Winter Diet Composition of Himalayan goral (Naemorhedus goral) in Kazinag National Park, Jammu and Kashmir, India

Jahangir Ahmad Dar, Mustahson F. Fazili, Bilal A. Bhat and Riyaz Ahmad

Abstract—Understanding winter diet composition of wild ungulates in temperate habitats is of paramount importance for informing conservation measures. The winter diet composition of Himalayan goral (Naemorhedus goral), one of the least studied ungulate species in Kazinag National Park (KNP) of Jammu and Kashmir, India was assessed after preparing reference photographs of various parts of 28 available plant species through micro-histological technique. On analyzing 60 faecal samples, 2454 plant fragments belonging to 17 plant species were identified after comparing reference plants. By applying Ivlev’s electivity index (IEI), it was revealed that shrubs were strongly preferred (IEI = 0.19) during winter. Among them, Indigotera heterantha (DSV =2.47) was strongly selected followed by Viburnum grandiflorum (DSV=1.64), Prunus tomentosa (DSV=1.51), Rosa macrophylla (DSV=1.40) and Lonicera obovata (DSV=1.21). Himalayan goral adopted a browser strategy during winter when availability of grasses was low as inferred from the ratio of browse to grass (59.55% : 28.88%). Chi-square goodness of fit test showed that Himalayan goral did not feed on all plant species uniformly (p< 0.05). Our findings suggest that Himalayan goral has feeding plasticity to adapt to uneven diet availability. We recommend that plant species which are the major components of winter diet of Himalayan goral during resource-lean winter be conserved and the propagation of these taxa be encouraged.

Index Terms— diet composition, himalayan goral, Kazinag National Park, resource-lean, winter.

1. INTRODUCTION

Winter, a season with harsh climatic conditions, is an important period for the survival of most mountain ungulates due to limited availability of preferred forage and energetic costs associated with movements through deep snow [1], [2],[3] and [4]. Environments with heavy snowfall and steep topography tend to have strong spatial and seasonal differences in food availability for ungulates [5] and [6]. The winter snow cover is one of the most important abiotic factors affecting the selection of resources. Ungulates inhabiting such extreme habitats cope with harsh winter and deep snow cover by using a variety of strategies like restriction of movements through deep snow [7] and [5]. Information about food habits of a species is a determining component for its survival, health, and mobility [8] and [9]. The composition and selection of various food items during different seasons is a fundamental element to understand multiple aspects of ungulate ecology [10]. The behavior of mountain ungulates is mainly affected by availability of food plants and the ways in which these are obtained during different seasons. The diet of an animal species is a determining aspect of ecological niche and its quantification has been one of the most significant steps in studying basic ecology of an animal [11] and [12]. Determination of diet composition of the wild ungulates is therefore, important for sustainable wildlife and ecosystem management [13], [14] and [15]. The Himalayan goral (Naemorhedus goral) is endemic to Himalayan stretch and is listed in Appendix I of the CITES [16]. Its status as Near Threatened [17] calls for an urgent conservation action. One of the important steps towards conservation is the identification of winter diet items. Winter a critical season with severe conditions and scarcity of food has adverse impact on the survival of wild animals and information on diet composition during this critical season is crucial to frame conservation action for maintaining viable populations in the wild [18]. The present study was undertaken with the aim to evaluate winter diet composition of one of the least studied ungulate species, Himalayan goral in Kazinag National Park (KNP) of Kashmir. The data on diet composition would be useful to conservation stakeholders for planning forage and habitat management measures.

2. Materials and Methods

2.1 Study Area

The study was conducted in KNP (34°10′0″N and 74°20′0″E) with an altitudinal range of 1,800 – 4,700m, located in the North-West Himalayan Bio-geographic zone of India (2A) [19] in the valley of Kashmir. Carved out from three protected areas, Lachipora Wildlife Sanctuary, Limber Wildlife Sanctuary and Naganari Conservation Reserve, the park comprises a total area of 157 km² (Fig.1). The vegetation in general is temperate coniferous, sub alpine and alpine type [20] dominated by Pine (Pinus wallichiana), Deodar (Cedrus deodara) and Fir (Abies pindrow) in the lower and middle elevations. At higher elevations, the subalpine forest is dominated by Birch (Betula utilis) and mixed forests where as the alpine vegetation is dominated by Juniper (Juniperus squamata) and alpine meadows. The lower areas of riverine forests are dominated by Horse
Chestnut (*Aesculus indica*) and cranberry bush (*Viburnum grandiflorum*). There are temperate grasslands with rolling terrain at lower elevations. Temperature varies from a minimum of $-10^\circ$ C in winter to a maximum of $30^\circ$ C in summer. The precipitation is mainly brought by Western disturbances during winter and fall largely as snow, and is surely a factor of importance in determining the type of forests and the seasons in the area. The four distinct seasons in the region are: Spring (March to May), Summer (June to August), Autumn (September to November) and Winter (December to February).

2.2 Data collection
The present study was carried out during winter from December, 2017 to February, 2018. The study was based on the microscopic recognition of indigestible plant fragments mainly the epidermal features characteristic of different plant groups obtained from faecal pellets. Faecal analysis was done by the procedures outlined by Holechek *et al.*, [21]. The process includes preparation of reference slides of plants, collection of faecal samples, preparation of slides of faecal samples and identifications of plant fragments from the slides of faecal samples using reference slides of plants as followed by [22], [23] and [24].

2.3 Preparation of plant reference slides
Reference slides of plants were prepared for available plant species, which were determined by vegetation sampling of the area and identified from the Centre of Plant Taxonomy, University of Kashmir. For this 12 line transects of 2km each, were laid in four different winter range habitats: coniferous forest, grassland, cliffy and riverine areas. Along each transect plots of radius 10m were laid at regular intervals of 200m. The selection of these species as potential food plants was based on field observations and interviews of wildlife officials and locals. Plant samples collected were dried, shredded and placed in a test tube. Nitric acid (33%) and water in the ratio of 1:3 were added to the test tube. The test tube was heated in a water bath for five minutes. When solid material settled down, nitric acid was decanted and fresh nitric acid (33%) was added. The mixture was again boiled till the material of the test tube became transparent (chlorophyll free). The material was then thoroughly washed in running water to remove nitric acid. The sample was stained with saffirein for two minutes to stain properly. After staining, the sample was washed repeatedly in distilled water and dehydrated by passing through a mixture of alcohol and distilled water in the ratio of 1:3, 1:1 and 3:1 respectively. The sample was finally placed in absolute alcohol. The mounting was done in canada balsam and photograph of each sample was captured using a digital microscope (Olympus BX60).

2.4 Field collection of faecal samples
Faecal samples totaling 60 pellet samples were collected along 12 permanent transects. Pellets of one group of faeces were considered as one sample. From one sample four pellets were randomly selected for analysis [14]. The pellets of Himalayan goral were differentiated from markhor, musk deer, sheep and goat on the basis of morphological characters viz., dimension, shape and size [25]. Sampling plots were designed in a systematic manner, from randomly placed starting points. All sampling points were laid parallel to the track and almost equidistant (100 m) from one another. Wherever pellets were collected, a widely used plot size of 10m x 10m was laid around the pellets for studying dietary patterns of wild animals [26], [27], [28] and [29]. We followed Latham *et al.*, [30] to age pellets as fresh (moist or oily texture), old (dry, slightly crusted), or aged (decaying).

2.5 Preparation of slides of faecal samples
Randomly selected oven-dried pellets from each faecal sample were grinded and passed through two successive sieves (mesh sizes: 5 and 3 mm). The course material was discarded and the fine powder was retained for further analysis. Fine material was transferred in a test tube having nitric acid (33%) and water in the ratio of 1:3. The test tube was allowed to heat in a water bath for 5 minutes. After settling, fresh nitric acid (33%) and water were added and the material was again boiled in order to obtain a fairly transparent (depigmented) material. The material was then thoroughly washed with running water repeatedly until the nitric acid is completely removed. The washed samples were used for preparing slides for analysis. Three slides were prepared for each sample giving a total of 180 (60 samples x 3 slides) for Himalayan goral in winter. While identifying the plant fragments, four fields of view (FOV) were considered giving a total of 720 FOV. Plant fragments from the pellets were identified with the help of reference slides of vegetation on the basis of characteristics such as cell wall, cell shape, trichomes and stomata [21].

2.6 Data Analysis
The relative frequency of a plant species in faecal samples was calculated and expressed as relative importance value (RIV), which is the total number of fragments identified for a given food species divided by the total number of all counts made in the sample and expressed as a percentage [31]. Diet selection value (DSV) was calculated after Jnawali, 1995 as follows:

$$DSV_x = \frac{RIV_x}{PV_x}$$

where $RIV_x$ is the RIV for species $x$, and reflects the relative frequency of a plant species in the faeces. $PV_x$ is the prominence value (PV) for species $x$, and reflects the relative availability of plant species in the goral habitat. PV was calculated following Koirala *et al.*, [32] as follows:
PV_x = M_x x \sqrt{I_x}

where M_x is the % cover of species x and f_x is the food occurrence of species x in sample quadrats. Food preference of goral was determined by calculating Ivlev's electivity index (IEI) [33] using the equation:

IEI = r_i - p_i / r_i + p_i,

where r_i is the proportion of vegetation type i in the diet of Himalayan goral, and p_i is the proportion of vegetation type i along all the systematically sampled quadrats (i.e., its availability in the habitat). IEI of 1.0 denotes maximum preference of a vegetation type, 0 denotes use in proportion to availability, and a value of -1.0 denotes complete avoidance [33]. The data was analyzed using statistical packages MS-Excel 2007 and MINITAB (version 13.2) at confidence level of 95 % and P<0.05 for significance.

3. Results

During winter, 28 species of plants from 28 genera and 19 families were recorded (Table 1). Species with highest prominence value, a measure of availability, included Pinus wallichiana (PV= 17.27), Cyanodon dactylon (PV= 12.61), Cedrus deodara (PV= 12.23), Picea smithiana (PV= 10.35), Stipa sibirica (PV= 8.85) and Indigofera heterantha (PV= 8.26). The overall availability of plant categories was different with trees having highest availability (PV= 53.21) followed by grasses (PV= 51.7), shrubs (PV= 45.06) and herbs (PV= 13.27). A total of 17 plant species belonging to nine different families from 2454 identified plant fragments were recorded by faecal analysis. Of these, 1463 represented browse species and 709 represented graze species (Fig. 2). Apart from the identified plants fragments, 282 unidentified fragments with a percent occurrence of 11.49 were excluded from statistical analysis. Among browse species, shrubs were most dominant with an overall occurrence of 50.93%. Grasses represented 28.88% of the identified fragments while as herbs were not recognized during the faecal analysis. The dominant shrubs in the diet were Indigofera heterantha (RIV= 20.41), Prunus tomentosa (RIV= 10.59), Lonicera obovata (RIV= 6.19) and Rosa macrophylla (RIV= 2.56). The dominant tree species in the diet was Pinus wallichiana (RIV= 3.87) and Poa pratensis was the dominant grass species (RIV= 12.02). We identified no tree species that goral consumed significantly in higher proportion than their availability. Plant species utilized more than their availability included Indigofera heterantha (PV= 8.26, RIV= 20.41), Prunus tomentosa (PV= 6.98, RIV= 10.59), Rosa macrofolia (PV= 1.82, RIV= 2.56), Poa pratensis (PV= 9.05, RIV= 12.02), Lonicera obovata (PV= 5.11, RIV= 6.19) and Viburnum grandiflorum (PV= 2.05, RIV= 3.74). However, Cedrus deodara (PV= 12.23, RIV= 1.95), Aesculus indica (PV= 4.52, RIV= 0.93), Picea smithiana (PV= 10.35, RIV= 1.71), Abies pindrow (PV= 8.00, RIV= 0.16), Pinus wallichiana (PV= 17.27, RIV= 3.87), Elaeagnus umbellata (PV= 8.05, RIV= 5.37), Cotoneaster nummularius (PV= 2.28, RIV= 2.07), Cyanodon dactylon (PV= 12.61, RIV= 6.76), Bothriochola ischaemum (PV= 6.21, RIV= 4.43), Themeda spp. (PV= 8.05, RIV= 3.34) and Stipa sibirica (PV= 8.85, RIV= 2.40) were utilized less than their availability. The dominant plant categories were trees and grasses in winter but were utilized relatively in lower proportions (Fig. 3). The number of identified plant fragments from pellets differed significantly at species level ($\chi^2=1674.36$, df $= 16$, $p=0.000$), at family level ($\chi^2= 1661.37$, df $= 8$, $p=0.000$) and at growth form level ($\chi^2= 573.52$, df $= 2$, $p=0.000$). Himalayan goral strongly selected Indigofera heterantha (DSV $= 2.47$) followed by Viburnum grandiflorum (DSV $= 1.64$), Prunus tomentosa (DSV $= 1.51$), Poa pratensis (DSV $= 1.32$) and Lonicera obovata (DSV $= 1.21$) during winter. Ivlev's electivity values show that Himalayan goral shows a strong preference for shrubs during winter and least preference for grasses and trees (Fig.4).

<table>
<thead>
<tr>
<th>Species</th>
<th>Family</th>
<th>Part consumed</th>
<th>PV</th>
<th>DSV</th>
<th>Mean Relative Importance Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pinus wallichiana (T)</td>
<td>Pinaceae</td>
<td>Leaf</td>
<td>17.27</td>
<td>0.22</td>
<td>3.87</td>
</tr>
<tr>
<td>Picea smithiana (T)</td>
<td>Pinaceae</td>
<td>Leaf</td>
<td>10.35</td>
<td>0.16</td>
<td>1.71</td>
</tr>
<tr>
<td>Abies pindrow (T)</td>
<td>Pinaceae</td>
<td>Leaf</td>
<td>8.00</td>
<td>0.02</td>
<td>0.16</td>
</tr>
<tr>
<td>Cedrus deodara (T)</td>
<td>Coniferae</td>
<td>Leaf</td>
<td>12.23</td>
<td>0.15</td>
<td>1.95</td>
</tr>
<tr>
<td>Aesculus indica (T)</td>
<td>Hippocastanaceae</td>
<td>Leaf</td>
<td>4.52</td>
<td>0.20</td>
<td>0.93</td>
</tr>
<tr>
<td>Celtis australis (T)</td>
<td>Ulmaceae</td>
<td>NU</td>
<td>0.84</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Prunus tomentosa (S)</td>
<td>Rosaceae</td>
<td>Leaf, Twig</td>
<td>6.98</td>
<td>1.51</td>
<td>10.59</td>
</tr>
<tr>
<td>Cotoneaster nummularius (S)</td>
<td>Rosaceae</td>
<td>Leaf, Twig</td>
<td>2.28</td>
<td>0.90</td>
<td>2.07</td>
</tr>
<tr>
<td>Rosa macrophylla (S)</td>
<td>Rosaceae</td>
<td>Leaf, Twig</td>
<td>1.82</td>
<td>1.40</td>
<td>2.56</td>
</tr>
<tr>
<td>Indigofera heterantha (S)</td>
<td>Fabaceae</td>
<td>Leaf, Twig</td>
<td>8.26</td>
<td>2.47</td>
<td>20.41</td>
</tr>
<tr>
<td>Lonicera obovata (S)</td>
<td>Caprifoliaceae</td>
<td>Leaf, Twig</td>
<td>5.11</td>
<td>1.21</td>
<td>6.19</td>
</tr>
<tr>
<td>Euonymus hamiltonianus (S)</td>
<td>Celastraceae</td>
<td>NU</td>
<td>1.52</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Lespedeza elegans (S)</td>
<td>Papilionaceae</td>
<td>NU</td>
<td>1.03</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Elaeagnus umbellatus (S)</td>
<td>Elaeagnaceae</td>
<td>Leaf, Twig</td>
<td>8.05</td>
<td>0.66</td>
<td>5.37</td>
</tr>
<tr>
<td>Viburnum grandiflorum (S)</td>
<td>Adoxaceae</td>
<td>Leaf, Twig</td>
<td>2.05</td>
<td>1.64</td>
<td>3.74</td>
</tr>
<tr>
<td>Plectranthus rugosus (S)</td>
<td>Lamiaecae</td>
<td>NU</td>
<td>7.96</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Cyanodon dactylon (G)</td>
<td>Poaceae</td>
<td>Aerial part</td>
<td>12.61</td>
<td>0.53</td>
<td>6.76</td>
</tr>
</tbody>
</table>
Poa pratensis (G)  Poaceae  Aerial part 9.05 1.32 12.02
Bothriochola ischaemum (G)  Poaceae  Aerial part 6.21 0.71 4.43
Themeda spp. (G)  Poaceae  Aerial part 8.05 0.41 3.34
Stipa sibirica (G)  Poaceae  Aerial part 8.85 0.27 2.40
Lolium perenne (G)  Poaceae  NU 6.68 0.00 0.00
Arabidopsis spp. (G)  Brassicaceae  NU 0.25 0.00 0.00
Dioscorea deltioidea (H)  Cuscutaceae  NU 5.01 0.00 0.00
Plantago lanceolata (H)  Plantaginaceae  NU 2.62 0.00 0.00
Oxalis acetosella (H)  Oxalidaceae  NU 0.46 0.00 0.00
Rumex nepalensis (H)  Polygonaceae  NU 4.36 0.00 0.00
Viola odorata (H)  Violaceae  NU 0.82 0.00 0.00
Unidentified  11.49
Identified total  88.51

PV=Prominence value (a measure of availability); NU= Not Utilized; T=trees; S=shrubs; G=grasses and H=herbs.

Fig. 2 Number of plant fragments of various plant categories recovered from faecal pellets of Himalayan goral

Fig. 3 Availability and utilization of different plant categories during winter in Kazinag National Park.

Fig. 4 Ivlev’s electivity index of plant categories identified from faecal pellets of Himalayan goral

4. Discussion
The composition and selection of food by ungulates is a fundamental element to understand dietary habits [10]. Knowledge regarding such habits of ungulates is of crucial importance for conservation, as food and food choice affect growth, development, vigour, disease resistance and reproductive success of an animal [34], [35] and [36]. The cryptic and sensitive nature of ungulates makes it difficult to obtain direct information on their feeding ecology. Therefore, pellet group analysis using micro-histological technique has become the most admissible indirect method to study their food components and feeding ecology [37]. The goral is believed to be principally a grazer, yet the magnitude of the grazing and the browsing diversify with the season and the area [38] and [39]. Availability of different forage categories is a function of habitat type. Himalayan goral usually prefers to forage in the early morning and late in the evening [40]. However such preferences change during winter and feeding continues throughout the day with short intervals as reported for Markhor [41].

At Kazinag National Park, shrubs and grasses were found to be important components of the goral diet during winter. The ratio of browse to graze (59.55% : 28.88%) obtained during present study clearly indicates that Himalayan goral shows a browsing strategy during winter and rely less on grazing. The reason behind such changed strategy of feeding during winter could be the environmental conditions as reported for grey goral in Pakistan [42]. The present findings are also supported by a study at Primorsky Krai.
Grasses were available in the goral habitat during winter but their proportion in the diet of Himalayan goral was relatively low. In contrast, a higher proportion of grasses was reported in several studies [48], [49] and [50]. Kazinag National Park receives precipitation mainly in the form of heavy snowfall during winter and could be the reason for low utilization of grasses as most of grasses remain under it. However, grasses in low snow areas were available to Himalayan goral but not in a sufficient quantity due to over grazing by livestock of herdsmen and locals during rest of the seasons. The negative impact of livestock grazing on forage availability in winter was also speculated in Kunlun Mountains of Qinghai, China [14]. The herbs were also available in the habitat during winter but didn’t appear in pellets during analysis. The underestimation of herbs in the diet may be attributed to their higher digestibility [51] Five species of trees (Cedrus deodara, Aesculus indica, Picea smithiana, Abies pindrow and Pinus wallachiana) were found in the winter diet of Himalayan goral. The consumption of species viz., Picea smithiana, Cedrus deodara and Abies pindrow by grey goral in Pakistan during winter season has been reported [24]. The trees were abundant (53.21%) in the habitat, but contributed only 8.26% to the diet, owing their utilization to availability rather than selection which is evident from diet selection values of trees (Table 1). The consumption of gymnosperms by mountain ungulates indicates diet adjustments when forage availability is very limited [52] and serves as an important emergency winter forage when deep snow makes other forages unavailable [53]. The consumption of leaves by Himalayan goral was supported by the explanation that leaves are preferred by ungulates in in winter to enhance the quality of food when grasses are in decline [54].

Our findings reveal that the winter diet of Himalayan goral is dominated by shrubs and trees which contributed 59.55% to the total consumption. These findings were in conformity with Kufeld et al., [55] who reported that winter diet of mule deer was dominated by browse species (74%) followed by graze species (26%) in western North America. Markhor consumes primarily grasses and forbs during spring and summer and shifts to browsing mode in winter for nourishment [56]. The dietary shift of Himalayan goral to browsing mode may be due to decline in availability of graze species in winter with increasing snow depth. A shift from a graminoid to browse diet due to reduced forage availability in winter have been reported in bharal [57]. Carpenter et al., [58] also found that there occurs an increased shrub use and decreased forb/grass consumption during winter with increased snow pack.

5. Conclusion
Within Indian limits Himalayan goral is a least studied ungulate species and detailed data on its ecological aspects is thus needed to design long term conservation planning. The information yielded on winter forage availability and diet composition of Himalayan goral in temperate climatic conditions of KNP is urgently needed for planning winter forage and habitat conditions during lean period of winter. There is a persistent need to evaluate the quality of winter food items for ascertaining the nutritional importance of each item in relation to survival of Himalayan goral.

6. Acknowledgments:
Our sincere thanks are due to SERB-DST, Govt of India for financing the work under the research project No. CRG/2019/002369. We are highly thankful to the Head of the Zoology Department, University of Kashmir for providing laboratory facilities. We are also thankful to the Department of Wildlife Protection, Jammu and Kashmir for permitting us to carry out this work in KNP.

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