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Cover: Himalayan Gray Langur *Semnopithecus ajax* (adult female) © Rupali Thakur.



## INTRODUCTION

The Himalayan Gray Langur was first described by Pocock in 1928 as the least known langur which is found in the western Himalaya (Pocock 1928). Previously, the Himalayan Gray Langur was considered as a sub-species of *S. entellus*. In 2005, it was separated as a species (Walker & Molur 2004; Groves et al. 2005). However, a recent study confirms the species status of the Himalayan langurs (Arekar et al. 2021) which supports *Semnopithecus schistaceus* to be the single species representing Himalayan langurs. The study does not support splitting of Himalayan langurs into three species or sub-species. But, it has been recorded that the western population of Himalayan langurs do form a well-supported subclade (Arekar et al. 2021). Also, the study supports the taxonomy given by Hill (Hill 1939) in which *S. ajax* was mentioned as a sub-species. Hence, this study will consider the population in Kalatop-Khajjiar Wildlife Sanctuary (Western Himalaya), which is close to the type locality of the species, as *Semnopithecus ajax* until a detailed taxonomic study on the western population clarifies this issue according to the International Code for Zoological Nomenclature guidelines.

According to previous research, the species is known to be found in three countries including India, Nepal, and Pakistan. It was found in Great Himalayan National Park, Kalatop-Khajjiar, and Manali Wildlife Sanctuary in Himachal Pradesh (Walker & Molur 2004). Strong evidences suggest that in Himachal Pradesh, *S. ajax* is restricted to Chamba valley (Pocock 1928; Brandon-Jones 2004; Walker & Molur 2004; Groves & Molur 2008). Currently, *Semnopithecus ajax* is considered 'Endangered' globally because "the population is very small, estimated to be less than 1,500 mature individuals in 15–20 subpopulations with no subpopulation having more than 150 mature individuals" (Kumar et al. 2020).

Studying the diet composition of animals facing harsh conditions offers an insight into their interaction with the extreme environments and understanding their ecology (Mir et al. 2015). It is crucial to gain information about the diet preferred by this endangered and endemic species of the Himalaya for future conservation actions. Scan sampling method has been used in many studies to estimate the diet composition of primates where it was not possible to follow a focal group for longer periods (Marsh 1981; Stanford 1991; Newton 1992; Dasilva 1994; Li & Rogers 2004; Dela 2007; Guo et al. 2007; Mir et al. 2015). This paper presents a preliminary information about diet of Himalayan Gray Langurs in Kalatop-Khajjiar wildlife sanctuary between September 2020 to

November 2020.

## Study area

The study was conducted in Kalatop-Khajjiar Wildlife Sanctuary located within the geo-coordinates (32.52417–32.56611 °N & 76.01–76.06667 °E) in Chamba district, Himachal Pradesh. The area of the sanctuary has been reduced to 17.17 km<sup>2</sup> subsequent to rationalization by the state government (Notification No. FEE-B-F (6)11/2005-II/Kalatop-Khajjiar dated 07 June 2013). The Kalatop-Khajjiar Wildlife Sanctuary is located in the western extremity of the Dhauladhar range of western Himalaya at an altitude ranging of 1,185–2,768 m. It is one of the oldest preserved forests of Himachal Pradesh (notified on 01.vii.1949) located in the catchment area of the Ravi River (Kumar et al. 2014; Shah et al. 2016). Mean annual rainfall is 800 mm and temperature ranges -10–35 °C. The area experiences southwestern monsoon rains in July–September (Shah et al. 2016). The vegetation of the Kalatop-Khajjiar Wildlife Sanctuary is mainly moist Deodar forest and western mixed coniferous forest with alpine pastures at some higher elevations (Champion & Seth 1968).

## METHODS

The study on the feeding ecology of the endangered Himalayan Gray Langur was conducted from August 2020 to January 2021. The data collection was divided into primary and secondary data.

### Secondary data

Previous research papers on the diet of *Semnopithecus ajax* were studied and separately analyzed. The resulting analyses from all the literature was then compared with each other and the common elements were estimated using statistical methods in MS Excel to plot graphs.

### Primary data via scan sampling

Feeding data for Himalayan Gray Langurs was collected via scan sampling method (Altmann, n.d. 1974) for two months between September 2020 to November 2020 focusing on the autumn diet of the species. The scan interval was set at 5 min for 15 min scan sample. The groups were followed from around 0900 h (first established visual contact with the group) to 1500 h (when visual contact was lost or no feeding). All the observations were done through the naked eye or DSLR (Nikon D3500). The entire wildlife sanctuary is divided into two forest divisions namely, Kalatop forest

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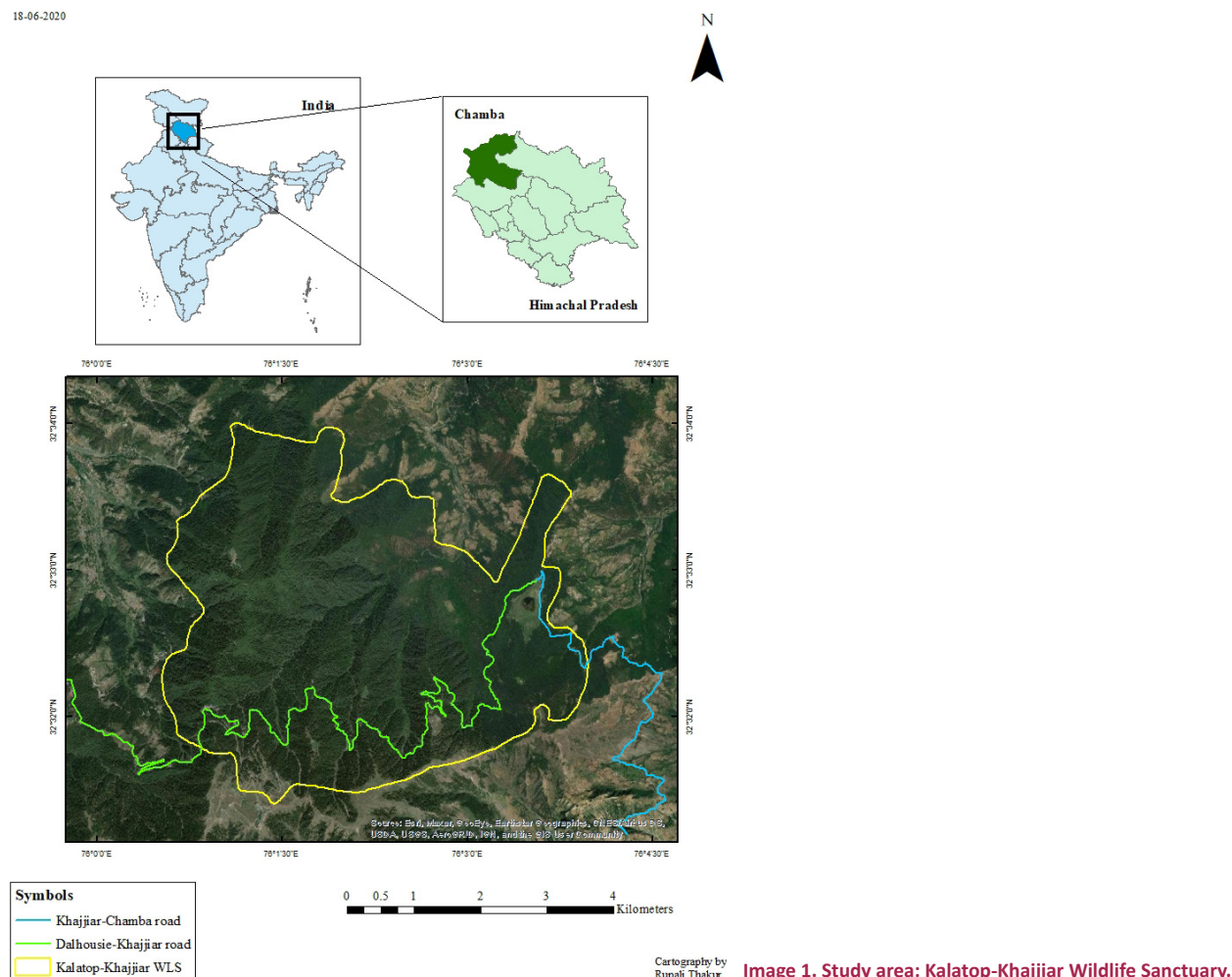
Cartography by  
Rupali Thakur

Image 1. Study area: Kalatop-Khajjiar Wildlife Sanctuary.

and Khajjiar forest. One month of sampling per forest was conducted. A total of 71 scan sampling observations were collected and later used for analysis. Data such as group identification, GPS coordinates, group composition (age-sex classification), and group size were collected in the initial 10–15 min after the encounter with langurs. During feeding behavior, each visible animal was observed for about 5–10 seconds and plant species and the part of plant eaten were observed. Plant specimens were later collected for further identification which were also used to prepare a dry herbarium. Plant parts were classified as leaves (Mature and young or leaf buds), bark or stem, fruit, flower, and seed.

### Analysis

**Diet:** Percentage contribution of each plant species in the diet of Himalayan Gray Langurs was estimated by using the formula:  $Pa = (na / N) * 100$

Where, na is the total number of times feeding was observed on species a, and

N is total feeding observed for all species during the study period

Percentage of time spent feeding on different plant parts have been calculated (Guo et al. 2007) as: (Number of scans where item i was recorded as food / Total number of scans where feeding was recorded) \* 100

A digital herbarium has been created with the help of Microsoft PowerPoint enlisting all the food plant species eaten by the Himalayan Gray Langurs inside the sanctuary.

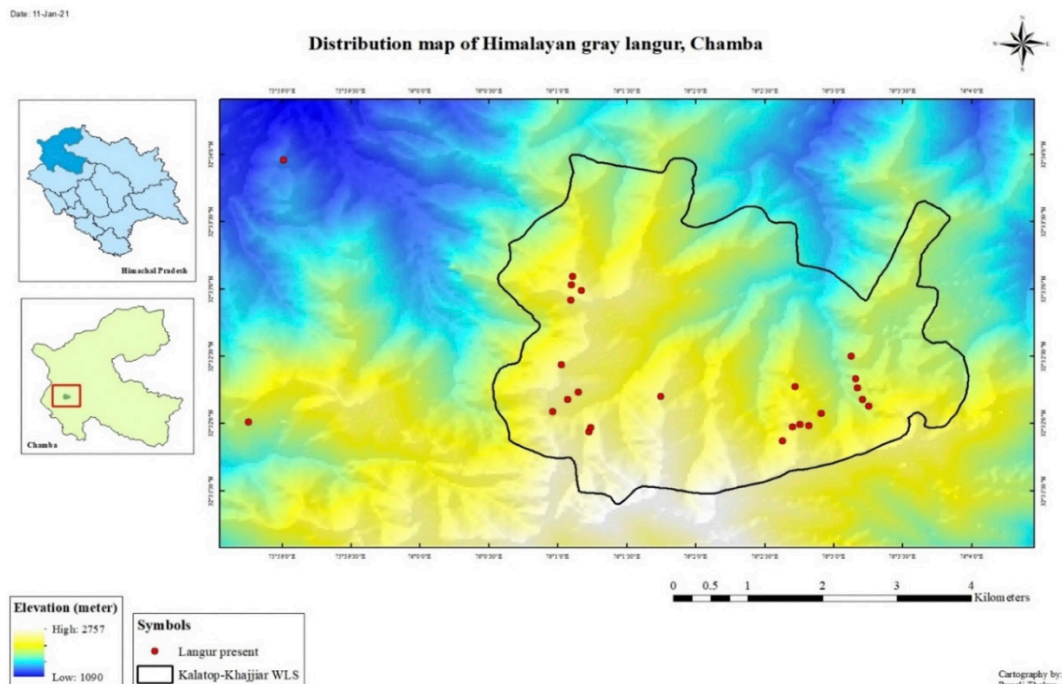
## RESULTS

### Diet composition from secondary data

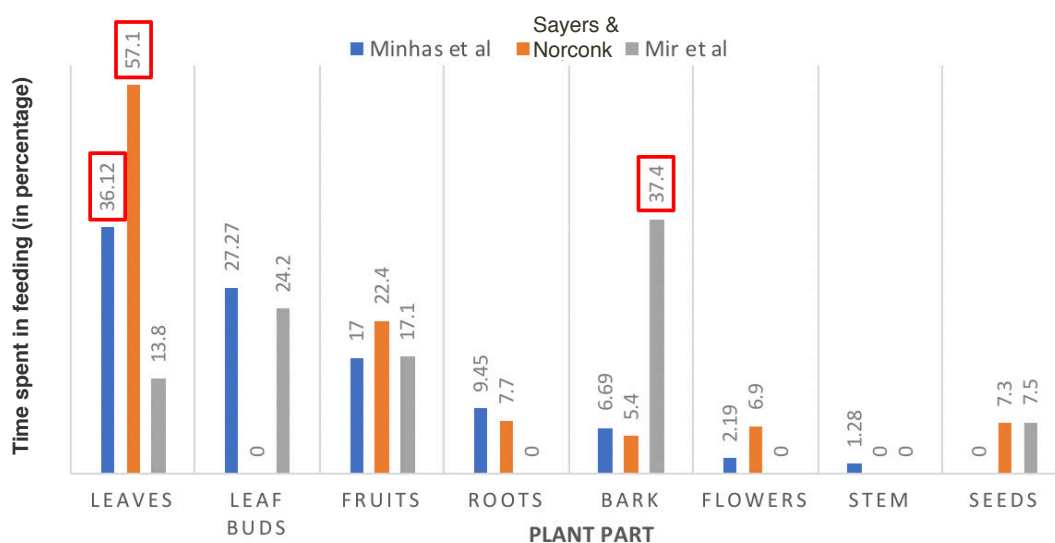
Six genera (*Aesculus*, *Quercus*, *Hedera*, *Salix*, *Berberis*, and *Prunus*) contributed to the major share of Himalayan Gray Langur's diet as shown from previous studies. It also reflects that genus *Aesculus* is the most preferred by langurs.



Date: 11-Jan-21



**Image 2.** The distribution of Himalayan Gray Langurs in and around the Kalatop-Khajjiar Wildlife Sanctuary.



**Figure 1.** Time spent on different plant parts by Himalayan Gray Langurs (in percentage).

From previous studies (Sayers & Norconk 2008; Minhas et al. 2010; Mir et al. 2015) it has been shown that Himalayan Gray Langurs spent most of their feeding time on leaves and leaf parts (Figure 1) which highlights their folivorous diet that has been clearly reflected in case of both Minhas et al. and Sayers (Sayers & Norconk 2008; Minhas et al. 2010). But Mir et al. (2015) observed that bark is more preferred as compared to leaves because this particular study was conducted in the

winter season and it was more focused on the winter survival strategies of these langurs in the Himalayan terrain of Dachigam National Park.

#### Results from primary data

Total five groups of langurs were observed during the entire study period (Table 1). Out of these five groups, two groups (A and B) were located outside the protected area near the boundaries. The distribution of Himalayan

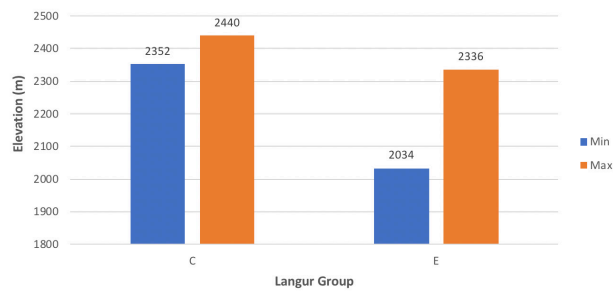


Figure 2. Distribution of Langur groups based on elevation.

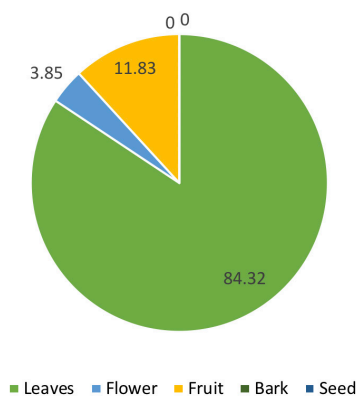


Figure 3. Composition of different plant parts (in percentage) in the diet of langurs during autumn season.

Gray Langurs inside and around the Kalatop-Khajjiar wildlife sanctuary is illustrated in Image 2 which shows the presence of langurs at varying elevations inside the study area ranging 1,400–2,500 m. Out of these five groups, two groups—Group C and Group E located in Kalatop forest and Khajjiar forest respectively—were followed for observation on diet composition as observations of all five groups were limited due to habitat characteristics. The elevation range for Group C was 2,352–2,440 m and for Group E was 2,034–2,336 m (Figure 2); average being 2,396 m for Group C (Kalatop) and 2,188 m for Group E (Khajjiar) with a difference of ~200 m.

### Diet composition

Langurs in Kalatop-Khajjiar were observed to feed on 20 plant species from 15 different botanical families found naturally in their habitat during the autumn season. Nearly half of the langur diet (54.39%) was found to be made up of leaves of *Hedera nepalensis* and *Quercus oblongata*. Fruits of *Ilex dipyrrena* also

Table 1. Group size and composition of five groups of Himalayan Gray Langurs in and around the Kalatop-Khajjiar Wildlife Sanctuary, Chamba, Himachal Pradesh.

Group	Group size	Group composition			
		Adult male	Adult female	Sub-adults	Infants
A	12	1	3	NA	2
B	20	1	7	4	NA
C	38	2	14	12	7
D	35	1	10	13	8
E	48	2	24	21	3
<b>Total</b>	<b>153</b>	<b>7</b>	<b>58</b>	<b>50</b>	<b>19</b>

Count of total individuals and sub-types are an estimate only (not exact) and few sub-types are marked as NA because they could not be counted accurately.

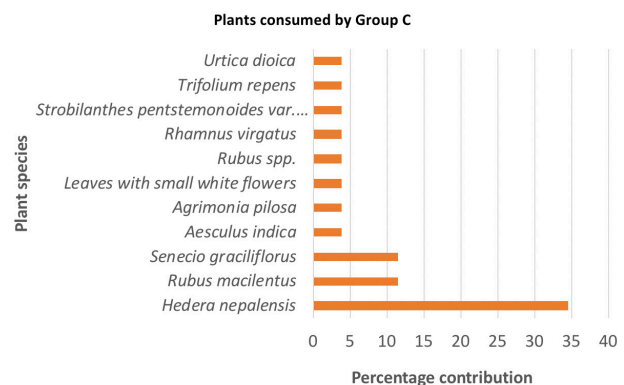


Figure 4. Percentage contribution of different plants for Group C (Kalatop).

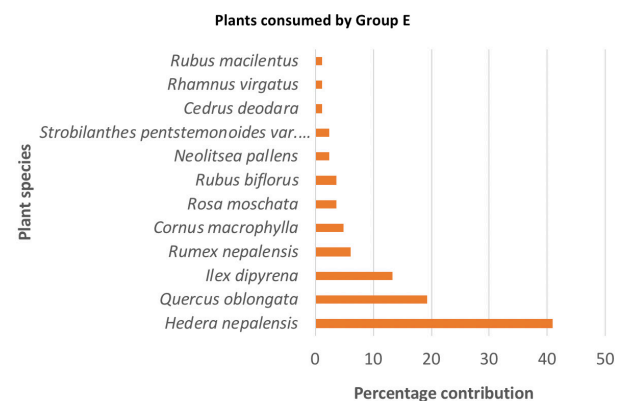


Figure 5. Percentage contribution of different plants for Group E (Khajjiar).

constituted nearly 10% of the langurs diet, followed by the leaves of *Rumex nepalensis*. The percentage contribution of other species to the langur diet is given in Table 2. Langurs from Kalatop forest were also observed to feed occasionally on a fungus species (*Russula* spp.) growing on the forest floor.

During the entire study period, langurs shown



Plants consumed by Himalayan gray langurs in Kalatop-Khajjiar WLS during the study period

S.no	Plant Species	Local name	Family	Type	Part consumed
1	Aesculus indica	Goon	Sapindaceae	Tree	Fruit
2	Agrimonia pilosa	Jharod	Rosaceae	Herb	Flower
3	Berberis lycium	Kaimlu	Berberidaceae	Shrub	Fruit
4	Cedrus deodara	Dyar	Pinaceae	Tree	Leaves
5	Cornus macrophylla	Haleu	Cornaceae	Tree	Fruit
6	Grass species	-	-	Herb	Leaves
7	Hedera nepalensis	Korein	Araliaceae	Climber	Leaves
8	Ilex dipyrena		Aquifoliaceae	Tree	Fruit
9	Neolitsea pallens	Chirndi	Lauraceae	Tree	Leaves
10	Quercus oblongata	Ban	Fagaceae	Tree	Leaves
11	Rhamnus virgatus		Rhamnaceae	Shrub	Fruit
12	Rosa moschata	Kareri	Rosaceae	Shrub	Fruit
13	Rubus biflorus	Akhe	Rosaceae	Shrub	Leaves
14	Rubus macilentus	Aakhredi	Rosaceae	Shrub	Leaves
15	Rubus spp.	-	Rosaceae	Shrub	Leaves
16	Rumex nepalensis	Jangali palak	Polygonaceae	Herb	Leaves
17	Senecio graciliflorus	Kakeyi	Asteraceae	Herb	Flower
18	Strobilanthes pentstemonoides var. dalhousieana	Saunda	Acanthaceae	Herb	Flower
19	Trifolium repens	Amlu	Fabaceae	Herb	Leaves
20	Urtica dioica	Aind	Urticaceae	Herb	Leaves

Image 3. Digital herbarium a—Title slide | b—List of plants consumed by Himalayan Gray Langurs.

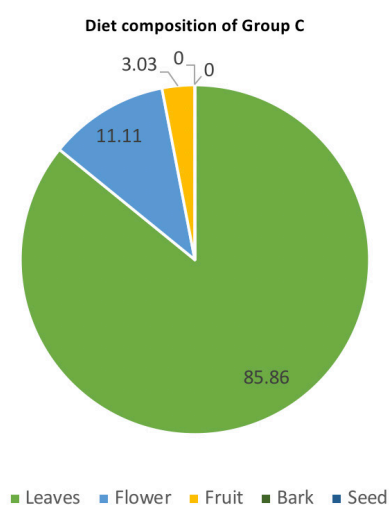


Figure 6. Diet composition of Group C.

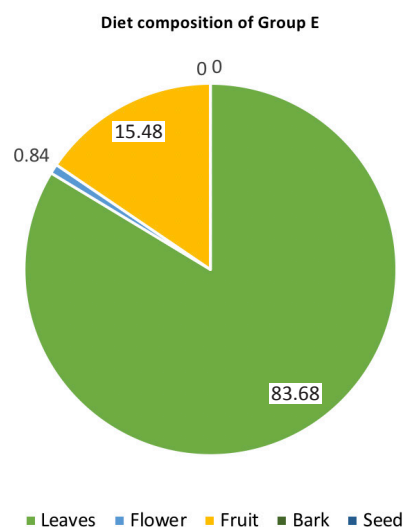


Figure 7. Diet composition of Group E.





Image 4. *Semnopithecus ajax*: a—Adult male | b—Adult female. © Rupali Thakur.



Image 5. *Semnopithecus ajax*: a—sub-adult | b—infant. © Rupali Thakur.



Image 6. Activities performed by *Semnopithecus ajax*: a—feeding | b—grooming. © Rupali Thakur.

**Table 2.** Plant species consumed by Himalayan Gray Langurs and their percentage contribution in Kalatop-Khajjiar wildlife sanctuary, Himachal Pradesh.

	Plant Species	Local name	Family	Type	Part consumed	Percentage contribution (%)
1	<i>Hedera nepalensis</i>	Korein	Araliaceae	Climber	Leaves	38.60
2	<i>Quercus oblongata</i>	Ban	Fagaceae	Tree	Leaves	15.79
3	<i>Ilex diphyrena</i>		Aquifoliaceae	Tree	Fruit	9.65
4	<i>Rumex nepalensis</i>	Jangali palak	Polygonaceae	Herb	Leaves	4.39
5	<i>Rubus macilentus</i>	Aakhredi	Rosaceae	Shrub	Leaves	3.51
6	<i>Cornus macrophylla</i>	Haleu	Cornaceae	Tree	Fruit	3.51
7	<i>Senecio graciliflorus</i>	Kakeyi	Asteraceae	Herb	Flower	2.63
8	<i>Strobilanthes pentstemonoides</i> var. <i>dalhousieana</i>	Saunda	Acanthaceae	Herb	Flower	2.63
9	<i>Rubus biflorus</i>	Akhe	Rosaceae	Shrub	Leaves	2.63
10	<i>Rosa moschata</i>	Kareri	Rosaceae	Shrub	Fruit	2.63
11	<i>Cedrus deodara</i>	Dyar	Pinaceae	Tree	Leaves	1.75
12	<i>Rhamnus virgatus</i>		Rhamnaceae	Shrub	Fruit	1.75
13	<i>Neolitsea pallens</i>	Chirndi	Lauraceae	Tree	Leaves	1.75
14	<i>Berberis lycium</i>	Kaimlu	Berberidaceae	Shrub	Fruit	0.88
15	<i>Agrimonia pilosa</i>	Jharod	Rosaceae	Herb	Flower	0.88
16	<i>Trifolium repens</i>	Amlu	Fabaceae	Herb	Leaves	0.88
17	<i>Urtica dioica</i>	Aind	Urticaceae	Herb	Leaves	0.88
18	<i>Aesculus indica</i>	Goon	Sapindaceae	Tree	Fruit	0.88
19	<i>Rubus</i> spp.	-	Rosaceae	Shrub	Leaves	0.88
20	Grass species	-	-	Herb	Leaves	0.88

a greater preference of leaves (84.32%) in the diet followed by fruits (11.83%) and then other parts of plants. However, no such feeding on bark or seeds has been recorded during the study period.

A difference in the contribution by plant species (Figure 4,5) and plant parts eaten (Figure 6,7) by Group C and E, respectively, has been recorded as well.

On comparing the diet consumption of both the study groups in the area, it can be seen that leaves constitute the major portion of the langur diet. However, after leaves langurs from Group C fed mostly upon flowers (11.11%) while that of Group E preferred fruits (15.49%) which may depend upon the difference in their distribution in terms of elevation and availability of particular plant part.

Langurs from Group C (Kalatop forest) were observed feeding upon a fungus (*Russula* spp.).

## DISCUSSION

The present study recorded 20 plant species used as food belonging to 15 botanical families and 17 genera,

utilized by Himalayan Gray Langurs living in the Kalatop-Khajjiar Wildlife Sanctuary during the autumn season. The most preferred species were *Hedera nepalensis*, *Quercus oblongata*, *Ilex diphyrena*, and *Rumex nepalensis*. In other studies at different locations, these langurs were reported to feed upon 13 plant species (Mir et al. 2015), 43 species (Sayers & Norconk 2008), and 49 species (Minhas et al. 2010) but that depends upon the time period of research study and seasons. It has been observed and estimated that the diet of langurs includes 84.32% leaves, 11.83% fruits, and 3.85% flowers. Similar results have been observed by others as well where leaves contributed to a large share of primates diet (Yoshida 1967; Stanford 1991; Sayers & Norconk 2008; Minhas et al. 2012; Nautiyal 2015). This may be the result because of high nutritional values in leaves such as high concentration of calcium in mature leaves and crude protein in young leaves and other factors such as high water content, easy digestibility, and low fiber (Oates et al. 1980; Ramanathan 1994). The second most preferred part was fruits as they are considered to contain large quantities of simple sugar in them thus a quick source of easy energy for primates (Ramanathan 1994).





Image 7. Activities performed by *Semnopithecus ajax*: a—resting | b—playing. © Rupali Thakur.

Also, on comparing the results of primary data analysis with secondary data it can be seen that leaves are the most preferred plant part in both the cases. Phenology plays a prominent role in determining the diet of these primates. Seasonal variation in phenology determines the presence of leaves, flowers, fruits in a forest. Thus, although langurs are generalist feeders, their diet selection depends upon phenology or food abundance as well (Adhikaree & Shrestha 2011).

Langurs according to this study fed upon mature leaves along with young leaves which supports that Himalayan Gray Langurs broaden the feeding repertoire by inhabiting such a difficult environment where they can feed upon mature leaves as well.

Overall, the langurs preferred leaves but; after leaves langurs from Group C fed mostly upon flowers while that of Group E preferred fruits which might depend upon the difference in their distribution in terms of elevation as Group C of Kalatop forest was located on higher elevation than Group E of Khajjiar forest with approximate difference of 200 m in elevation along with the availability of particular plant part. Altitude is a strong predictor for the diet of Colobines (Tsuji et al. 2013), but it was mostly recorded in large elevation ranges only.

## RECOMMENDATIONS

An annual study on their diet is recommended. People who wish to conduct a long-term study on this primate species in the area should include a comparison of diet or behaviour in forested groups and urbanized groups as it can bring new insights. This can also help to formulate specific conservation action for both the groups. The results from this study can help in forming an initial

baseline data for upcoming studies in the area.

A population census for Himalayan Gray Langurs in the district is recommended as it will help in estimating the current scenario for this primate and then further improve the conservation practices. Honking should be avoided as much as possible because the area holds immense wildlife. A pre-determined speed limit should be followed inside the sanctuary. Engagement with wild animals is highly prohibited and should be avoided. A small nature awareness area may be constructed to guide tourists on the significance of the sanctuary and the animals with some 'Dos' and 'Don'ts'.

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