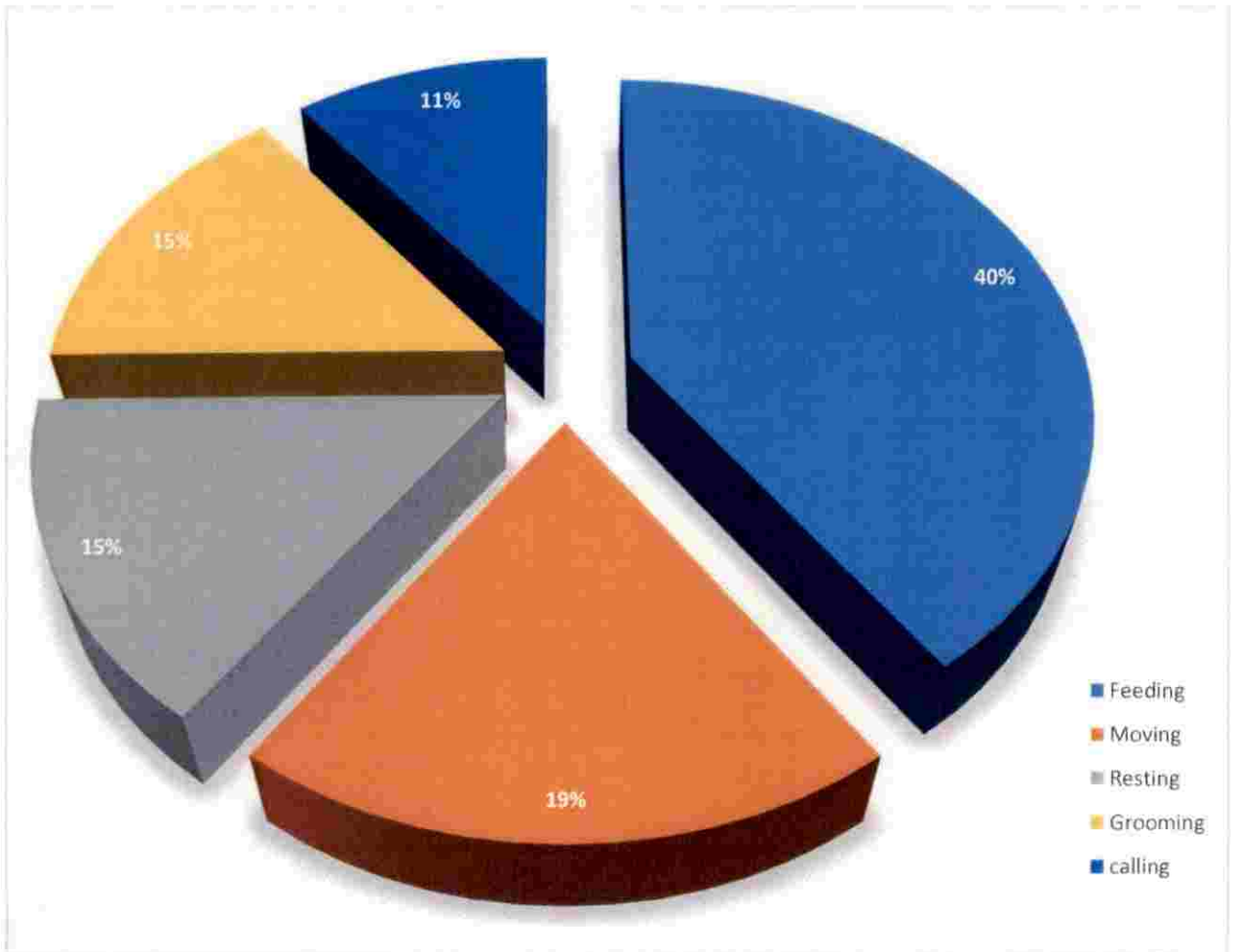


Figure 38. The percentage time budget activity of Himalayan Grey Langur during the winter season

Thus, during the winter season, the main activity performed by the Himalayan Grey Langur was feeding followed by moving and resting.

The frequency of various activities performed by the Himalayan Grey Langur during the winter season

During the winter season (October – April), a total of 365 incidences of various activities were recorded. Out of 365 incidences, there were 147 incidences of feeding, 71 incidences of moving, 55 incidences of resting, 53 incidences of grooming, 39 incidences of calling (Figure 39). Thus, during the winter season, the preferred activity of the Himalayan Grey Langur was feeding followed by resting, grooming and calling.

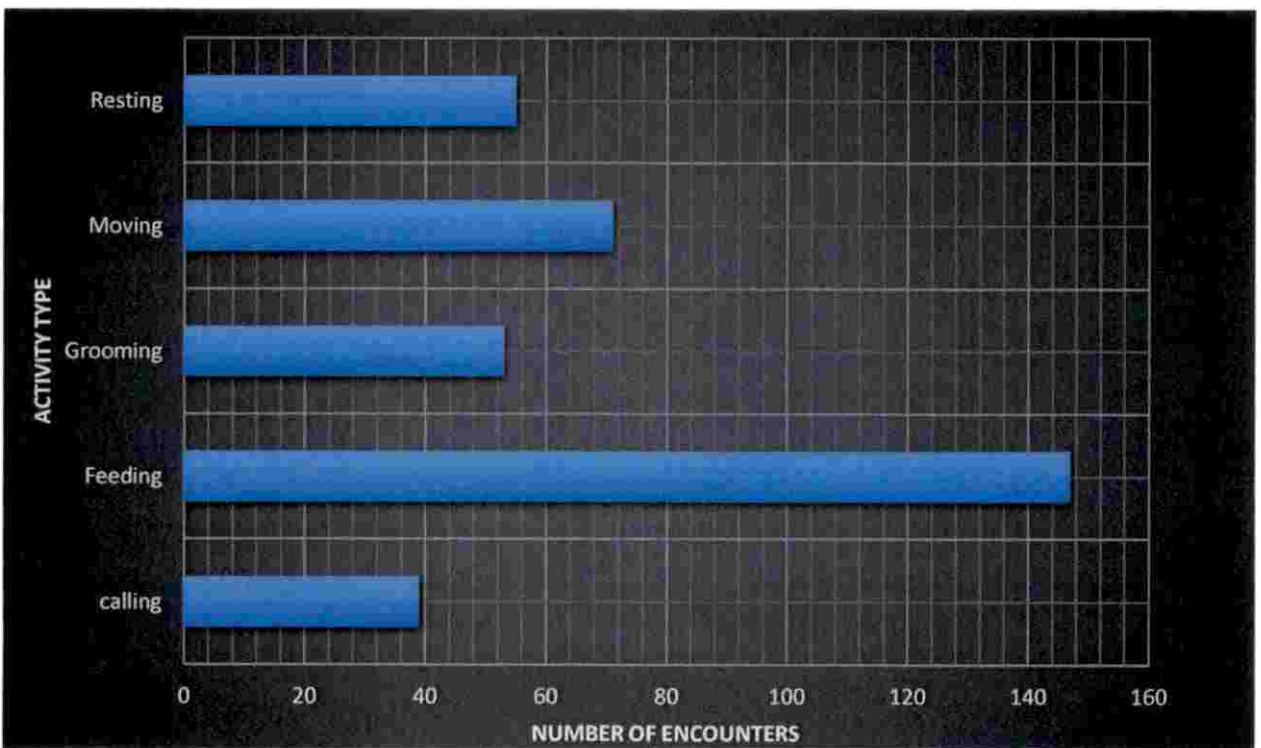


Figure 39. The frequency of various activities by Himalayan Grey Langur during the winter season at Dachigam National Park

Mean duration of activities performed by the Himalayan Grey Langur during the winter season

During the winter season, the mean duration was calculated by dividing the total duration of a particular activity by the number of occurrence of that activity. During the winter season, the mean duration for all activities came to be the same (Table 7).

Table 6. The mean duration of activities of the Himalayan Grey Langur during the winter season at Dachigam National Park

Sl. No	Activity	Total duration of event (minutes)	Frequency of event	Mean duration (minutes)
1.	Calling	390	39	10
2.	Feeding	1470	147	10
3.	Grooming	530	53	10
4.	Moving	710	71	10
5.	Resting	550	55	10

The average height of various activities during the winter season

During the winter season, the Himalayan Grey Langur performed different activities at different heights of trees. The average height of the various activities was calculated based on the height at which a particular activity was performed. The overall average height during the winter

season was observed to be 4.96 m. The maximum average height was observed in case of calling (5.84 m), followed by feeding (5.76 m), resting (5.27 m), grooming (4.88 m) and moving (2.61 m) (Figure 40).

4.2.3 COMPARISON OF TIME BUDGET ACTIVITY OF HIMALAYAN GREY LANGUR ACROSS DIFFERENT SEASONS

Percentage duration of activities of the Himalayan Grey Langur across different seasons

In both the seasons, summer as well as winter the percentage duration of feeding was more compared to other activities. During the summer season, the percentage duration of feeding was observed to be 43.67 percent (Table. 8), while as in winter feeding duration was slightly less comprising of 40.27 percent. The more feeding duration time during the summer season can be attributed to the easy availability of food while as in winter season food resources are somewhat scarce. During the summer season, the Himalayan Grey Langur was observed frequently moving (21.53 %) while as during winter season, moving contributed only 19.45 percent of the total

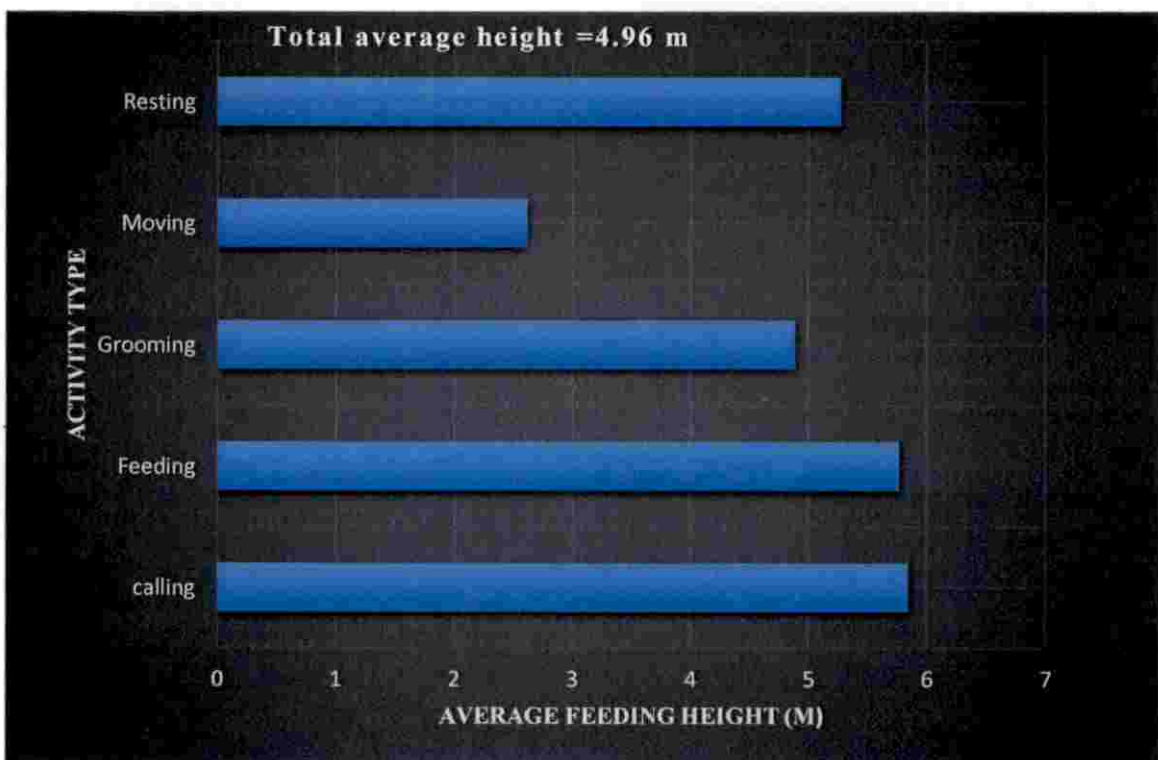


Figure 40. the average height of various activities performed by the Himalayan Grey Langur during winter season

percentage of time budget activity. In the summer season, more time was attributed to resting than the winter season and contributed 18.98 percent during the summer season and 15.07 percent during the winter season. In case of grooming almost same time duration was attributed in summer (14.69 %) as well as winter (14.52 %). In case of calling a significant difference was observed and was more in winter season than the summer season. In the summer season, calling contributed 1.13 percent of total time budget activity while in the winter season, calling activity was as much as 10.58 percent of the total time duration (Figure 41).

Table 7. The percentage duration of time budget activity of the Himalayan Grey Langur across the different seasons

Sl. No	Season	Percentage duration of activity				
		Feeding	Moving	Resting	Grooming	Calling
1.	Summer	43.67	21.53	18.98	14.69	1.13
2.	Winter	40.27	19.45	15.07	14.52	10.53

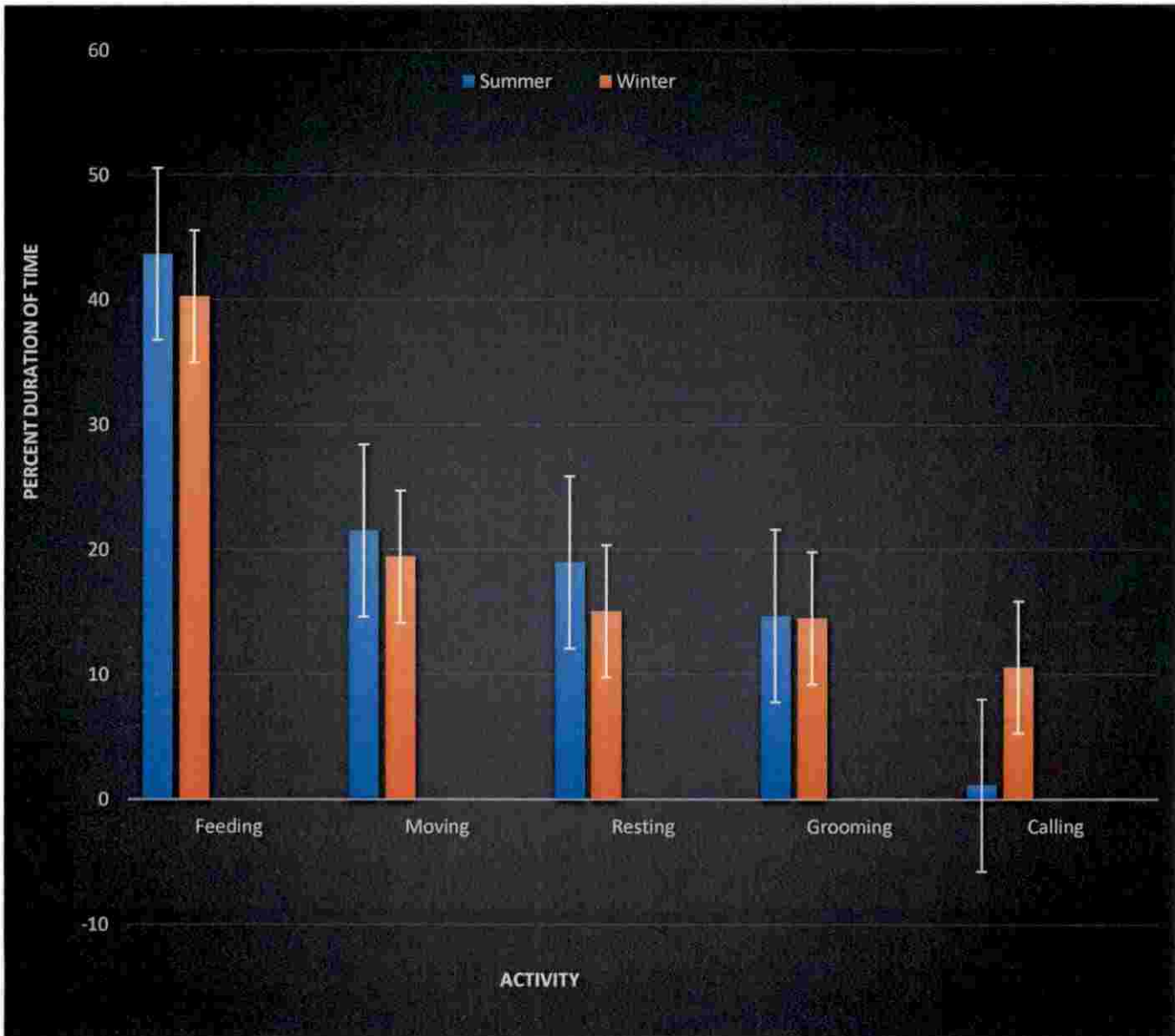


Figure 41. The percentage duration of time budget activities by Himalayan Grey Langur across different seasons

Percentage frequency of activities of the Himalayan Grey Langur across different seasons

The percentage frequency occurrence of various activities across the seasons was analyzed and it was observed that the percentage frequency was maximum in both the summer as well as winter (Table 8).

Table 8. The percentage frequency of activities performed by the Himalayan Grey Langur at Dachigam National Park across the different seasons

Sl. No	Season	Percentage frequency of activities				
		Feeding	Moving	Resting	Grooming	Calling
1	Summer	42.33	23.93	17.18	15.34	1.23
2	Winter	40.27	19.45	15.07	14.52	10.68

The percentage frequency of moving was more during the summer season (23.93 %) than the winter season (19.45 %). The animal rested more during the summer season (17.18 %) than the winter season (15.07 %). The percentage frequency of occurrence of calling activity was more during the winter season (10.68 %) as compared to the summer season (1.23 %) (Figure. 42).

The average height of various activities performed by the Himalayan Grey Langur across different seasons

The average height of various activities across the different seasons was analyzed and it was observed that the average height was maximum for calling during the summer season (7.5 m) as well as winter season (5.8 m), (Fig. 43). The average height was more during the winter season

(5.7 m) as compared that of the summer (4.7 m). The average moving height was comparatively less than other activities owing to the fact that the animal also moved along the ground. During

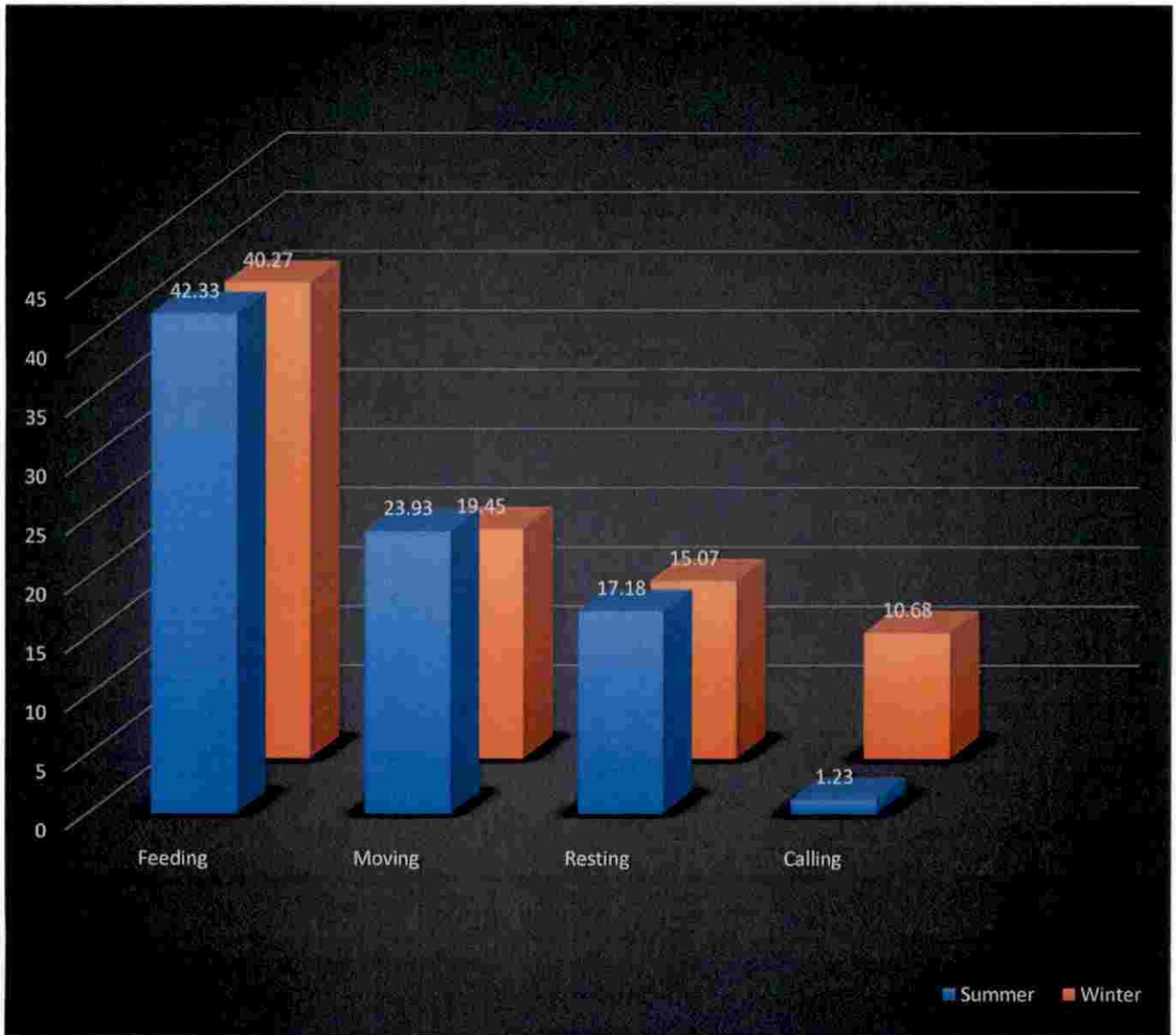


Figure 42. The percentage frequency of activities by the Himalayan Grey Langur across the different seasons

the summer season, the animal rested much higher than winter season (Figure 43).

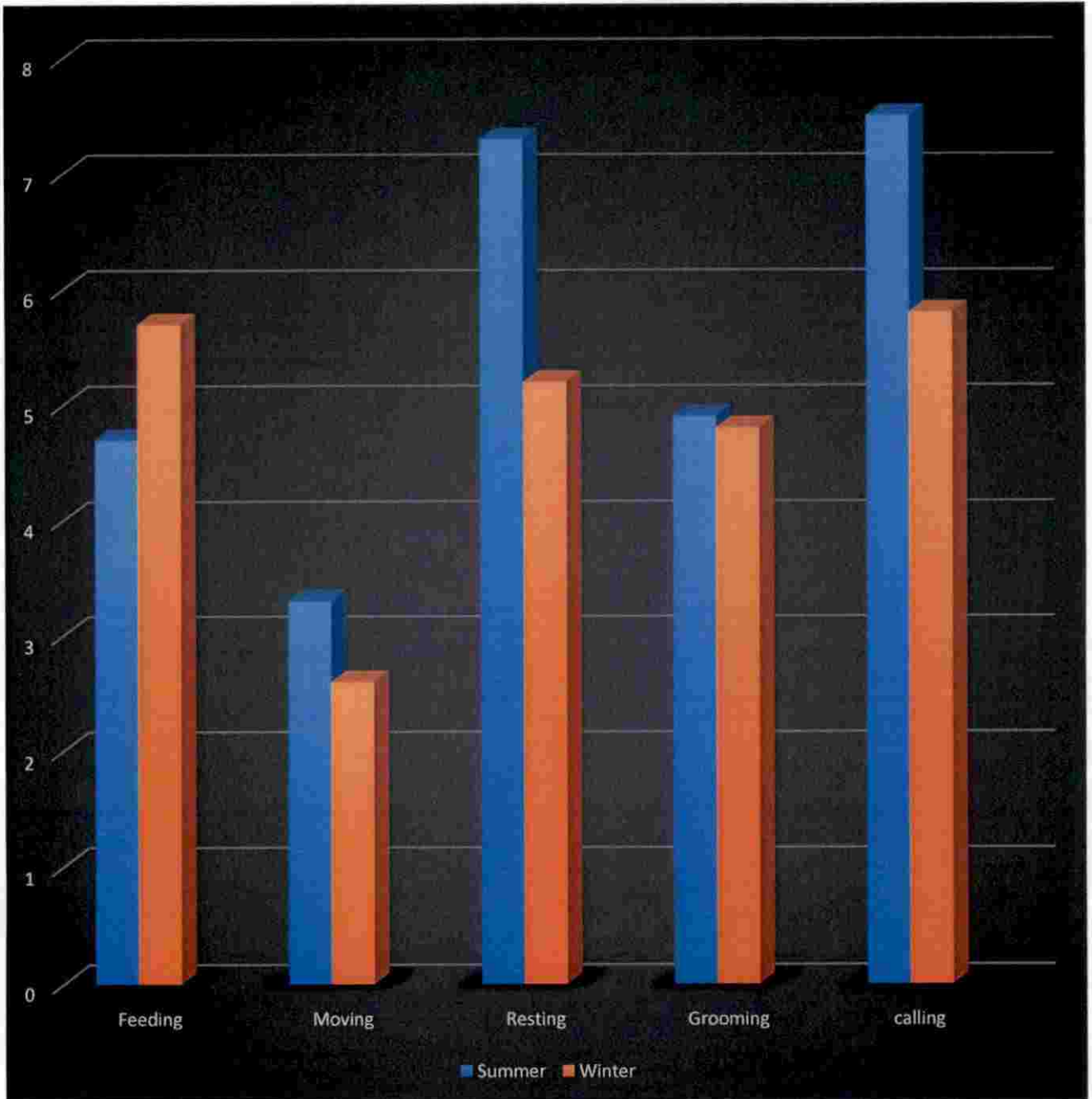


Figure 43. The average height of feeding by Himalayan Grey Langur across different seasons

4.4 POPULATION DISTRIBUTION AND POPULATION DENSITY OF HIMALAYAN GREY LANGUR

The population estimation was carried out using the Line Transect sampling method. The population estimation was carried out in two seasons *viz.*, the summer season and the winter season. A total of 77 transects were taken during the whole study period. The overall density of the Himalayan Grey Langur was observed to be 2926 per Km² with cluster density of 500.

Table 9. The population density of the Himalayan Grey Langur at Dachigam National park

Estimate		% CV	df	Interval
Ds	500	5.7	76	560.03
D	2629	12	75.4	3713.5
N	0.41263E+06	12	75.4	0.52360E+06

The detection probability was found to be 22.5 with the cluster size of 77.5.

Table 10. The detection probability and cluster size of the Himalayan Grey Langur at Dachigam National Park

Estimate		%CV	df	95 % confidence	interval
Average cluster size	5.8529	10.56	48.00	4.7357	7.2335
r	0.000		48.00		
r - p	0.50000				
E(s)	5.8529	10.56		4.7357	7.2335

Population distribution of the Himalayan Grey Langur

The entire population of the Himalayan Grey Langur was found in the habitats such as the mixed coniferous, broadleaved deciduous and riverine forest type. The Himalayan grey usually avoided the scrub and grassland area (Figure.44). There were 51 sightings of the Himalayan Grey Langur. Out of 51 sightings 38 were made in broadleaved forest, six each in mixed coniferous and riverine forest while single sighting was recorded in coniferous forest type.

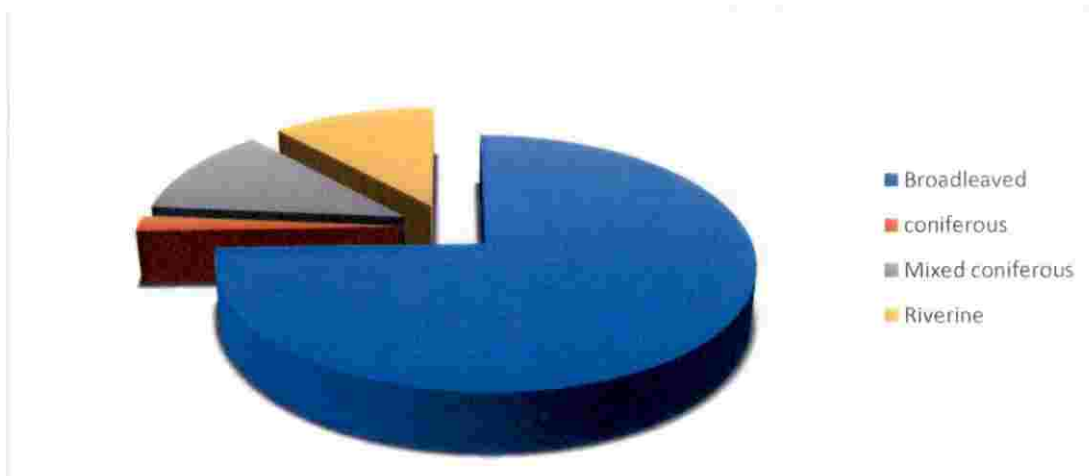


Figure 44. The sighting of Himalayan Grey Langur in various habitats of Dachigam National Park

The Himalayan grey used the riverine and broadleaved habitats across all seasons of the year. During the winter season, the Himalayan Grey Langur used the valleys with flat areas protecting the Himalayan Grey Langur from the extreme cold and snow and provide a better shelter during the harsh conditions. Besides the valley areas being very luxirant in vegetation provide food during this pinch period. The Himalayan grey was found in habitats with the elevations from 1,600 m to 3,000 m altitude.

Home range of the Himalayan Grey Langur

The current study revealed the home range of all male band was comparatively more than that of bisexual troop or multi – male multi – female troop. The all male band used extensive areas and their home range varies from 2.5 Km² to 5 Km². The home range of bisexual troop ranged between 2 Km² to 5 Km².

4.5 VEGETATTION ANALYSIS OF THE HABITAT OF THE HIMALAYAN GREY LANGUR

During the study period, a total 70 quadrants having area of 100 m² were sampled for the study of the Himalayan Grey Langur habitat. The parameters such as girth at breast height (GBH) and height of tree species with GBH more than 10 cm were measured. A total of 26 species belonging to 16 different families were observed from the 70 quadrants sampled during the study period. A total of 842 individuals were observed in 70 sampling plots with a total basal area of 335. 7422 m².

4.5.1 RELATIVE DENSITY AND ABUNDANCE OF TREE SPECIES AT DACHIGAM NATIONAL PARK

The species such as *Pinus wallichiana*, *Paratiopsis jacquemontiana*, *Quercus robur*, *Morus alba*, *Robina pseudoacacia*, *Celtis australis* and *Ulmus wallichiana* were most abundant tree species at the Dachigam National Park (Table 11).

Table 11. The relative density and abundance of tree species in Dachigam National Park

S. No	Plant species	Family	Relative Density	Total number of trees
1.	<i>Pinus wallichiana</i>	Pinaceae	16.50	139
2.	<i>Paratiopsis jacquimontiana</i>	Hamamelidaceae	16.38	138
3.	<i>Quercus robur</i>	Fagaceae	9.02	76
4.	<i>Morus alba</i>	Moraceae	7	59
5.	<i>Robinia pseudoacacia</i>	Fabaceae	7	59
6.	<i>Celtis australis</i>	Cannabaceae	6.29	53
7.	<i>Ulmus wallichiana</i>	Ulmaceae	6.29	53
8.	<i>Celtis caucasica</i>	Cannabaceae	4.75	40
9.	<i>Prunus armeniaca</i>	Rosaceae	4.75	40
10.	<i>Salix alba</i>	Salicaceae	3.44	29
11.	<i>Prunus ceracifera</i>	Rosaceae	2.49	21
12.	<i>Juglnas regia</i>	Juglandaceae	2	16
13.	<i>Ulmus villosa</i>	Ulmaceae	1.78	15
14.	<i>Aesculus indica</i>	Sapindaceae	1.42	12
15.	<i>Prunus persica</i>	Rosaceae	1.42	12
16.	<i>Acer caesium</i>	Sapindaceae	1.30	11
17.	<i>Alianthus altissima</i>	Simaroubaceae	1.30	11

18.	<i>Juglans nigra</i>	Juglandaceae	1.30	11
19.	<i>Rhus succedanae</i>	Anacardiaceae	1.30	11
20.	<i>Populus deltoides</i>	Salicaceae	1.18	10
21.	<i>Populus cillita</i>	Salicaceae	0.95	8
22.	<i>Fraxinus floribunda</i>	Oleaceae	0.71	6
23.	<i>Rosa webbiana</i>	Rosaceae	0.47	4
24.	<i>Taxus wallichiana</i>	Taxaceae	0.47	4
25.	<i>Betula utilis</i>	Betulaceae	0.23	2
26.	<i>Morus nigra</i>	Moraceae	0.23	2
Total				842

The whole of the area of Dachigam National Park falls within the Dachigam range. The vegetation of Dachigam National Park is very patchy with one forest type on the one and other forest type on the other side in strips. In Dachigam National Park, the pine forests the pine forest are common and grow on wide range on the slopes along the north and north and north – eastern aspects. The *Pinus wallichiana* is the most dominant conifer in the pine forests. The *Pinus wallichiana* on some occasions reaches upto the scrub and grassland areas and form patches. There is very little undergrowth observed in the lower areas of Dachigam National Park in case of *Pinus wallichiana*. In lower and upper areas of Dachigam National Park, the *Pinus wallichiana* was observed to be found in association of many broadleaved and shrubs which include *Paratiopsis jacquemontiana*, *Rosa webbiana*, *Prunus ceracifera*, *Berberis lyceum*, and *Rhus succedane*. The relative dominance of *Pinus wallichiana* was found to be 16.50 with total of 139 individuals sampled. The *Pinus wallichiana* was found to be distributed through the altitudinal range of 1,600 m – 3,000 m.

Oak patches

During the study period, seven oak patches were observed of which two were bigger area while rest five were too small (Plate) The oak were observed to be main feeding item for the Himalayan Grey Langur and contributed 4.77 percent of the feeding items during the study period. Besides oaks are important food for the critically endangered *Cervus hanglu hanglu* and Asiatic Black Bear. The total area of oak plantations at Dachigam National Park is near about 2 Km² with largest patch comprising of 500 m². The *Quercus robur* (English oak) which is exotic to Kashmir is the dominant tree species in the oak patches. The relative density of the *Quercus robur* was observed to be 9.02 with 76 individual trees sampled.

In Dachigam National Park, there are vast stretches of open lands on the slopes facing the South – west lying between the altitudes of 1,650 m – 2,600 m. These vast areas comprise of sparse vegetation of both broadleaved as well as patches of *Pinus wallichiana* with some xerophytic undergrowth. The dominant trees and shrubs of the scrub and grasslands are *Paratiopsis jacquemontiana*, *Prunus armenica* and *Celtis australis*. The scrub and grasslands contain luxuriant vegetation and is very important for the survival of most of the animal species present in the Dachigam National Park.

4.5.2 GIRTH CLASS DISTRIBUTION OF TREE SPECIES IN DACHIGAM NATIONAL PARK

The girth at breast height (GBH) of the all trees above the diameter of 10 cm within the sampled plots were enumerated and measurements were taken. *Ulmus wallichiana* has highest GBH with 465 cm followed by *Pinus wallichiana* 454 cm of GBH and *Aesculus indica* with 450 cm. The lowest GBH was recorded in case of *Juglans regia regia* with 10 cm GBH and *Celtis australis* with 11 cm GBH. The girth class distribution of all tree species recorded from the same plots were taken. Girth classes were taken at an interval of 10 cm. Girth class frequency distribution in Dachigam National Park shows that 12 percent of the individuals in the sampled plots belonged to the girth class of 10 cm – 20 cm indicating ample amount of regeneration in the Dachigam National Park (Figure 45).

174842

116

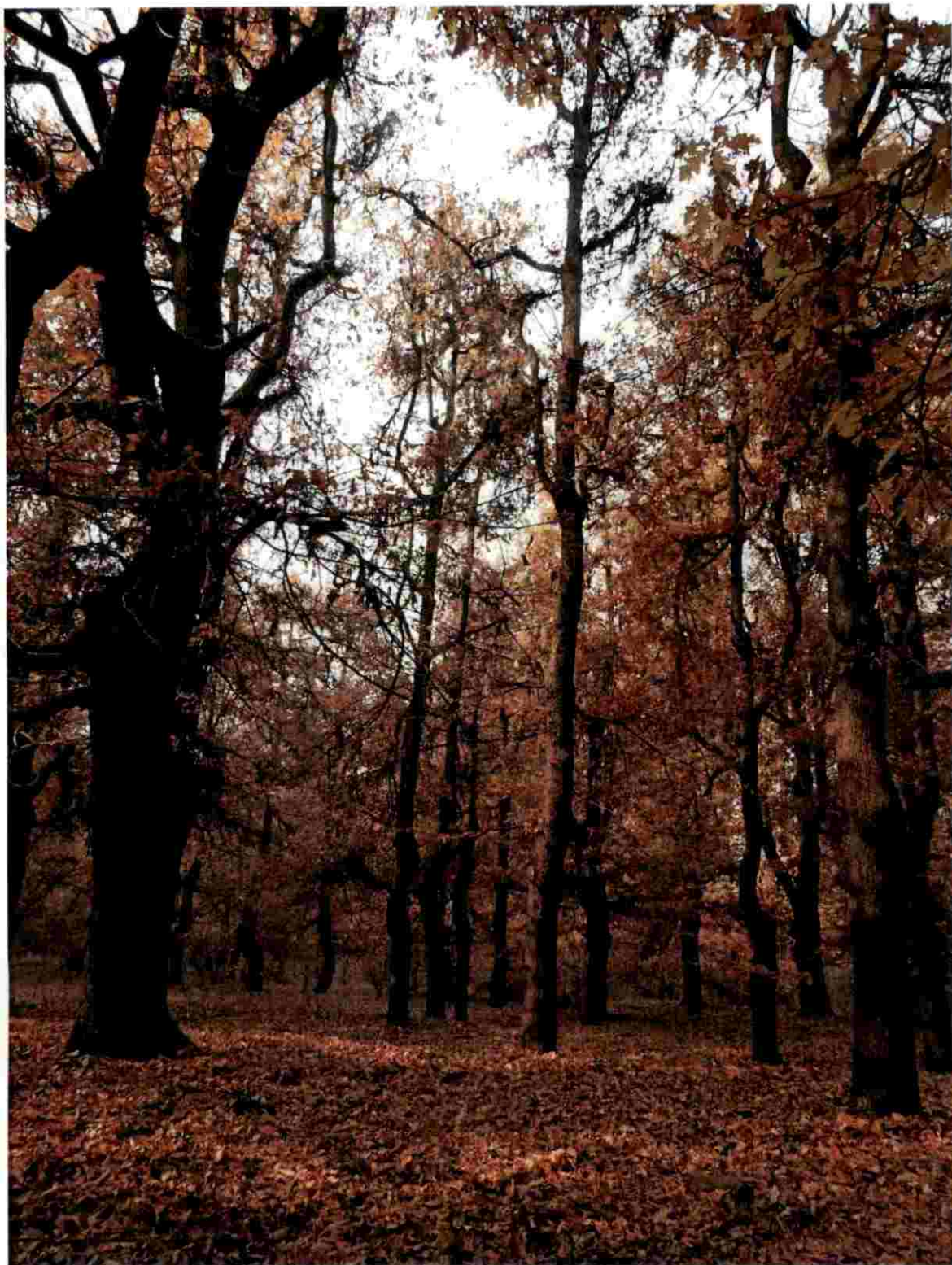


Plate 8. Oak Patch in Dachigam National Park



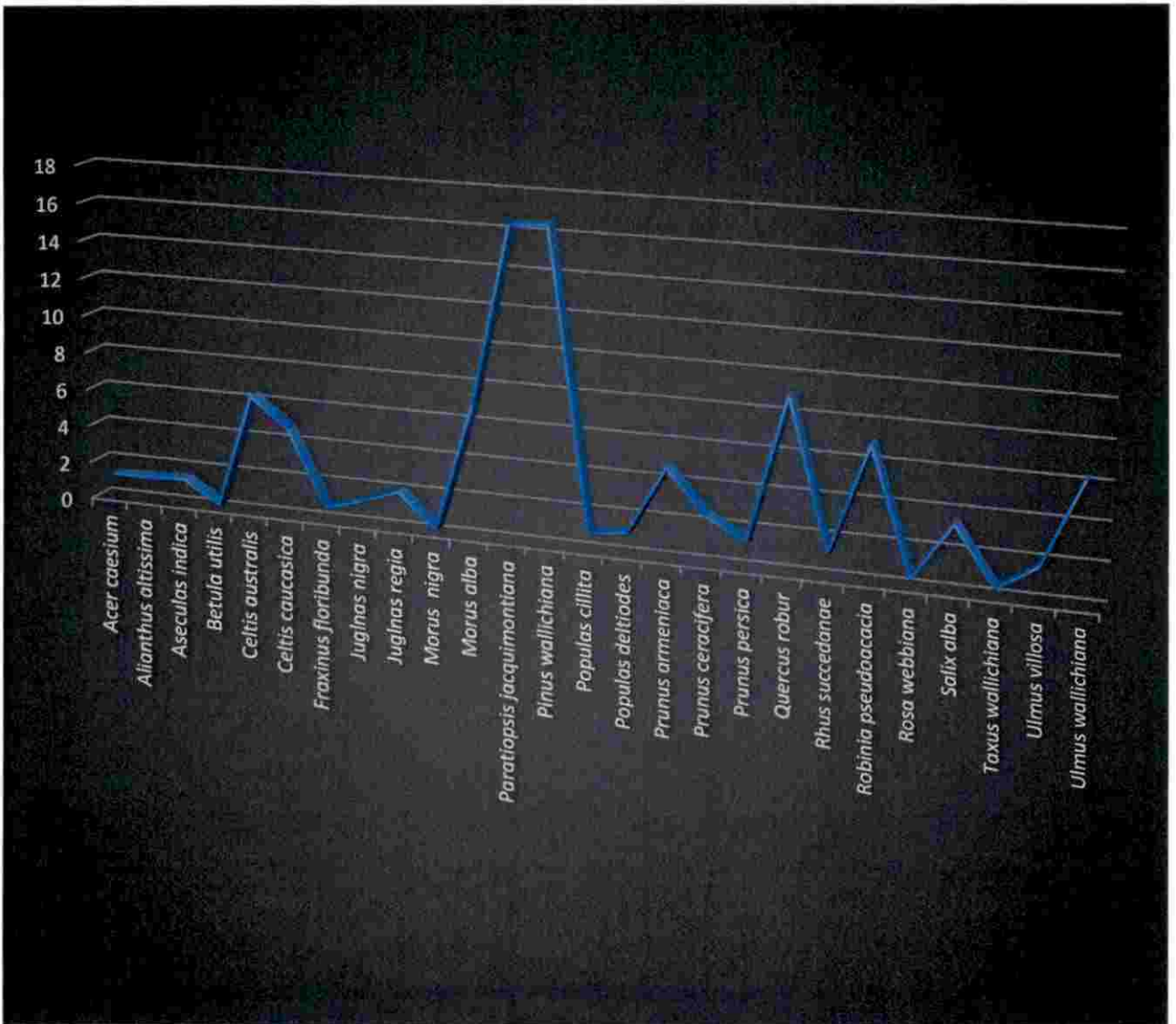


Figure 45. The relative percentage of trees species in Dachigam National Park

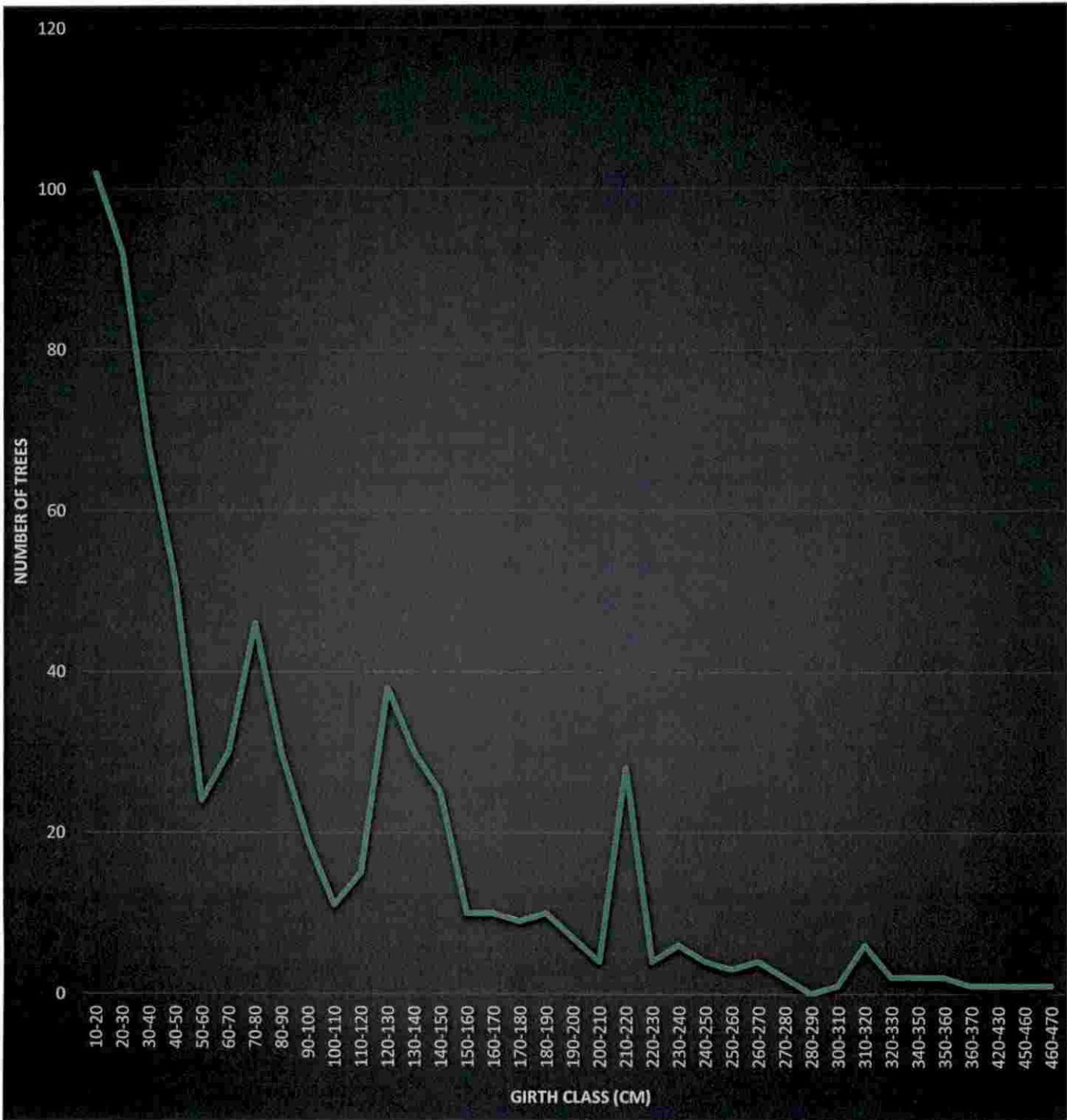


Figure 46. Girth class distribution of all tree species (above 10 cm GBH) in Dachigam National Park

The new young regeneration was observed across all vegetation types within the Dachigam National Park. The ample amount of regeneration was observed during the study period as is characterized by the larger percentage (12 %) of individual trees belonging to the girth classes below than 50 cm. The results of the study indicate that regeneration is extremely good and Dachigam National Park is in a healthy situation and does not face any acute challenge as of now.

Girth class distribution in Pine forest type

The *Pinus wallichiana* is the dominant conifer at Dachigam National Park with overall relative density of 16.05 %. Out of 139 sampled individual trees of *Pinus wallichiana* most of the trees belonged to the girth class of 140 cm – 150 cm with total of 10.79 % of the sampled trees belonging to this category. The regeneration of *Pinus wallichiana* was observed to be fairly low compared to overall regeneration of the study area. Only 9.35 % of the sampled trees belonged to the girth class less than 50 cm as against 12 % of overall sampled trees belonging to girth class less than 50 cm. The girth class distribution of *Pinus wallichiana* is shown in figure 47.

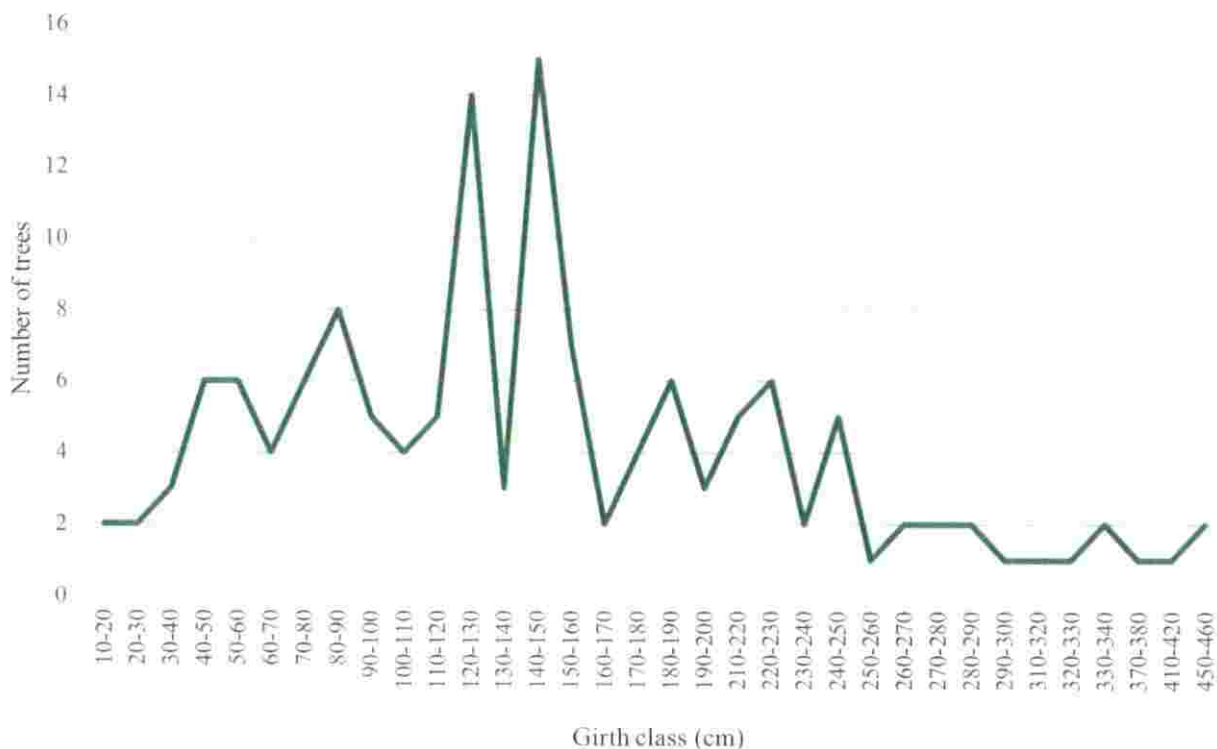


Figure 47. The girth class distribution of *Pinus wallichiana* at Dachigam National Park

Girth class distribution of Broadleaved deciduous forest

The girth at breast height (GBH) of all trees having diameter above 10 cm within the sampled plots were enumerated and measurements were taken. In the broadleaved deciduous forest *Aesculus indica* had highest GBH of 420 cm followed by *Ulmus wallichiana* with 360 cm, *Ulmus villosa* 340 cm and *Populus deltoides* 320 cm. The girth classes were made at an interval of 10 cm. The results of this study show that maximum number of trees sampled in broadleaved deciduous forest belonged to diameter class 10 cm – 20 cm (12.35 %) followed by the girth class of 20 cm – 30 cm (11.52 %) (Figure 48).

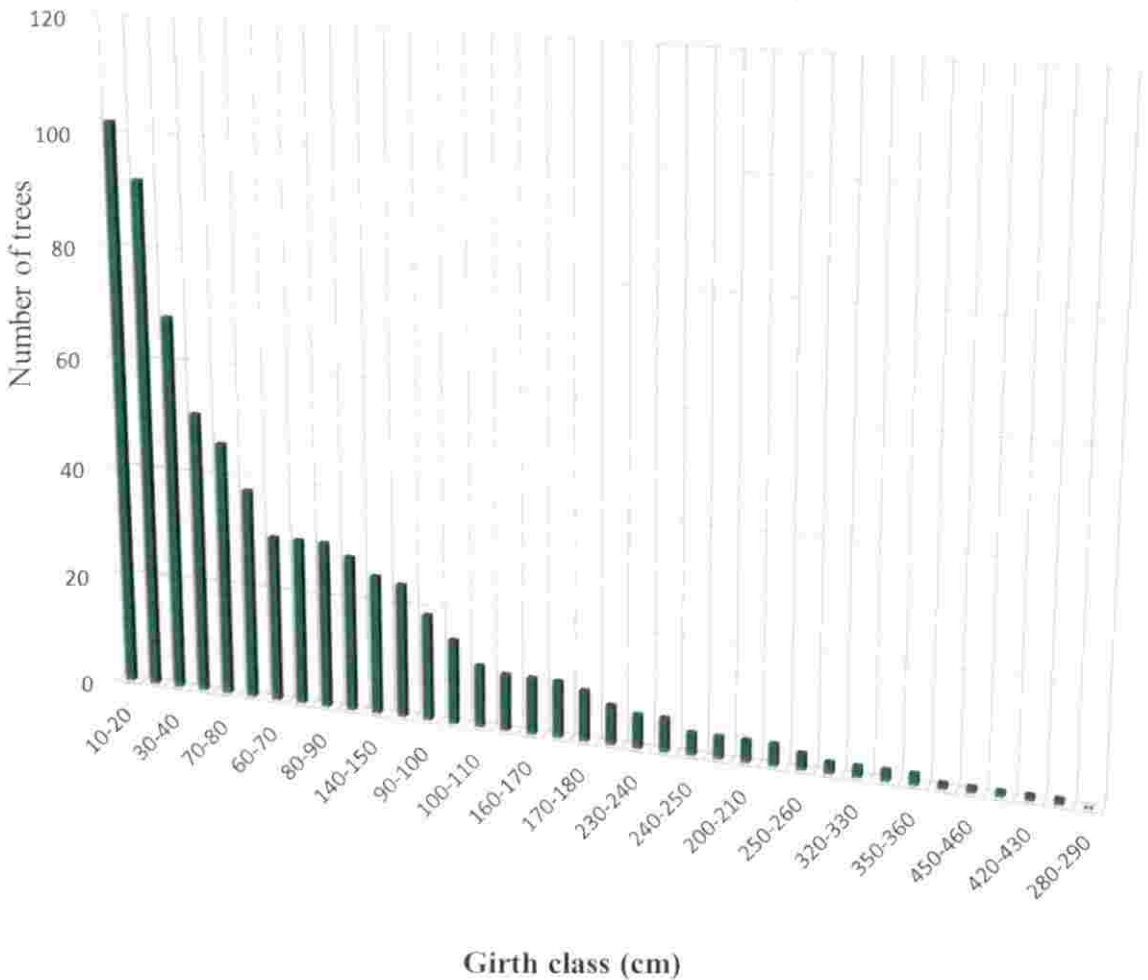


Figure 48. The girth class distribution in broadleaved deciduous forest type in Dachigam National Park

During the study period, regeneration in broadleaved deciduous forest in Dachigam National Park was observed to be excellent as 41.51 % of the sampled trees in broadleaved deciduous forest belonged to the girth class 10 cm – 50 cm. The ample number of trees were also observed in the mature category falling in the diameter class of more than 200 cm. The overall regeneration and health conditions of the broadleaved deciduous forest was observed to be excellent.

4.5.3 HEIGHT CLASS DISTRIBUTION OF TREES IN DACHIGAM NATIONAL PARK

The height class distribution of trees in various habitats of Dachigam National Park indicate that most of trees sampled belonged to the height class of 5 m – 10 m (figure. 49), followed by the height class of 10 m – 15 m while as least number trees belonged to the height class of 30 m – 35 m. 38.12 % of the total trees sampled during the study period, belonged to the height class of 5 m – 10 m, while least number of trees (0.24 %) belonged to the height class of 30 m – 35 m. The trees in the lower height classes were abundant and well distributed all over the area indicating good regeneration conditions in Dachigam National Park. The greater height classes were few and sparsely distributed over the area.

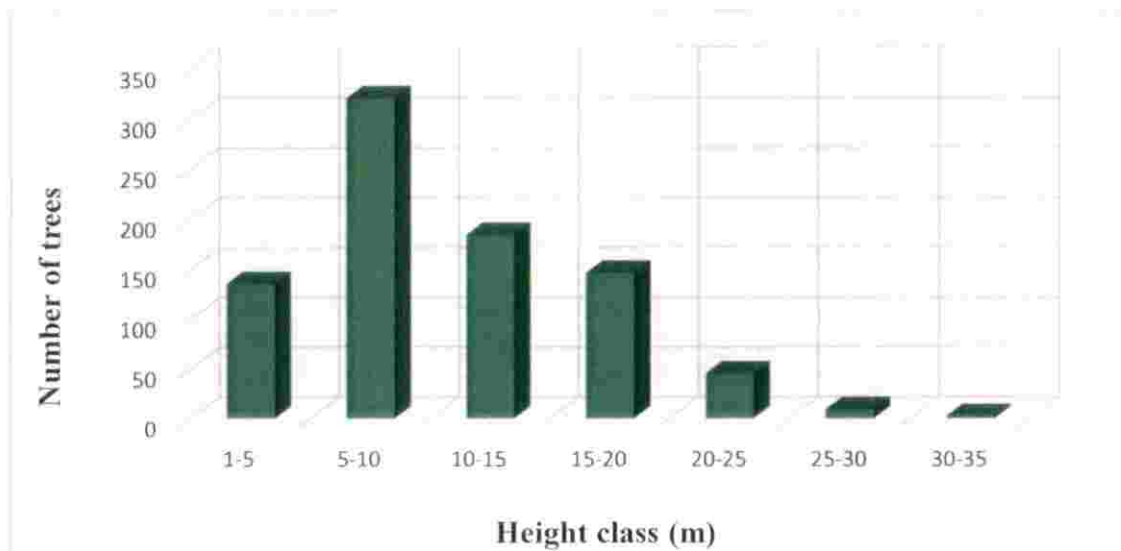


Figure 49. Height class distribution of trees in Dachigam National Park

4.5.4 IMPORTANT VALUE INDEX (IVI) OF FAMILIES OF TREES IN DACHIGAM NATIONAL PARK

Important value Index (IVI) of individual trees in Dachigam National Park

The Important Value Index (IVI) of the individual trees sampled in various habitats of Dachigam National Park were calculated. The results of the IVI of individual trees show the relative importance of the each tree in Dachigam National Park in various habitats. The IVI of the various trees sampled during the study period is shown in the table 12.

Table 12. The IVI of the tree species in Dachigam National Park

Sl. No.	Plant species	Family	Relative Density	Relative frequency	Relative basal area	IVI	RIVI
1.	<i>Pinus wallichiana</i>	Pinaceae	16.50	10.9	31.34	58.74	20.3
2.	<i>Paratiopsis jacquimontiana</i>	Hamamelidaceae	16.38	10.9	1.52	28.8	9.98
3.	<i>Quercus robur</i>	Fagaceae	9.02	3.31	13.43	25.76	8.93
4.	<i>Morus alba</i>	Moraceae	7	9	5.28	21.28	7.38
5.	<i>Ulmus wallichiana</i>	Ulmaceae	6.29	7.58	4.52	18.29	6.34
6.	<i>Celtis australis</i>	Cannabaceae	6.29	9.4	2.34	18.03	6.25
7.	<i>Robinia pseudoacacia</i>	Fabaceae	7	4.26	3.74	15	5.20

8.	<i>Celtis caucasica</i>	Cannabaceae	4.75	7.4	1.57	13.72	4.75
9.	<i>Prunus armeniaca</i>	Rosaceae	4.75	5.21	2.32	12.28	4.25
10.	<i>Salix alba</i>	Salicaceae	3.44	2.84	3.37	9.65	3.34
11.	<i>Juglans regia</i>	Juglandaceae	2	3.31	3.32	8.63	2.99
12.	<i>Ulmus villosa</i>	Ulmaceae	1.78	3.31	3.26	8.35	2.89
13.	<i>Prunus ceracifera</i>	Rosaceae	2.49	4.7	0.34	7.53	2.61
14.	<i>Populus deltoides</i>	Salicaceae	1.18	0.94	3.48	5.6	1.94
15.	<i>Aesculus indica</i>	Sapindaceae	1.42	0.94	3.16	5.52	1.91
16.	<i>Rhus succedanae</i>	Anacardiaceae	1.30	2.84	1.002	5.14	1.78
17.	<i>Juglans nigra</i>	Juglandaceae	1.30	1.89	1.66	4.85	1.68
18.	<i>Acer caesium</i>	Sapindaceae	1.30	1.89	0.37	3.56	1.23
19.	<i>Prunus persica</i>	Rosaceae	1.42	1.89	0.18	3.49	1.21
20.	<i>Alianthus altissima</i>	Simaroubaceae	1.30	1.42	0.51	3.23	1.12
21.	<i>Fraxinus floribunda</i>	Oleaceae	0.71	1.89	0.58	3.18	1.10
22.	<i>Populus cillita</i>	Salicaceae	0.95	0.94	1.08	2.97	1.03
23.	<i>Rosa webbiana</i>	Rosaceae	0.47	1.42	0.21	2.1	0.72
24.	<i>Taxus wallichiana</i>	Taxaceae	0.47	0.47	0.047	0.98	0.33
25.	<i>Morus nigra</i>	Moraceae	0.23	0.47	0.21	0.91	0.31
26.	<i>Betula utilis</i>	Betulaceae	0.23	0.47	0.01	0.71	0.24

The dominant trees were *Pinus wallichiana* (IVI - 58.74), followed by *Paratiopsis jacquemontiana* (IVI - 28.28), *Quercus robur* (IVI - 25.76), *Morus alba* (21.28), *Ulmus wallichiana* (18.29), *Celtis australis* (18.03). Thus, the highest IVI was recorded in case of *Pinus wallichiana* (IVI - 58.74) while as the lowest IVI was recorded in case of *Betula utilis* (IVI -0.71).

Important Value Index of the tree families in Dachigam National Park

The Important Value Index of the trees sampled in the Dachigam National Park was calculated. The results of the Important Value Index (IVI) shows the relative importance of each family in the Dachigam National Park in various habitats. The Pinaceae family had the highest IVI in the Dachigam National Park since the most dominant tree *Pinus wallichiana* belonged to this family. Other families with high IVI include Hamamelidaceae (*Paratiopsis jacquemontiana*), Ulmeace (*Ulmus wallichiana* and *Ulmus villosa*), Fagaceae (*Quercus robur*), Cannabaceae (*Celtis australis*, *Celtis caucasia*) and Rosaceae (*Prunus ceracifera*, *Prunu armeniaca*). The IVI of the families is given in table 13. Thus, highest IVI was recorded incase of Pinaceae and was most important family in Dachigam National Park while lowest IVI was recorded in case of Betuleaceae.

Table 13. Important Value Index of the tree families in Dachigam National Park

Sl.No	Family	Relative density	Relative frequency	Relative basal area	IVI	RIVI
1.	Pinaceae	16.50	10.9	31.34	58.74	20.3
2.	Cannabaceae	11.04	16.8	3.91	31.75	11
3.	Hamamelidaceae	16.38	10.9	1.52	28.8	9.98
4.	Ulmaceae	8.07	10.89	7.68	26.64	9.23
5.	Fagaceae	9.02	3.31	13.43	25.76	8.93
6.	Rosaceae	9.13	13.22	3.05	25.40	8.78
7.	Moraceae	7.23	9.47	5.49	22.19	7.69

8.	Salicaceae	5.57	4.72	7.93	18.22	6.31
9.	Fabaceae	7	4.26	3.74	15	5.20
10.	Juglandaceae	3.30	5.20	4.98	13.48	4.67
11.	Sapindaceae	2.72	2.83	3.53	9.08	3.14
12.	Anacardiaceae	1.30	2.84	1.002	5.14	1.78
13.	Simaroubaceae	1.30	1.42	0.51	3.23	1.12
14.	Oleaceae	0.71	1.89	0.58	3.18	1.10
15.	Taxaceae	0.47	0.47	0.047	0.98	0.33
16.	Betulaceae	0.23	0.47	0.01	0.71	0.24

DISCUSSION

DISCUSSION

5.1.1 FEEDING ECOLOGY OF THE HIMALAYAN GREY LANGUR

Understanding of food and feeding behavior is essential for understanding the ecological and environmental adaptations of a species. Like any other animals, food and foraging is an essential part of Grey langur's daily activities as food and feeding are vital for the maintenance of life and reproduction of animal. Grey langurs are mainly classified as folivorous, having the sacculated stomach, specialized for digestion of leaves (Amerasinghe *et al*, 1971). This study reported langurs feeding on leaves and many other parts of the plants. Roberts (1997), reported that the langurs are exclusively herbivores, feeding mainly on young leaves, buds, and other vegetation but observations in open scrub forests of Jodhpur reveal that insects may also constitute a regular part of their diet and that insectivory is prevalent during monsoon months July – September (Srivastava, 1991). Hence, most of the studies suggest that the classification of langurs as folivorous seems to be very narrow-minded as langurs can consume a wide range of provisioned food in different habitats in India (Rajpurohit, 2005).

The present shows the Himalayan Grey Langur fed on 34 plant species during the study period. In many previous studies, they were found to be feeding on 32 – 82 plant species (Rahman, 1973; Starin, 1973; Yoshiba, 1967; Ripley, 1970; Haldik and Haldik, 1972; Mohnot, 1974). During this study period, the grey langur was observed feeding on insects and the insectivory was prevalent during the summer season only. Minhas *et al.*, (2010), also reported several episodes of insect feeding. Moore (1985) has also reported that the langurs preyed and fed on insect pupae and eggs during several observations. He concluded that insect eating by langurs was best explained by an energy and nutrient maximization model rather than any special characteristic of the insect itself. Srivastava (1991) and Rajpurohit (2005) also reported the insectivory in case of langurs. One of the most interesting feeding habit reported in the present was the salt licking by the langur.

The present study shows that the Himalayan Grey Langur at Dachigam National Park were very flexible in selecting the feeding plant species across the study area. During the study period, the Himalayan Grey Langur was observed feeding on 34 plant species. The flexibility in selecting a large number of feeding species suggests that the Himalayan Grey Langur were not selective in

their diet. It is also possible due to different productivity in different seasons and some plants were fed in one season while other plant species were fed in another season.

The Himalayan Grey Langur at Dachigam National during the current study showed no significant difference in the proportion of animals seen feeding across the seasons in contrast to other grey langurs in the low lands who spend less time feeding during summer season or monsoon season (Oppenheimer, 1978; Newton, 1992). Sayers and Norconk (2008), reported that the feeding efforts in case of the Himalayan Grey Langur at Langtang increased as the total vegetation abundance decreased. Minhas *et al.*, (2013), reported that the Himalayan Grey Langur at Machiara National Park did not respond to adverse conditions by increasing foraging efficiency. The present study also observed that the Himalayan Grey Langur at Dachigam National Park did not respond food shortage and climatic conditions by increasing the feeding efforts or increasing the time devoted to feeding. The possible reasons for this difference may be the availability of preferred food for which the langur adjusted their foraging efforts as well as the time budget activity.

Koenig and Borries (2001), reported a positive co-relation between consumption and the abundance for the young leaves, flowers, and fruits in the lowland grey langur populations, and reported that the langurs feed on everything that is available except the mature leaves. The current study also observed the same pattern that if the mature leaves specifically and other resources get substituted as a fallback food the grey langur inhibit the area so marginally that they ingest mature leaves whenever available. The ability of the grey langurs to subsist the seasonally non – preferred food may be one of the reasons for the expansive geographical and ecological range of the grey langurs.

Kirkpatrick (1999; Waterman and Kool 1994), reported that most of the colobines while having a diverse diet and choices favor young leaves, ripe fruits seeds, mature leaves often related to chemical attributes and nutritional value of the plant part. The present study clearly reports that the Himalayan Grey Langur prefers broadleaved deciduous leaves both mature and young, as they take former and not later in close relation to their abundance.

5.1.1.1 FOOD COMPOSITION

It has been observed in the present study that the langur diet consists of 27.18 percent of leaves, 22.75 percent of fruits, 10.49 percent seeds, 7.63 percent buds, 6.68 percent grasses, 5.52 percent flowers and 4.77 percent bark and buds. Minhas *et al.*, (2010), reported that the grey langur diet consisted of 36.12 percent leaves, 17 percent fruits, 2.19 percent flowers and 9.45 percent bark. Rajpurohit (2005), observed during one year the diet of the langurs consists of 60 percent leaves, 23 percent young leaves, and 7 percent flowers. Similarly, Rahman (1973) reported 85.4 percent leaves as a yearly diet of the grey langurs. Yoshiba (1967) reported that langurs spent 94.6 percent of time activity feeding on leaves and 1.2 percent on flowers. Thus, the langurs almost consume (86%) more leaves compared to other feeding parts and are exclusively herbivores. A large amount of leaves in the diet is due to several physiological and behavioral adaptations. The more leaf content in the diets of langurs helps them to survive on un – nutritional diet through most of the day and gain more energy through steady foraging for the long periods involving little movement.

The present study observed that during the winter season, the Himalayan Grey Langur shifted their food preference towards the non – folivorous parts, as there was little foliage present on the trees. The present study reports during the winter season, the Himalayan Grey Langur diet comprises of 11 percent buds, 7 percent bark, and twigs and 4 percent bark alone. Sayers and Norconk (2008) studied the general ecological behavior and reported similar results at Nepal where the leaf buds constituted a major portion of the grey langur diet in the winters. The current study observed that Himalayan Grey Langur feeding on the bark of four plant species usually avoided in the other seasons.

Mckay (1981; Dasilva, 1994) reported that some Colobinae select seeds more strongly than the other food items including the young leaves. The current study reported that the seeds and fruits are important seasonal foods for the Himalayan Grey Langur and particularly during the summer season showed a preference towards feeding on seeds and fruits. Sayers (2013) also reported that seeds and fruits are important seasonal foods at Langtang for the grey langur. However, given that the deciduous leaves, ripe fruits, leaf buds remain available different times of the season and the year and that the Himalayan Grey Langur consumed them in relation to their abundance, it is difficult to determine the preference of one over the other.

5.1.1.2 FEEDING DURING WINTER SEASON

Mir *et al.*, (2015), reported, that the Himalayan Grey Langur diet consisted of 37.4 percent bark, 24.2 percent buds, 17.1 percent fruits, 13.8 percent leaves, and 7.5 percent seeds during the winter season. The present study observed that the Himalayan Grey Langur diet during the winter season consisted of 27 percent leaves, 15 percent seeds, 13 percent fruits, 8 percent flowers, 7 percent bark and twigs, 6 percent kinds of grass and 4 percent bark. The higher percentage of feeding on leaves during the winter season can be attributed to the fact that the animal fed on the fallen leaves of the *Populus deltoides* and spent a large amount of time (11.35 %) feeding on *Hedera nepalensis*. The high percentage of feeding on fruits can be attributed to feeding on the fruits of *Rosa webbiana* (14.8 %). This may be of the first report where the Himalayan Grey Langur is reported to be feeding on *Rosa webbiana*, *Rubus niveus*, *Rubus fruticosus* and some grasses such as *Trifolium pratense* and *sorghum halepense* (Plate).

5.1.1.3 FEEDING DURING SUMMER SEASON

The present study observed that the Himalayan grey showed a typical preference towards the fruits during the summer season. The Himalayan Grey Langur was reported feeding on fruits such as walnut, oak, horse chestnut and wild rose. In the present study, fruits constitute 41 percent of the langur diet. The fruit and seeds of *Aesculus indica* are known for having high nutritional value containing good amounts of various mineral nutrients (Majeed *et al.*, 2010). The nutritional value of *Quercus sp.* is known to be containing large quantities of nutrients per kg of biomass compared to other commercial forest species in the region (Miguel *et al.*, 2006). Similarly, walnuts are very rich source of proteins. Hence, all these fruits provided an excellent dietary supplement to the langurs.

Minhas *et al.*, (2010), reported that during the summer season, the Himalayan Grey Langur spent the Himalayan Grey Langur consumed 37 plant species. The main plant species fed during the summer season includes *Betula utilis*, *Polygonum alpinum*, *Skimmia laureola*, *Juniperus communis*, *Rheum emodi*, *Ribes alpestre*, *Quercus incana*, *Jurinea dolomiaea* and *Prunus cornuta*. These species consisted of 55 percent of the total time of feeding. The present study observed that during the summer season the Himalayan Grey Langur fed on 16 plant species

belonging to 12 different families. During the present study, the main species fed during the summer include *Aesculus indica*, followed by *Juglans regia*, *Sorghum halepense*, *Morus alba*, *Populus deltoides*, *Prunus armeniaca* and *Trifolium pratense*. These species constituted 71.61 percent of the total feeding during the summer season.

The study for the first time reported the Himalayan Grey Langur feeding on the certain grass species like *Sorghum halepense*, *Trifolium pratense*, and *Hydrocotyl sp.* As the grasses are more nutritive, the Himalayan Grey Langur spent considerable time on feeding these grass species.

5.1.2 FEEDING ECOLOGY OF THE TUFTED GREY LANGUR

The better understanding of the feeding ecology is very helpful tool in determining and assessing the environmental and ecological adaptations of any animal species. The grey langurs are old – world monkey feeding mainly on the leaves (folivorous), but the grey langurs also feed on other food items such as fruits, flowers, seeds, twigs and bark. Roberts (1997) reported that the langurs are exclusively herbivores and mainly feed on young leaves, buds, twigs, bark and other type of vegetation. During the current study, the Tufted Grey Langur was reported feeding on leaves, fruits as twigs.

The present study revealed that the Tufted Grey Langur fed on the 12 plant species belonging to the seven different families. Similar observations were reported by Rahman (1973) where grey langurs were reported to be feeding on 32 – 84 plant species.

The current study observed a co – relation between abundance of food articles and their consumption. If the young leaves were, absent fallen leaves substituted them or the animal moved to the other place. Koeing and Borries (2001) reported a similar positive co – relation between consumption and the abundance for the young leaves, flowers and fruits on low land grey langur populations and reported that the grey langurs feed on anything that is available than mature leaves. This ability of the grey langurs to subsist the seasonally non – preferred food may be one of the reasons for the presence of grey langurs in the vast and expansive geographical and ecological range.

Waterman and Kool (1994) reported that most of the colobines while having varied choices for the food and feeding items prefer young leaves, ripe fruits and seeds due to their nutritional attributes. During the present study, there was clear preference for the young leaves as mature

leaves were mostly ignored. The preference towards the young leaves was also due to moisture content as it was dry season during the study period. After leaves, the Tufted Grey Langur preferred the small twigs and fruits respectively.

The present study observed that the Tufted Grey Langur diet consisted of 60.38 % of leaves, 20.75 % twigs and 18.87 % of fruits. Rajpurohit (2015) also observed same sort of results and reported that the grey langur diet consisted of 60 percent leaves, 23 percent fruits and 7 percent flowers. Yoshiba (1967) reported that the grey langurs spent 94.6 percent of their feeding activity on leaves and 1.2 percent on flowers. The consumption of more folivorous diet helps the grey langurs to survive the less nutritional diet and gain the nutrient value and energy by the steady foraging for long duration with little movement.

Dasilva (1994) reported the preference of some of the colobines in selecting fruits and seeds over other food items. Sayers (2003) also reported that the fruits and seeds are the important food items of the grey langurs. The current study also observed that fruits constitute important constituent of the diet of Tufted Grey Langur. During the present study period, the fruits constitute 18.87 percent of the total diet of the Tufted Grey Langur.

5.2 SOCIAL BEHAVIOR OF THE HIMALAYAN GREY LANGUR

5.2.1 TIME BUDGET ACTIVITY

The activity profile is the way to approach the problems and how an animal species allot their time to the daily activities, utilize the resources and adapt to the environmental conditions (Rajpurohit, 2005). Just like the other primate species, the langurs are diurnal animals and during the daytime, they strictly follow the routine of daily activities. They spent the day in well-organized time budget plans. Rajpurohit (1994) reported that the activity plans might get disturbed due to the presence of predators, resource competing animals and weather conditions such as rain, or the extremes of temperatures. The present study observed the Himalayan Grey Langur spent 40.91 percent of the time budget activity in feeding, 20.83 percent moving, 15.72 percent resting, 14.77 percent grooming, while as the animal spent 7.77 percent of the total time budget activity in calling.

Minhas *et al.*, (2010), reported, that the Himalayan Grey Langur spent 44.96 percent in resting including monitoring and dozing. Rajpurohit (2005) reported that in a relatively rich environment the langurs spent more time (57.40 %) in resting.

Yoshiba (1967) reported that *Presbytis* langurs spent 30 – 60 percent of the time budget activity in feeding. The present study also observed 40.9 percent of the time budget activity on feeding. Sugiyama (1976) stated that out of the total time budget activity, the langurs spent 40 percent on feeding as was reported in the current study. All the above results and studies suggest that the langurs spent their time in different activities according to the available environments. In rich environments having a sufficient amount of food supply, the langurs spent more time on feeding than resting and vice versa.

Schneider *et al.*, (2010) reported that in general the time budget activity of the folivorous colobines are largely influenced by their diet. Therefore, the availability of the food and resources largely influences their time budget activity. They usually spend the majority of their time resting and considerably less time feeding and moving (Clutton - Brock, 1977; Stanford, 1991; Fleagle, 1999). The Himalayan Grey Langur spends more time in social activities, followed resting and locomotion as was reported during the current study also. Hill (2006) reported that the feeding may be high compared to other daily activities due to more energy consumption for thermoregulation at lower temperatures and they might be on negative energy budget during the winter season thereby requiring more food more often, thus spend more time in foraging. The allocation of more time to feeding from the time budget activity in the winter season may be also due to food scarcity due to the presence of snow covering during the winter season. The present study also observed during the winter season the Himalayan Grey Langur allots more time to feeding (40.27 %) compared to resting (19.45 %). The more feeding time can be attributed to the fact that during the study period it snowed heavily at Dachigam National Park during the first week of November. To regulate body temperature and other physiological activities the animal allotted more time in feeding than resting. Van Doorn *et al.*, (2010) and Majolo *et al.*, (2013) also reported that primates respond to snow coverage by and low temperature by maximizing feeding efficiency and trying to ingest more food.

Minhas *et al.*, (2010), reported, that the Himalayan Grey Langur spent 10.02 percent of their average time in grooming activities. The grooming activity was between the female – female, male and female and an adult individual and a juvenile individual. The present study reported that

the Himalayan Grey Langur spent 14.77 percent of their time budget in grooming activities. The current study also observed grooming between female – female, male – male, female and male. In general, a lower ranked individual groomed higher ranked individual.

5.2.2 SOCIAL ORGANIZATION OF HIMALAYAN GREY LANGUR

The langurs are social animals with a definite social organization pattern. The sociability among the animal species bring several potential benefits such as increased vigilance and surveillance, increased defense mechanism, collective rearing of the off springs in the form of allo-mothering (Rajpurohit, 2005). Apart from all the advantage, the sociability has its own drawbacks in the form of increased competition for scarce food resources (Walter and Seyfarth, 1987). Being social animals, the langurs are usually found in organized groups. These groups may include multi-male multi-female or bisexual group, resident male group or the all-male band. All-male band is usually a loose gathering (Mohnot, 1984). The present study also showed the langur troops were organized into two groups *viz.*, multi- male multi- female or the bisexual group and all-male band. In the bisexual troop was very well organized in which there was a proper hierarchy.

5.3 POPULATION DISTRIBUTION AND DENSITY OF HIMALAYAN GREY LANGUR

Grooves (2001) first time reported the distribution of the Himalayan Grey Langur (*Semnopithecus ajax*) in Kashmir. Sharma and Ahmed (2015) established the presence of the Himalayan Grey Langur in Bhaderwah at elevations of 2635 m to 3228 m mainly in the upper reaches. Mir *et al.*, (2015) conducted the study on the seasonal population density in Dachigam National Park. The current study established the presence of the Himalayan Grey Langur at elevations between 1600 m to 3000 m. The distribution of the species mainly determined by the presence of food and food resources available. As the study area is having ample food resources throughout the seasons the presence of the species in the lower elevations is well justified.

The overall density of the Himalayan grey during the current study was reported to be 2926 individual per Km², which is much more than the density obtained in similar ecosystems by Mir *et al.*, (2015) and Minhas *et al.*, (2012). This may be attributed to the lesser area coverage and restricted sampling compared to overall area particularly during the summer season.

The current study observed the home range of all male band was more than the bisexual troop used extensive areas with average home range of 2.5 km² to five km². The home range of the bisexual or multi-male multi-female varied with average home range of two km² to four km². The similar results were obtained by Minhas *et al.*, (2012) in Machiara National Park were the home range of the bisexual troop varied between 2.33 km² to 5.4 km² and all male band home range 4 km² to 6 km². Rajpurohit (2005) also reported similar results from Jodhpur.

A number of factors are responsible for the variation in the langur home range including the abundance and availability of the food resources, provisioned food, group size and composition, agricultural crops, population density and the predator pressure. During the current study all these factors except the provisioned food, as there are and were never the incidences of feeding on provisioned food in Dachigam National Park, were taken into consideration for the cause of the home range variation.

The present study revealed a positive co – relation between troop size and the home range *viz.*, smaller the size of troop smaller was the home range and larger the troop size more extensive was the area of the home range. The larger troop size containing more number of individuals require more food and hence have to cover more distance to fulfill their daily requirements. The results of this study are in affirmation with Minhas *et al.*, (2012).

In Kashmir, the presence of the Himalayan Grey Langur has been reported in Dachigam National Park and its adjoining areas and Sharma and Ahmed (2015) in Bhaderwah have reported scattered population of the Himalayan Grey Langur.

The langurs are forest dwelling animals adaptable to varied ecological habitats including dry savannah to the tropical rain forests. The Langurs are arboreal and diurnal species. In the current study, in Dachigam National Park, the Himalayan grey is distributed in temperate coniferous forest, mixed coniferous forest, deciduous broadleaved forest and riverine forest areas from the elevations of 1,600 m – 3,000 m. Nowak (1999), Hilton and Taylor (2000) also reported the species to be present between 2,000 m to 4,000 m in sub – tropical, moist temperate, alpine, coniferous, broadleaved forests including scrub lands.

The population and the geographic range of the Himalayan Grey Langur is very limited and its endemism to the rough and precipitous mountain ranges of the western Himalayas renders the species in the “Endangered” list of the Red data book of International Union for Conservation of Nature and Natural resources (IUCN) (Grooves and Molur, 2008). Nowak (1999) stated that the

Semnopithecus ajax was endangered due to the encroaching of its natural habitats and unchecked and unregulated expansion of the agriculture at the cost of the forest ecosystems. The IUCN (2008) categorized *S. ajax* as “Endangered” in the recent assessment of the species. The species is listed in the Appendix I on the Convention on International Trade of Endangered Species (CITES) restricting its international trade.

5.4. VEGETATION ANALYSIS IN DACHIGAM NATIONAL PARK

The current study is one the preliminary studies of the vegetation analysis in Dachigam National Park, as the earlier studies did not attempt the calculation of various diversity indices including the Important Value Index. During the study, a total of 70 quadrants were studied. During the study period total of 26 species of trees belonging to 16 different families were recorded. The species such as *Pinus wallichiana*, *Parrotiopsis jacquemontiana*, *Quercus robur*, *Morus alba*, *Celtis australis* and *Ulmus wallichiana* were dominant. Ahmed and Farooq (2018) studied the vegetation classification of the Dachigam National Park and reported 22 tree species. The maximum tree diversity indices were recorded in case of mixed wood lots and riverine habitats. The current study reported 26 trees in various habitats such as mixed broadleaved, coniferous and scrub and grassland in Dachigam National Park. The maximum diversity indices were also observed in case of broadleaved forest and riverine forest type.

Ecological succession, good power of regeneration and ecological amplitude of a species is governed by the high value of Important Value Index (IVI). High value of IVI and density indicate the dominance by *Pinus wallichiana* is due to environmental suitability and the ability of the species to survive the harsh environmental conditions. Difference in the species composition from site to site is widely due to micro environmental changes (Mishra *et al.*, 1997).

The species diversity is the reflection of the health and productivity of the forest ecosystem. The diversity was reported high in case of Pine forests, broadleaved and riverine forests, which may be due to the number of co – existing and interacting species having overlapping niche (Saxena and Singh, 1982).

The observations of the current study are in accordance with the findings of Malik and Malik (2012) who reported a positive co – relation between diversity and altitude. Differences in

altitude aspect and slope result in variation in species diversity. The pine vegetation starting from the north – west were having greater diversity and dominance than other vegetation types.

Ahamad *et al.*, (2006) characterized the subtropical ecotone forest in broadleaved forest and mixed pine forest and temperate zone into broadleaved forest, temperate mixed forest and temperate coniferous forest. The present study area has patchy and various types of vegetations such as broadleaved, coniferous, riverine were observed in fragments.

Bhat and Pandit (2012), reported constant decrease in the Important Value Index (IVI) for the *Pinus wallichiana* from the protected to unprotected areas. The reason being its vulnerability to felling by the local people. The current study reports maximum IVI for the *Pinus wallichiana* compared to the other tree species. The reason being the areas as the well protected and regeneration in plenty. The dominance of the *Pinus wallichiana* can be attributed to the ability of the tree species to grow in various habitats, aspects and slopes. In Dachigam National Park, the *Pinus wallichiana* is quite common and grows on wide range of habitats on the slopes of north and north – eastern aspects. The *Pinus wallichiana* on some occasions reaches up to the scrub and grasslands and forms patches. Besides the *Pinus wallichiana* is found to be associated with many broadleaved and shrub species such as *Ulmus wallichiana*, *Prunus ceracifera*, *Celtis australis*, *Prunus armeniaca*, *Rosa webbiana*, *Berberis lyceum* and *Indigofera heterantha*. Bhat and Pandit (2012) studied the impact of biotic interference on Yousmarg forest ecosystem, Kashmir and reported the *Pinus wallichiana* being dominant in the lower altitudes while as the *Abies pindrow* and *Picea simthana* being dominant in the higher altitudes. The similar results were obtained in the current study in which *Pinus wallichiana* being dominant in the lower and middle areas of the Dachigam National Park.

The high value of IVI of a species indicates its dominance and ecological success, its good power of regeneration and the greater ecological amplitude. During the study period, *Pinus wallichiana*, *Parrotiopsis jacquemontiana*, *Quercus robur*, *Celtis australis* and *Morus alba* showed higher IVI compared to the other tree species indicating their greater adaptability and ecological amplitude to various habitats and good power of regeneration.

Bokhari and Khan (2013) while studying the forest communities of Azad Kashmir, Pakistan observed that in mono specific forest of *Pinus wallichiana* the density ranged from 160 - 183 trees per hectare with the basal area ranging between 31 – 85 m² per hectare. The current study reported the density of 105 trees per hectare with basal area of 102 m² per hectare. The less density

and more basal area can be attributed to the fact that the species is found in patches all over the area and no monospecific forests are found in the present study area.

Pauses and Austin (2001) suggested that over the large area of a region the distribution of the species richness is likely to be governed by two or more environmental factors. The present study observed the maximum density, basal area and height for the conifer species, followed by the broadleaved species, which is attributed to the gregariousness and high girth. Low basal area, density and height was reported in case of scrub species.

The present study reports that both density and diversity decreases with increase in basal area in the localities dominated by conifers. The Hara *et al.*, (1997) obtained similar set of results in Taiwan and by Singh and Kushal (2006) in India.

The present study of vegetation analysis in Dachigam National Park observed that maximum species richness and diversity is reported in the lower elevation compared to the higher elevations. The similar sort of observations recorded by Kumar and Ram (2005) and Sharma (2009).

SUMMARY

SUMMARY

The primates including the Himalayan Grey Langur (*Semnopithecus ajax*) and the Tufted Grey Langur (*Semnopithecus priam*) at the ecosystem level exert a vital feedback control on vegetation of the forest ecosystem. The grey langur is an important component of the forest ecosystems for maintaining the vitality and homeostasis of the forest ecosystems especially play a crucial role in regeneration and survival of the forest ecosystems. The primates perform essential ecological services such as seed dispersal, pollinator and being food for some top predators, which is very important to maintain the health of forest ecosystems.

Understanding the feeding ecology of any animal species is the key feature of understanding the conservation status of the species. Sound knowledge of the ecology in general and feeding ecology in particular are very important to formulate the conservation strategies. The current study first elaborative study to study the feeding ecology of the two endemic langur species and characterize their feeding habits. The methods employed in the current study to study the food and feeding habits of the Himalayan Grey Langur (*Semnopithecus ajax*) and Tufted Grey Langur (*Semnopithecus priam*) were the 'Focal Animal Sampling' method, Instantaneous scan sampling method to study the social behavior of the Himalayan Grey Langur and Line transect method to study the population estimation and distribution of the Himalayan Grey Langur. Besides quadrant survey for vegetation sampling, a total of 70 quadrants of dimension 10 m x 10 m were sampled. The salient findings of the current study are summarized as below.

1. The Himalayan Grey Langur was observed feeding on 34 plant species, which include 22 tree species, 5 shrub species, 4 grass species and 3 climbers at Dachigam National Park.
2. The Himalayan Grey Langur at Dachigam National Park was observed feeding on plant species belonging to 21 different families Rosaceae was most preferred family.
3. The most preferred tree species of the Himalayan Grey Langur for feeding were *Rosa webbiana*, *Populus deltoides*, *Salix alba*, *Hedera nepalensis*, *Sorghum halepense*, *Pinus wallichiana*, *Quercus robur*, *Morus alba* and *Juglunas regia*.

4. The most preferred food item of the Himalayan Grey Langur was leaves (27.18 %), followed by fruits (22.75 %), seeds (10.49 %), Buds (7.39 %), flowers (5.29%) and bark and twigs (4.77 %).
5. The Himalayan Grey Langur was observed feeding on the insects and this insectivory was most prevalent during the summer season and subsequently formed 2.95 % of the diet.
6. The Himalayan grey langur preferred fruits during the summer season while, as the leaves were most preferred during the winter season.
7. The overall average height of feeding for the Himalayan grey was 5.8 m which was maximum in case of *Aesculus indica* (11 m) and *Pinus wallichiana* (11 m), followed by *Ulmus villosa* (9.8 m) and *Ulmus wallichiana* (9.7 m).
8. The Tufted Grey Langur was observed feeding on 12 tree species belonging to seven different families.
9. The most preferred tree species of the Tufted Grey Langur at Wayanad Wildlife Sanctuary was *Anogeissus latifolia* and *Samanea saman* (18 %), followed by *Gmelia tillifolia* (10 %), *Dalbergia lanceolaria* and *Terminalia bellarica* (8%) and *Pongamia pennata* (6 %).
10. The leaves constituted the majority portion of the diet of the Tufted Grey Langur at Wayanad Wildlife Sanctuary followed by the twigs and fruits.
11. The diet of the Tufted Grey Langur constituted of leaves (60.38 %), twigs (20.75 %) and fruits (18.87 %).
12. The average height of the feeding of Tufted Grey Langur at Wayanad Wildlife Sanctuary was 8.88 m.
13. The overall average height was maximum in case of *Hydnocarpus pentandra* (12 m), followed by *Terminalia bellarica* (10.5 m), *Gmelia arborea* (10.3 m) and *Dalbergia latifolia* (9 m).
14. The Himalayan Grey Langur spent maximum of their time budget activity in feeding followed by moving, resting, grooming and calling.
15. The Himalayan Grey Langur spend 41 % of their time budget activity in feeding, 21 % in moving, 16 % in resting, 15 % grooming while as 8 % of the time budget activity was spent on calling.

16. The overall average height of various activities performed by the Himalayan grey was observed to be 4.9 m.
17. During the study period, the overall average height was found out to be 4.9 m. The average maximum height was observed in case of resting (5.96 m), followed by calling (5.92 m), feeding (5.4 m), grooming (4.91 m) and moving (2.86 m).
18. During the study period, two types of social groups were observed at Dachigam National Park *viz.*, multi-male multi- female or bisexual troop and the all- male troop. The bisexual troops comprised of many individuals of adult, sub- adult and juvenile of both the sexes.
19. The male all – band comprised very less number of individuals and during this study, as much as two individuals were seen in such troops. The multi – male multi – female troops were much organized having proper and strong association than the all – male band. There was prominent hierarchy observed among the bisexual troop, which was clearly missing, in the all – male troop. The males of all ages were present in the bisexual troop. Usually an alpha adult male would lead the troop.
20. During the study period, the allo grooming was observed between female-female, female – male, adult individual groomed by sub – adult individual. In general, low ranked individual groomed a high ranked individual.
21. The alpha individual of the troop by the call “Whoops” started the daily routine of activities for the Himalayan Grey Langur troop. The communication system and calling behavior was well developed among the troops of Himalayan Grey Langur at Dachigam National Park. During the study period, the Himalayan Grey Langur spent 7.7 percent of the total time budget activity on calling. During the study period, three types of calls were observed through which the Himalayan Grey Langur communicate with each other *viz.*, connecting call, breeding call and danger call.
22. The main activity performed by the Himalayan Grey Langur during the summer season was feeding (43.67 %), followed by moving (21.53 %), resting (18.98 %), grooming (14.69 %) while as calling during summer season accounted only for 1.13 percent.

23. The percentage frequency during the summer season was highest in case of feeding (42.33 %), followed by moving (23.93 %), resting (17.18 %), grooming (15.34 %), while as calling accounted only 1.23 percent.
24. The average height during the summer season, was observed to be maximum in case of calling (7.5 m), followed by resting (7.3 m), grooming (4.9 m), feeding (4.7 m) and moving (3.3 m).
25. The maximum mean duration of time was observed highest in case of feeding (30.92 minutes), followed by resting (12 minutes), grooming (10.4 minutes), calling (10 minutes) and moving (9.6 minutes) during the summer season.
26. The main activities performed by the Himalayan Grey Langur during the winter season includes feeding (40.27 %), moving (19.45 %), resting (15.07 %), grooming (14.52 %) and calling (10.68 %).
27. A total of 77 transects were taken during the whole study period. The overall density of the Himalayan Grey Langur was observed to be 2926 per Km² with cluster density of 500.
28. The entire population of the Himalayan Grey Langur was found in the habitats such as the mixed coniferous, broadleaved deciduous and riverine forest type.
29. The home range of all male band was comparatively more than that of bisexual troop or multi – male multi – female troop. The all-male band used extensive areas and their home range varies from 2.5 km² to 5 km². The home range of bisexual troop ranged between 2 km² to 5 km².
30. A total 70 quadrants having area of 100 m² area were sampled for the study of the Himalayan Grey Langur habitat in Dachigam National Park.
31. A total of 26 species belonging to 16 different families were observed from the 70 quadrants sampled during the study period. A total of 842 individuals were observed in 70 sampling plots with a total basal area of 335. 7422 m².

32. The species such as *Pinus wallichiana*, *Parrotiopsis jacquemontiana*, *Quercus robur*, *Morus alba*, *Robina pseudoacacia*, *Celtis australis* and *Ulmus wallichiana* were most abundant tree species at the Dachigam National Park.
33. The *Pinus wallichiana* was found to be distributed through the altitudinal range of 1,600 m – 3,000 m.
34. The total area of oak plantations at Dachigam National Park is near about 2 Km² with largest patch comprising of 500 m². The relative density of the *Quercus robur* was observed to be 9.02 with 76 individual trees sampled.
35. Girth class frequency distribution in Dachigam National Park shows that 12 percent of the individuals in the sampled plots belonged to the girth class of 10 cm – 20 cm indicating ample amount of regeneration in the Dachigam National Park. *Ulmus wallichiana* has highest GBH with 465 cm followed by *Pinus wallichiana* 454 cm of GBH and *Aesculus indica* with 450 cm. The lowest GBH was recorded in case of *Juglunas regia* with 10 cm GBH and *Celtis australis* with 11 cm GBH.
36. The height class distribution of trees in various habitats of Dachigam National Park indicate that most of trees sampled belonged to the height class of 5 m – 10 m followed by the height class of 10 m – 15 m while as least number trees belonged to the height class of 30 m – 35 m. 38.12 % of the total trees sampled during the study period, belonged to the height class of 5 m – 10 m, while least number of trees (0.24 %) belonged to the height class of 30 m – 35 m.
37. The Pinaceae family had the highest IVI in the Dachigam National Park since the most dominant tree *Pinus wallichiana* belonged to this family. Other families with high IVI include Hamamelidaceae (*Parrotiopsis jacquemontiana*), Ulmeace (*Ulmus wallichiana* and *Ulmus villosa*), Fagaceae (*Quercus robur*), Cannabaceae (*Celtis australis*, *Celtis Caucasia*) and Rosaceae (*Prunus ceracifera*, *Prunus armeniaca*).
38. Although the major areas where the population of the Himalayan grey and Tufted grey are observed yet special efforts are required to protect these value species by employing

concrete identification, thorough ecological studies, physical characteristics along with the molecular analysis.

REFERENCES

REFERENCES

- Ahamad, K, Sathyakumar, S and Qureshi, Q. 2005. Feeding Preferences of Hangul (*Cervus elaphus hanglu*) at Dachigam National Park, Kashmir, India. Final Report of the Department of Wildlife Protection, Jammu & Kashmir Government, Srinagar, and Wildlife Institute of India, Dehradun.
- Ahmed, K. B, Awan, M. S and Anwar M. 1999. Status of major wildlife species in the Moji Game Reserve, Leepa valley Azad Kashmir. *Proceedings of Pakistan Congress of Zoology*, 19: 173-182.
- Ahmed, M., Hussain, T., Sheikh, A. H., Hussain, S. S., Siddiqui, M. F. 2006. Phytosociology and structure of Himalyan forests from different climatic zones of Pakistan. *Pak. J. Bot.* 38 (2):361 – 383.
- Altman, J., 1974. Observational study of behavior: Sampling methods, *Behavior*, 49: 227-267.
- Amerasinghe F. P, Cuylenberg B. W. B., Haldik C. M. 1971. Comparative histology of the alimentary tract of Ceylon primates in correlation with the diet. *Ceylon J. Sci. Biol. Sci.*, 9: 75-87
- Bennett, E. L. 1986. Environmental correlates of ranging behavior in the banded langur; *Presbytis melalophos*. *Folia Primatol.* 47:26–38
- Bennett, E. L, Davies, A. G. 1994. The ecology of Asian colobines. In: Davies AG (ed.) *Colobine monkeys: their ecology, behavior and evolution*. Cambridge University Press, Cambridge, 129–171pp.
- Bokhari and Khan. 2013. *FUUAST J. Biol.*, 3(1): 137-145
- Borries, C., Sommer, V. and Srivastava, A. 1991. Dominance, age and reproductive success in free ranging female Hanuman langur (*Presbytis entellus*). *Int. J. Primatol.*, 12: 231-257.

- Borries, C. 1997. Infanticide in seasonally breeding multi male groups of Hanuman langurs (*Presbytis entellus*) in Ramnagar (South Nepal). *Behav. Ecol. Sociobiol.*, **41**: 139-150.
- Brandon – Jones, D. 2004. A taxonomic revision of the langurs and leaf monkeys (Primates: Colobinae) of South Asia. *Zoos' print J.*, 19: 1552-1594.
- Blanford, W. T. 1992. *Primates of the World*. Rod and Ken Preston - Mafhan, U.K.
- Champion, H. G. and Seth, S. K. 1968. A Revised Forest Types of India. Manager of Publications, Government of India, Delhi.
- Clutton – Brock, T. H. 1977. Some aspects of interspecific variation in feeding and ranging behavior in primates. In: Clutton-Brock, T. H (ed.) *Primate ecology: studies of feeding and ranging behavior in lemurs, monkeys, and apes*. Academic Press, London, 536–539pp.
- Curtis, J. T. and Macintosh, R. P. 1950. The interrelations of certain analytic and synthetic phytosociological characters. *Ecology* 31:434-455.
- Curtin, R. A. 1982. Range use of gray langurs in highland Nepal. *Folia Primatol.* 38:1–18
- Dasilva, G. L. (1994). Diet of *Colobus polykomos* on Tiwai island: Selection of food in relation to its seasonal abundance and nutritional quality. *International Journal of Primatology*, 15, 655–680.
- David, G. F. X. and Ramaswami, L. S. 1969. Studies on the menstrual cycles and other related phenomena in the langur (*Presbytis entellus entellus*). *Folia Primatol.* 11: 300-316.
- Fan, P. F, Ai, H. S, Fei, H. L, Zhang, D and Yuan, S. D. 2012. Seasonal variation of diet and time budget of eastern Hoolock gibbon (*Hoolock leuconedys*) living in a northern montane forest. *Primates* 54:137–146
- Fleagle, J. 1999. Primate adaptation and evolution, Academic Press, San Diego. *Glob. J. Sci. Front*

Res 10(4):17

Groves, C. 2001. *Primate Taxonomy*. Smithsonian Institution Press

Groves, C. 2005. *Mammal species of the world* (eds. D.E. Wilson and R.D. Reeder) (3rd ed.).

Johns Hopkins University Press. Baltimore. 174 – 17 pp.

Groves, C. P and Molur, S. 2008. *Semnopithecus ajax*. The IUCN Red List of Threatened Species.

Version 2014.2. www.iucnredlist.org. Downloaded on 25 August 2014.

Groves, C. P. 1989. A theory of human and primate evolution. Oxford University Press. Oxford.

Grueter, C. C, Li D, Ren B, Xiang Z, Li M. 2012. Food abundance is the main determinant of

high-altitude range use in snub-nosed monkeys. *Int. J. Zool.*

Harley, D. 1985. Birth spacing in langur monkeys (*Presbytis entellus*). *Indian J. Primatol.*, 6:

227–242.

Harley, D. 1988. Patterns of reproduction and mortality in two captive colonies of Hanuman

langur monkeys (*Presbytis entellus*). *Am. J. Primatol.*, 15: 103-114.

Hara, M. K, Hirarta, M., Fujihaxa, K., Oono Hsich, C.F. 1997. Floristic composition and stand

structure of three evergreen broadleaved forests in Taiwan, with special reference to the

relationship between micro landform and vegetation pattern. *Nat. His.* 4: 81- 112.

Harris, T. R, Chapman, C. A, Monfort, S. L. 2010. Small folivorous primate groups exhibit

behavioral and physiological effects of food scarcity. *Behav. Ecol.* 21:46–56

Hill, R. A. 2006. Thermal constraints on activity scheduling and habitat choice in baboons. *Am J.*

Phys. Anthropol. 129:242 – 249

Haldik CM, Haldik A. 1972. Disponibilities allimentariret domains vitaux des primates a Ceylon.

Terre Vie, 26: 149-215.

Hrdy, S. B., 1974. Male-male competition and infanticide among the langurs (*Presbytis entellus*)

of Abu Rajasthan. *Folia Primatol.* 22: 19-58.

- Iftikhar, N. 2006. *Wildlife of Azad Kashmir* (in Urdu). Al-Sheikh Press, Muzaffarabad, AJK.
- IUCN. 2018. *IUCN Red List of Threatened Species*. <http://www.iucnredlist.org/>.
- Jay, P. C. 1965. The common langur of North India. In: *Primate Behavior* (ed. I. DeVore). Holt, Rinehart and Winston, New York. pp. 197-249.
- Karanth K. U, Sanquist M. E. 1995. Prey selection by tiger, leopard and dhole in tropical forests. *J. Anim Ecol.* 64:439–450
- Karanth K. P., Singh L., Collura R. and Stewart C. 2008. Molecular phylogeny and biogeography of Langurs and leaf monkeys. *Mol. Phylogenet. Evol.* 46, 683 – 694
- Kirkpatrick, R. C, Grueter, C. C. 2010. Snub-nosed monkeys: multilevel societies across varied environment. *Evol. Anthropol.* 19:98–113
- Kirkpatrick, R. C. 2011. The Asian colobines: diversity among leaf eating monkeys. In: Campbell, C. J, Fuentes, A, Mackinnon, K. C, Panger M, Bearder S. K. (eds.) *Primates in perspective*, 2nd edn. Oxford University Press, New York, pp 186–200
- Koenig, A., Borries, C., Chalise, M. K. and Winkler, P., 1997. Ecology, nutrition, and timing of reproductive events in an Asian primate, the Hanuman langur (*Presbytis entellus*). *J. Zool.*, 243: 215-235.
- Kumar, A and Ram, J. 2005. Anthropogenic disturbances and plant biodiversity in forests of Uttaranchal, central Himalayas. *Biodiversity Conservation*. 309 – 331pp.
- Lancaster, J. B. and Lee, R. B. 1965. The annual reproductive cycle in monkeys and apes. In *Primate behavior. Field studies of monkeys and apes*: 486 - 513. De Vore, I. (Ed.). New York: Holt, Rinehart and Winston.
- Lee, P. C. 1987. Nutrition, fertility and maternal investment in primates. *J. Zool. (Lond.)* 213: 409-422.

- Lee, P. C. and Bowman, J. E. 1995. Influence of ecology and energetics on primate mothers and infants. In *Motherhood in human and nonhuman primates*: 47-58. Pryce, C. R., Martin, R. D. and Skuse, D. (Eds.). Basel: Karger
- Li Y, Jiang Z, Li C, Grueter C. C. 2010. Effects of seasonal folivory and frugivory on ranging patterns in *Rhinopithecus roxellana*. *Int. J. Primatol.* 31:609–626
- Lohiya, N. K., Sharma, R. S., Puri, C. P., David, G. F. and Kumar, T. C. 1988. Reproductive exocrine and endocrine profile of female langur monkeys, *Presbytis entellus*. *J. Reprod. Fertil.* 82: 485-492.
- Malik, Z. H., Malik, N. Z. 2012. High altitude forest composition diversity and its component in a part of Ganga chotti and Bedori hills district Bagh, Azad Jammu and Kashmir, Pakistan. – *AGD Landscape Environ.* 6(1): 31-40.
- Matsuda, I, Tuuga, A, Higashi, S. 2009. Ranging behavior of proboscis monkeys in a riverine forest with special reference to ranging in inland forest. *Int. J. Primatol.* 30:313–325
- Majeed M, Khan MA, Bashir A, Hussain A (2010) Nutritional Value and oil content of Indian Horse-Chestnut seed. *Glob J. Sci. Front Res* 10(4):17–19
- Majolo, B, McFarland, R, Young, C, Qarro, M. 2013. The Effect of Climatic Factors on the Activity Budgets of Barbary Macaques (*Macaca sylvanus*). *Int. J. Primatol.* doi: 10.1007/s10764-013-9678-8
- McKey, D., Gartlan, J. S., Waterman, P. G and Choo, G. M. 1981. Food selection by Black colobus monkeys (*Colobus satanas*) in relation to plant chemistry. *Biological Journal of the Linnean Society*, 16, 115–146
- Menon, V. 2014. *Indian mammals – A Field guide*. Hachette Book Publishing India Pvt. Ltd., 54p.
- Miguel, A., Balboa - Murias Rojo, A., Alvarez, J. G., Merino, A. 2006. Carbon and nutrient stocks in mature *Quercus robur* L. stands in NW Spain. *Anna For Sci.* 63:557–565

- Mir, Z. R, Noor A, Habib, B and Veeraswami, G. G. 2015. Seasonal population density and winter survival strategies of endangered Kashmir gray langur (*Semnopithecus ajax*) in Dachigam National Park, Kashmir, India. *Springer Plus*, 4: 562
- Minhas, R. A., Ahamed, K. B., Awan, M. S. and Dar, N. I. 2010. Social organization and reproductive biology of Himalayan grey Langur (*Semnopithecus ajax*) in Machira National Park, Azad Kashmir (Pakistan). *Pak. J. of Zoo.* Vol. 42: 143 – 156p.
- Minhas, R. A, Basharat, K. A, Awan, M. S and Dar, N. I. 2010. Social Organization and Reproductive Biology of Himalayan Grey Langur (*Semnopithecus entellus ajax*) in Machiara National Park, Azad Kashmir (Pakistan). *Pakistan J. Zool.*, vol. 42(2), pp. 143-156, 2010.
- Minhas, R. A, Ahmed, K. B, Awan, M. S, Zaman, Q, Dar, N. I and Ali, H. 2012. Distribution patterns and population status of the Himalayan Grey Langur (*Semnopithecus ajax*) in Machiara National Park, Azad Jammu and Kashmir, Pakistan. *Pakistan J. of Zool.*, 44(3):869-877.
- Mohnot, S. M. 1971. Some aspects of social changes and infant killing in the Hanuman langur (*Presbytis entellus*) (Primates: Cercopithecoidea) in Western India. *Mammalia*, 35: 175-198.
- Mohnot, S. M. 1974. *Ecology and behavior of the common Indian langur, Presbytis entellus*. Ph.D. thesis, University of Jodhpur, Jodhpur India.
- Mishra, D., Benerjee, S. K., Mishra, T. K. 1997. Comparative phytosociological and soil physio-chemical aspects between managed and unmanaged lateritic land. *Ann. For.* 5(1): 16 – 25.
- Moore, J. 1985. Insectivory by grey langurs. *J. Bombay Nat. Hist. Soc.*, 82(1): 38-44.

- Molur, S., Brandon-Jones, D., Dittus, W., Eudey, A., Kumar, A., Singh, M., Feeroz, M. M, Chalise, M, Priya, P and Walker S. 2003. Status of south Asian primates: Conservation assessment and management plan (C.A.M.P.), vol. 5, Workshop Report, 2003. Zoo Outreach Organization/CBSG-South Asia, Coimbatore, India. p432.
- Newton, P. N. 1986. Infanticide in an undisturbed forest population of hanuman langurs, *Presbytis entellus*. *Anim. Behav.*, 34: 785-789.
- Nandi, J. S, Tikute, S. A, Chhangani, A. K, Potdar, V. A, Tiwari-Mishra, M, Ashtekar R. A, Kumari, J, Walimbe, A, Mohnot, S. M. 2003. Natural infection by simian retrovirus-6 (SRV-6) in Hanuman langurs (*Semnopithecus entellus*) from two different geographical regions of India *J. Virology*, 311(1): 192-201.
- Newton, P. N. 1987. The social organization of forest hanuman langur (*Presbytis entellus*). *Int. J. Primatol.* 8: 199-232.
- Nikolei, J. and Borries, C. 1997. Sex differential behavior of immature hanuman langurs (*Presbytis entellus*) in Ramnagar, South Nepal. *Int. J. Primatol.*, 18: 415-437.
- Nowak, R. M. 1999. Walker's Mammals of the World. Baltimore: The Johns Hopkins Press.
- Orlando, P. 2003. Status of south Asian primates Conservation Assessment and Management Plan (C.A.M.P.) Workshop Report
- Pocock, R. I. 1928. The langurs or leaf monkeys of British India. *J. Bombay Nat. History Society*, 32: 660 – 672
- Poirier, F. E, Bellisari, A, Haines, L. 1978. Functions of primate play behavior. In: Smith EO (ed.) *Social Play in Primates*. Academic Press, New York, 143–168pp.
- Prater, S. H. 1965. *The book of Indian animals*, 2nd ed. (revised), Bombay Natural History Society, Bombay. 323p.
- Pauses, J. G., Austin, M. P. 2001. Patterns of plant species richness in relation to different

environments: An appraisal. *J. Veg. Sci.* 12:153 – 166.

154

- Rahman, H. 1973. The langurs of Gir Sanctuary (Gujarat). A preliminary survey. *J. Bomb. Nat. Hist. Soc.*, 70: 194-314.
- Rajpurohit, L. S., 1987. Male social organization in hanuman langurs (*Presbytis entellus*). Ph.D. thesis, University of Jodhpur, Jodhpur.
- Rajpurohit, L. S., Srivastava, A. and Mohnot, S. M., 1994. Birth dynamics in hanuman langurs, *Presbytis entellus* of Jodhpur, India. *J. Biosci.* 19: 315 – 324.
- Rajpurohit, L. S., Sommer, V. and Mohnot, S. M. 1995. Wanderers between harems and bachelor bands: Male Hanuman langurs (*Presbytis entellus*) at Jodhpur in Rajasthan. *Behavior*, 132: 255-300.
- Rajpurohit, L. S., Chhangani, A. K. and Mohnot, S. M. 2003. Observation of a sudden resident-male replacement in a uni male bisexual troop of hanuman langurs, *Semnopithecus entellus*, around Jodhpur (India). *Folia Primatol.* 74:85-87.
- Rajpurohit, D. S. 2005. Study the dominance hierarchy and its role in social organization in Hanuman langur, *Semnopithecus entellus* Ph.D. thesis, Jai Narain Vyas University, Jodhpur, Rajasthan India.
- Ripley S. 1970. Leaves and leaf monkeys: the social organization of foraging in gray langurs, (*Presbytis entellus thersites*). Napier JR, Napier PH. Old World Monkeys: Evolution, Systematics and Behavior. London: Academic Press, 481-509.
- Roberts, T. J. 1997. *The Mammals of Pakistan* (Revised Edn). Oxford University Press, Karachi, 1-525p.
- Roberts, T. J. 1997. *The Mammals of Pakistan* (Revised Edn). Oxford University Press, Karachi, 1-525p.
- Roonwal, M. L. and Mohnot, S. M. 1977. *Primates of South Asia*. Harvard University Press,

- Sayers, K, Norconk, M. A. 2008. Himalayan *Semnopithecus entellus* at Langtang National Park, Nepal: diet, activity patterns, and resources. *Int. J. Primatol.* 29:509–530
- Sadleir, R. M. F. S. 1969. *The ecology of reproduction in wild and domestic mammals*. London: Methuen
- Saxena, A. K., Singh, J. S. 1982. A phytosociological analysis of woody species in forest communities of a part of Kumaun Himalaya. – *Vegetatio*. 50(1): 3-22.
- Schneider I, Tielen, I. H. M, Rode, J, Levelink, P and Schrudde, D. 2010. Behavioral Observations and Notes on the Vertical Ranging Pattern of the Critically Endangered Cat Ba Langur (*Trachypithecus poliocephalus poliocephalus*) in Vietnam. *Primate Conserv.* 25:111–117
- Sharma, C. M., Suyal, S. 2009. Species richness and diversity along an altitudinal gradient in moist temperate forests of Garwal Himalayas. *J. Amer. Sci.* 119 – 128pp.
- Sharma, N and Ahmed, M. 2017. Distribution of Endangered Kashmir Grey Langur (*Semnopithecus ajax*) in Baderwah, Jammu and Kashmir. *J. Wild. research.* 125 – 127 P.
- Singh, G and Kachroo, P. 1978. Plant community characteristics in Dachigam Sanctuary, Kashmir. Natraj Publications, Dehradun.
- Singh, K. N and Kaushal, R. 2006. Diversity and quantitative analysis of dominant tree species in district Chamba of Himachal Pradesh. *Indian J. For.* 29 (3): 251 – 254.
- Southwick, C. H. and Lindburg, D. G. 1986. The primates of India: Status, trends, and conservation. *Primates Proceedings in Life Sciences.* pp. 171-187.
- Srivastava, A. 1991. Insectivory and its significance to langur diets *J. Primates*, 32(2): 237-241.
- Struhsaker, T. T and Leland, L. 1987. Colobines: Infanticide by adult males. In: *Primate Societies*

- (eds. B. B. Smuts, D.L. Cheney, R. M. Seyfarth, R.W. Wrangham, and T. T. Struhsaker), University of Chicago Press.
- Stanford, C. B. 1991. The capped langur in Bangladesh: behavioral ecology and reproductive tactics. *Contrib. Primatol.* 26:1–179
- Sugiyama, Y. 1965. On the social change of hanuman langurs (*Presbytis entellus*) in their natural conditions. *Primates*, 6: 213-247.
- Sugiyama, Y. 1976. Characteristics of the ecology of the Himalayan langurs. *J. Hum. Evol.* 5:249–27
- Thorington, R. W and Anderson, J. S. 1984. *Orders and Families of Recent Mammals of the World* John Wiley and Sons, New York
- Thomas, L., Buckland, S. T., Rexstad, E. A., Laake, J. L., Strindberg, S., Hedley, S. L., Bishop, J. R. B. Marques, T. A., and Burnham, K. P. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. *J. Appl. Ecol.* 47, 5 – 14.
- Tritsch, M. F. 2001. *Wildlife of India*. Thomson Press Ltd., New Delhi
- Oppenheimer, J. R. 1977. *Presbytis entellus*, the Hanuman langur. In: Bourne GH (ed.) Rainier III (Grimaldi) Prince of Monaco. Academic, Primate Conservation. New York, 469–512pp.
- Van Doorn, A. C, O’Riain, M. J, Swedell, L. 2010. The effects of extreme seasonality of climate and day length on the activity budget and diet of semi-com-mensal chacma baboons (*Papio ursinus*) in the Cape Peninsula of South Africa. *Am J. Primatol.* 72:104 – 112
- Vogel, C. and Loch, H. 1984. Reproductive parameters, adult-male replacements, and infanticide among free ranging langurs (*Presbytis entellus*) at Jodhpur (Rajasthan), India. In: *Infanticide: comparative and evolutionary perspectives* (eds. G. Hausfater and S.B. Hrdy),

Aldine, Hawthorne, N.Y.

Walker, S. and Molur, S. 2004. *Summary of the status of South Asian primates extracted from the CAMP 2003 Report* (2nd Edn.), Zoo Outreach Organization, CBSG South Asia and WILD, Coimbatore, India

Walters, J. and Seyfarth, R. M., .1987. Conflict and co – operation. In: *Primate Societies* (ed. B.B. Smuts, D. L. Cheney, R. M. Seyfarth, R. W. Wrangham and T.T. Struhsaker), University of Chicago Press, Chicago. 306-317pp.

Wilson, D., E. and Reeder, D. M. (Eds.).1992. *Mammal species of the world. A taxonomic and geographic reference*, (2nd Edn.), Smithsonian Institution Press, Washington D. C., 1312.

Zhou Q, Huang C, Li M, Wei F. 2011. Ranging behavior of the Francois' langur (*Trachypithecus francoisi*) in limestone habitats of Nonggang, *China. Integr Zool.* 6:157–164

**COMPARISON OF FEEDING ECOLOGY OF TWO ENDEMIC SPECIES OF
LANGURS,
HIMALAYAN GREY LANGUR (*Semnopithecus ajax*) AND TUFTED GREY LANGUR
(*Semnopithecus priam*)**

By

AAKIB HUSSAIN PAUL

(2017 – 17 – 009)

ABSTRACT OF THE THESIS

Submitted in partial fulfillment of the requirements for degree of

MASTERS OF SCIENCE IN FORESTRY

Faculty of Forestry

Kerala Agricultural University



DEPARTMENT OF WILDLIFE SCIENCE

COLLEGE OF FORESTRY

VELLANIKKARA, TRISSUR – 680 656

KERALA, INDIA

2019

ABSTRACT

159

A field study was conducted to study the feeding ecology of two endemic species of the langurs viz., the Himalayan grey langur (*Semnopithecus ajax*) and Tufted grey langur (*Semnopithecus priam*). The study was conducted from August 2018 to April 2019 in Dachigam National Park, Srinagar and Wayanad Wildlife Sanctuary, Kerala.

The Himalayan grey langur showed typical preference towards a particular feeding item during different seasons. Although the Himalayan grey langur is folivorous yet consumes a variety of food items such as fruits, roots, flowers, buds, bark and twigs. The Himalayan grey langur spent a considerable amount of time in searching and feeding of insects to maintain the ionic balance. The overall maximum feeding was reported in case of *Rosa webbiana* (9.54 %), followed by *Populus deltoides* (8.11 %), *Salix alba* (7.63 %), *Hedera nepalensis* (7.63 %) and *Aesculus indica* (6.9 %). Rosaceae family was most preferred followed by Salicaceae. The most preferred food item was leaves (27.18 %) followed by fruits (22.75 %) and seeds (10.49 %). Average height of feeding was reported to be 5.68 m, which was maximum, in case of *Aesculus indica* and *Pinus wallichiana* (11 m), followed by *Ulmus villosa* (9.8 m) and *Ulmus wallichiana* (9.7 m).

The Tufted grey langur was reported to be feeding on 12 tree species belonging to seven different families. The maximum duration of feeding in case of *Anogeissus latifolia* and *Samanea saman* (18.87 %) followed *Dalbergia lanceolaria* and *Gmelia tillifolia* (9.43 %), *Terminalia bellarica* (7.55 %). The Tufted grey langur diet mainly comprised of leaves, twigs and fruits. The leaves comprised of 60.38 %, twigs 20.75 % and fruits 18.87 %. The average height of feeding was 8.8 m, which was maximum in case of *Hydnocarpus pentandra* (12 m) followed by *T. bellarica* (10.5 m).

The Himalayan grey langur spent maximum time in feeding followed by resting and grooming. The Himalayan grey langur spent 41 % of the time budget activity on feeding, followed by moving (21 %), resting (16%) and grooming (15%).

Vegetation studies using quadrant survey showed a total of 26 species belonging to 16 different families. The species such as *P. wallichiana*, *P. jacquemontiana*, *Q. robur* and *M. alba* as dominant. The IVI was computed to show quantitative relationship among vegetation and

highlight the importance of trees. The IVI values show that most important family of trees is Panacea, Hamamelidaceae, Ulmeace, Fagaceae, Cannabeaceae and Rosaceae.

Although major population areas of *S. ajax* and *S. priam* are protected areas yet special efforts are required for conservation of these valuable species which have been categorized as 'Endangered' and Near threatened' by IUCN.

