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RESEARCH ARTICLE

Dietary ecology of Markhor(*Capra falconeri cashmiriensis*) in winter range of Kazinag National Park, Kashmir, J&K, India.

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Abstract

Background/Objective: Understanding winter diet composition of wild ungulates in temperate habitats is of paramount importance for devising conservation measures. The winter diet composition of Markhor (*Capra falconeri*), one of the least studied ungulate species, was assessed in Kazinag National Park (KNP) of Jammu and Kashmir, India. **Methods:** Reference slides of 15 available plant species, through micro-histological technique were prepared. Tests like Diet Selection Values (DSV), Ivlev's Electivity Index (IEI) and Chi-square tests were applied to study the selection and preference of dietary items. **Findings:** 80 fecal samples of markhor were analyzed in winter seasons of 2017 & 2018, and compared with reference slides to evaluate the winter diet. Fifteen (15) plant species belonging to 7 families were identified in the diet. Use of Ivlev's Electivity Index (IEI), revealed that, shrubs were strongly preferred during this season, besides one graminoid species (*Poa pratensis)*. Among the most preferred species are, *Poa pratensis* (DSV=6.17) followed by *Prunus tomentosa* (DSV=2.42), *Indigofera heterantha* (DSV=2.23), *Lonicera spp.* (DSV=1.66) and *Euonymus hamiltonianus* (DSV=1.63). Chi-square goodness of fit test showed that markhor did not feed on all plant species uniformly ($p< 0.05$). **Novelty**: Our findings infer that, markhor shows feeding flexibility to adapt to change in forage availability. We recommend that plant species which are the major components of diet of markhor during resource- lean winter be conserved and propagated on priority.

Keywords: Diet composition; fecal analysis; Kazinag National Park; markhor; winter

1 Introduction

To meet the dietary need is the fundamental task for a wild ungulate to survive in harsh environmental conditions. Winter, a season with severe

climatic conditions, is a tough period for the survival of majority of ungulate species due to little choice of preferred forage and more energetic demands associated with movements through snow covered habitats [1–3] and is thus crucial period from animal ecologist's viewpoint [4]. Habitats with rugged terrain and snow cover, tend to have strong spatial and seasonal variations in food availability for ungulates [5]. In highly seasonal environment, as in KNP, diet quality and its availability act as strong constraint [6]. The winter snow cover is one of the important abiotic factors affecting the resource selection by ungulates inhabiting such extreme environments and tend to cope up with these conditions by using different strategies like limited movements through snow [5,7] and by altering their rumen physiology and metabolism to adjust to lignin rich and nutrient poor winter diets [8,9], thus show plasticity to cope up with seasonal changes in nutritional quality and its quantity. Consumption of unusual plant material during such conditions leads to poor health and reproductive performance [10,11].

Information on the diet and its selection, during different seasons is a primary element to know multiple aspects of ungulate ecology [12] and is a determining component for their survival, health, and mobility [13]. Nutritive qualities of winter forage is poor and are least studied, hence, a comprehensive study must be initiated to fill the gap on data on this issue. The behavior of high altitude ungulates is mainly affected by the nature of availability of food in their habitats and the ways in which these are obtained during different seasons.

Kashmir markhor also called flare horned markhor (*Capra falconeri cashmiriensis*), a true goat is distributed from Afghanistan to Pakistan, PoK and Jammu & Kashmir [14]. In India, markhor exists in Kashmir valley only [15–17], which is among the primary areas for the Pirpanjal markhor in India. In recent state-wide surveys of markhor only two viable populations totaling approximately 250, were confirmed in Kashmir, besides identifying a few more markhor potential areas in the state [17,18]. These include the Kazinag National Park and Hirpura Wildlife Sanctuary [18].

Winter, a critical season with harsh conditions and scarcity of food has detrimental effect on the survival of this threatened goat and information on diet utilization during this critical season is a prerequisite for the effective and proper management steps to be taken for maintaining its viable populations in the wild. Although some work on distribution, status and habitat of this caprid has been conducted in Kashmir [15–22] but there is dearth of data on its winter diet composition in Kashmir. With this aim, to understand the dietary composition and selection by markhor during resource-lean season of winter, the study was undertaken in Kazinag National Park, and the data procured, through this study, is expected to be useful to conservation stakeholders for planning apt management measures for the survival of this wild caprid.

2 Material and Methods

2.1 Study Area

The work was conducted in Kazinag National Park (34°10'0"N latitude and 74°2'0"E longitude) with an altitudinal range of 1,800-4,700m asl, located in Western Himalaya of India [23] in the valley of Kashmir (Figure 1).The vegetation is temperate coniferous, alpine and sub-alpine type [24] dominated by Pine (*Pinus wallichiana*), Deodar (*Cedrus deodara*) and Fir (*Abies pindrow*) in the mid-lower elevations. At higher elevations, the subalpine forest is dominated by Birch (*Betula utilis*) and mixed forests whereas the alpine vegetation is dominated by Juniper (*Juniperus squamata*) and alpine meadows. The riverine forests are dominated by Horse Chestnut (*Aesculus indica*) forests and *Viburnum grandiflorum* shrubs whereas temperate grasslands with rolling terrain at lower elevations. Temperature varies from -10° C in winter to +30°

C in summer. The precipitation is received as snow during winter, rains in spring and occasional showers in summer. The typical seasons in the region are: spring (March-May), summer (June-August), autumn (September-November) and winter (December-February).

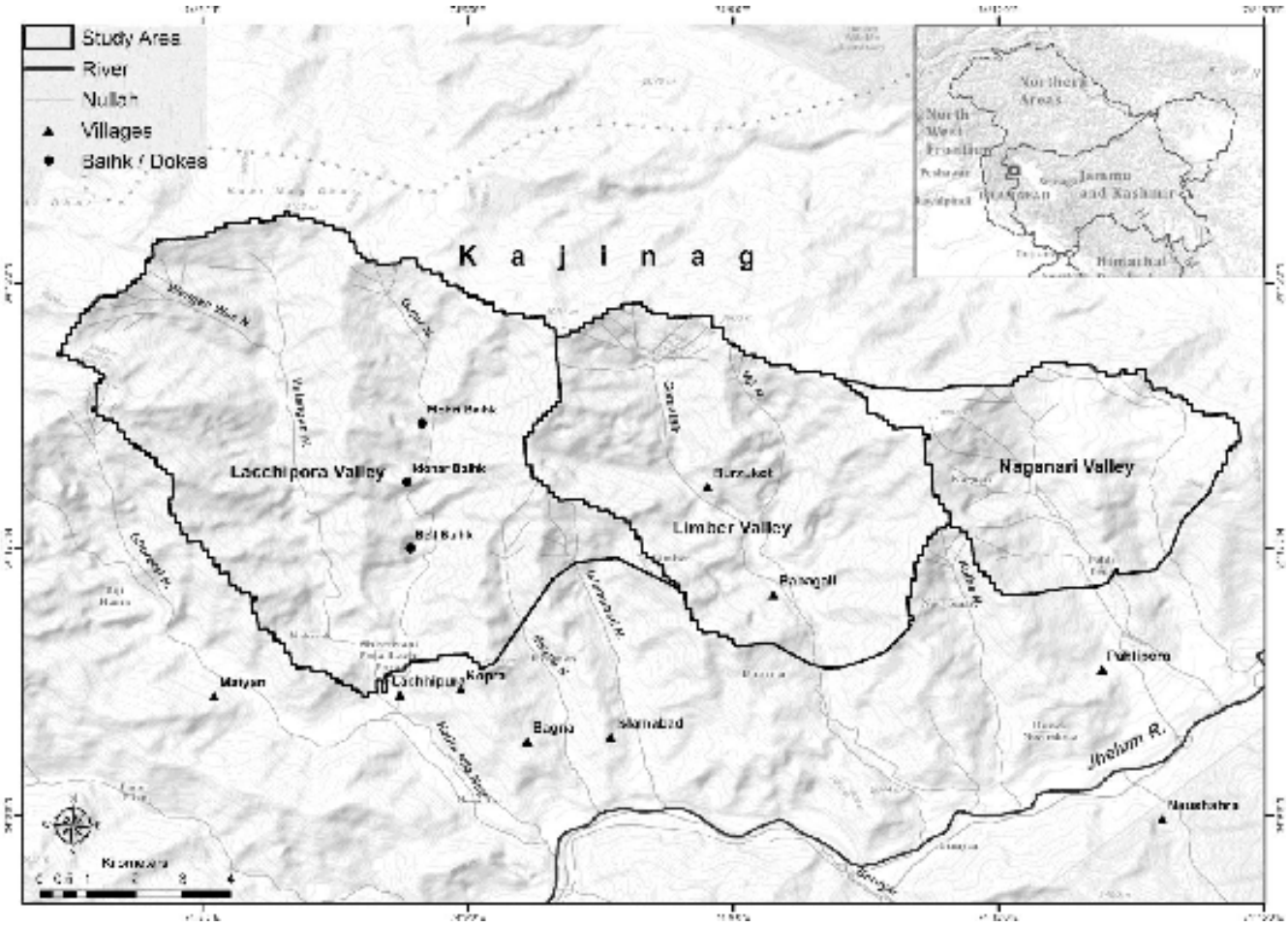

Fig 1. The Map of study area (KNP)

2.2 Data collection

The field data was collected during winter seasons (December-February) of 2017 and 2018. Our study was centered on the identification of microscopic, undigested plant remnants chiefly the epidermal features, characteristic of each plant species, obtained from fecal pellets [25]. For the purpose, reference slide preparation of food plants, their microphotography to establish a reference library, collection of fecal samples, making slides of fecal samples and identification of fragments of plants from the slides of fecal samples by comparing with the microphotographs of reference key was done [26–28].

2.2.1 Preparation of plant reference slides

Reference slides of potential food plants of markhor were prepared, as key, after collection from the study site and identified from the Center for Plant Taxonomy and Biodiversity, University of Kashmir, Srinagar. For this, 12 line-transects of 2km each, were laid in all four winter range habitats: coniferous forest,

grassland, cliffy areas and riverine areas. In each transect, plots (10m radius) were laid after every 200m. The plant species that were potential food of markhor, were collected, after thorough field observations on feeding, and confirmed from wildlife officials, field experts and locals. Plant samples collected were dried, shredded and put in glass test tube containing 33% Nitric acid and water in 1:3 ratio. This test-tube was heated in a water-bath for 5 minutes. When solid material settled down, Nitric acid was decanted, and fresh Nitric acid (33%) was added. The material was again boiled till it became transparent. Then the transparent material was washed with water to remove Nitric acid. It was followed by staining the material, just for two minutes, with safranin. The sample was again washed in water and then dehydrated by processing through different grades of alcohol. Dehydration was completed by placing it in absolute alcohol. Mounting was done in Canada balsam and microphotographs were captured with the help of a digital binocular microscope (Olympus, BX60).

2.2.2 Field collection of fecal samples

Fecal samples (n=80) were collected from 12 permanent transects. Pellets of one group of faeces were counted as one sample. The pellets of markhor were differentiated from that of goral, musk deer, sheep and goat on the morphological characters viz. dimension, size & shape [29]. Sampling plots were systematically designed, laid parallel and were almost equidistant (100m) from one another. Wherever pellets were collected, a widely used plot size of 10m $\times$ 10m for the study of dietary patterns of wild animals was laid around the pellets [30–33]. Pellets were aged, as fresh, comparatively old, or very old, based on texture [34].

2.2.3 Slide preparation (fecal samples)

Randomly selected, oven-dried pellet groups from each sample were crushed and sieved through two small-mesh sieves of mesh size 5mm and 3 mm respectively. The fine sieved material was put to further analysis whereas the course material was discarded. Fine material was placed in a test-tube having 33% nitric acid and water in 1:3 ratio. Further processing and slide preparation was done in the similar manner as was done for the reference material. Three slides were prepared for each sample with 240 slides in all (80 samples $\times$ 3 slides). While identifying the plant fragments, 4 microscopic viewing fields, for each slide were considered with sum total of 960 FOV. Fragments of diverse plant species, from the pellets, were identified by comparing with the microphotographs of reference vegetation, on the basis of characteristics viz. cell-wall, cell shapes, trichomes, and stomata [25].

3 Data Analysis

The relative proportion of a particular plant species in the given fecal sample, which is sum of remnants identified for that plant species divided by the total count of all fragments, was symbolized as relative importance value(RIV), and was expressed as percentage [35].

Diet selection value (DSV) was calculated as follows [35]:

$$\mathrm{DSVx} = \frac{\mathrm{RIVx}}{\mathrm{PVx}}$$

Where RIV_x is the RIV for species x, and expresses its relative frequency in the faeces. PV_x shows the prominence value (PV) for species x, and expresses the relative availability of that plant in the markhor habitat. PV was calculated as follows [36]:

$$\mathrm{PV}_x = \mathrm{M}_x \times \sqrt{\mathrm{f}_x}$$

Where M_x is the % cover of species x, and f_x is the frequency of occurrence of species x in sample quadrats.

Food preference of markhor was determined by calculating Ivlev's electivity index (IEI) [37] as:

$$IEI_i = r_i - p_i / r_i + p_i$$

Where 'r_i' is the share of vegetation type 'i' in the markhor diet, and 'pi' is the total proportion of vegetation type 'i' along all systematically sampled quadrats (i.e.in the habitat). IEI of '1.0' express high preference for a vegetation type, '0' denotes use in proportion to availability, and '-1.0' denotes complete avoidance [37].

3.1 Statistical analysis

The data was analyzed with Statistical packages MS-Excel 2007 and MINITAB software version 13.2 (Minitab-2002) with confidence level of 95% and P<0.05 for significance.

4 Results

We recorded availability of 15 species of plants that belong to 7 families (Table 1). Species with the highest prominence value, a measure of availability, included *Pinus wallichiana* (PV=17.27), *Cynodon dactylon* (PV=10.61), *Picea smithiana* (PV=10.35), *Themeda spp.* (PV=8.05), *Stipa spp.* (PV=6.85), *Viburnum grandiflorum* (PV= 6.29) and *Indigofera heterantha* (PV=6.26). The overall availability of plant categories was different with trees having the highest availability (PV=32.14) followed by shrubs (PV=28.22) and grasses (PV=25.80). Fifteen (15) plant species of 7 different families were documented from 2903 recovered plant fragments by fecal analysis. Of these 2903 fragments, 1069 (36.28%) represented browse species and 1226 (42.23%) represented graze species while as herbs were not recognized (Figure 2).

Apart from the identified plant fragments, 608 unidentified fragments with a proportion of 21% were recorded and were eliminated from statistical analysis. Among browse species, shrubs were far dominant with an overall occurrence of 81.85%. The dominant shrubs were *Indigofera heterantha (R*IV=13.98), *Prunus tomentosa* (RIV=7.23) and *Lonicera spp*. (RIV= 3.51). The dominant tree species in markhor diet was *Pinus wallichiana* (RIV=2.68) whereas *Cynodon dactylon* was the dominant grass species (RIV=13.43). We could not find any single tree species that markhor consumed in significantly higher proportion than their availability. Plant species which were utilized more than their availability include *Indigofera heterantha* (PV=6.26,RIV=13.98), *Prunus tomentosa* (PV=2.98,RIV=7.23), *Stipa spp.* (PV=6.85,RIV=9.81), *Poa pratensis* (PV=0.29, RIV=1.79), *Cynodon dactylon* (PV=10.61,RIV=13.43), *Themeda spp.* (PV=8.05,RIV=10.05), *Bothriocholoa ischaemum* (PV=6.21,RIV=7.13), *Lonicera spp.* (PV=2.11,RIV=3.51) and *Euonymus hamiltonianus* (PV=1.52,RIV=2.48). However, *Rosa macrophylla* (PV=1.82,RIV=1.34), *Viburnum grandiflorum* (PV=6.29,RIV=1.41), *Aesculus indica* (PV=4.52,RIV=2.13), *Picea smithiaina*, (PV=10.35,RIV=1.86), *Pinus wallichiana* (PV=17.27,RIV=2.68) and *Lespedeza eleganus* (PV=1.03,RIV=0.17) were utilized less than their availability. The abundant plant categories available during winter were trees, followed by shrubs and grasses but were utilized in different proportions (Figure 3). The recognition of fragments of various plant species from pellets differed significantly at species level (χ^2=1529.731, df =14, p<0.000), at family level (χ^2=2382.947, df =6, p<0.000) and at growth form level (χ^2=606.972, df =2, p<0.000). We also observed that markhor strongly selected *Poa pratensis* (DSV=6.17), followed by *Prunus tomentosa* (DSV=2.42), *Indigofera heterantha* (DSV=2.23) *Lonicera spp*. (DSV=1.66) and *Euonymus hamiltonianus* (DSV=1.63). Ivlev's electivity index (IEI) values revealed that, markhor shows a strong preference for shrubs and grasses during winter season and least preference for trees (Figure 3).

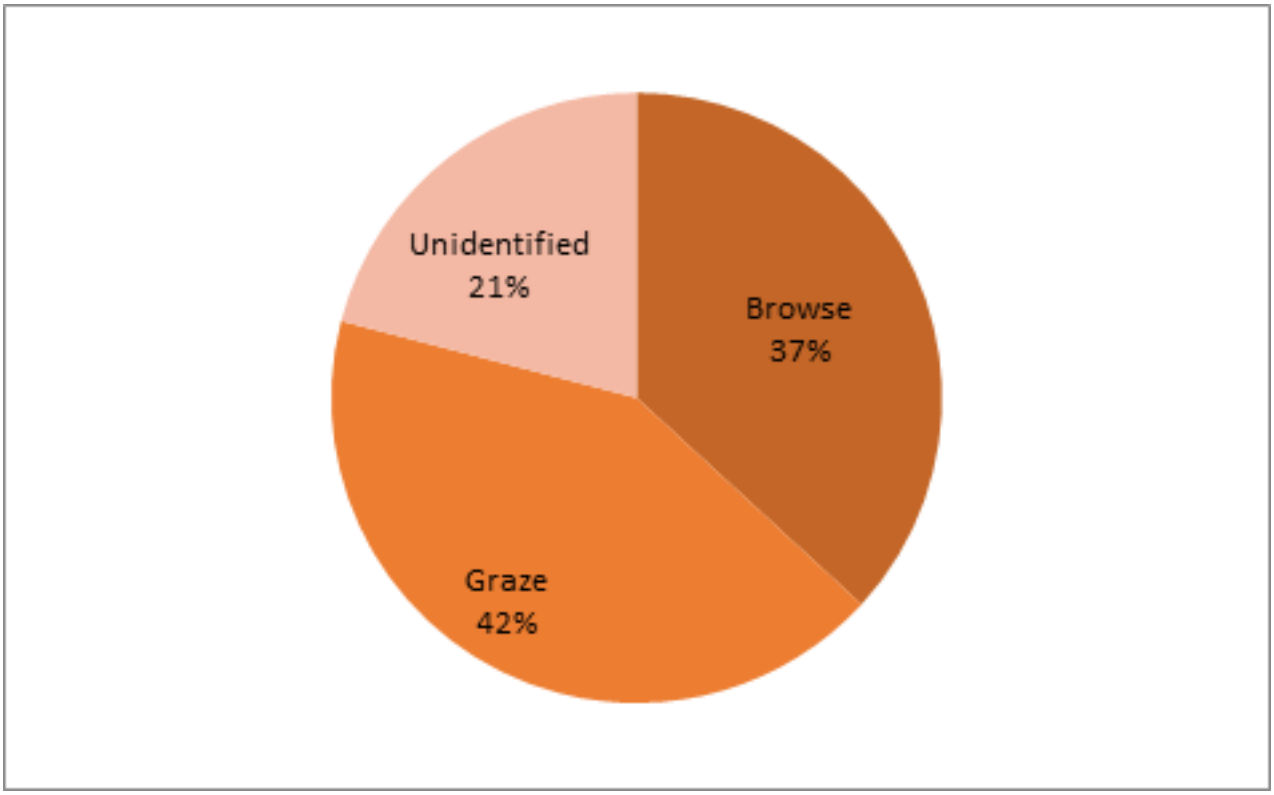

Fig 2. The percentage of fragments of various plant categories recovered from markhor pellets

Table 1. Showing, PV, DSV, and RIV of markhor diet during winter in Kazinag National Park

S.No	Plant species	Family	PV	DSV	% Occurrence (RIV)
1.	*Poa pratensis*	Poaceae	0.29	6.17	1.79
2.	*Stipa spp.*		6.85	1.43	9.81
3.	*Cynodon dactylon*		10.61	1.26	13.43
4.	*Themeda spp.*		8.05	1.24	10.05
5.	*Bothriochloa ischaemum*		6.21	1.14	7.13
6.	*Rosa macrophylla*	Rosaceae	1.82	0.73	1.34
7.	*Prunus tomentosa*		2.98	2.42	7.23
8.	*Euonymus hamiltonianus*	Celasteraceae	1.52	1.63	2.48
9.	*Lespedeza eleganus*	Fabaceae	1.03	0.16	0.17
10.	*Indigofera heterantha*		6.26	2.23	13.98
11.	*Lonicera spp.*	Caprifoliaceae	2.11	1.66	3.51
12.	*Viburnum grandiflorum*		6.29	0.22	1.41
13.	*Aesculus indica*	Hippocasteraceae	4.52	0.47	2.13
14.	*Pinus wallichiana*	Pinaceae	17.27	0.15	2.68
15.	*Picea smithiana*		10.35	0.17	1.86
16.	Unidentified	21.00			

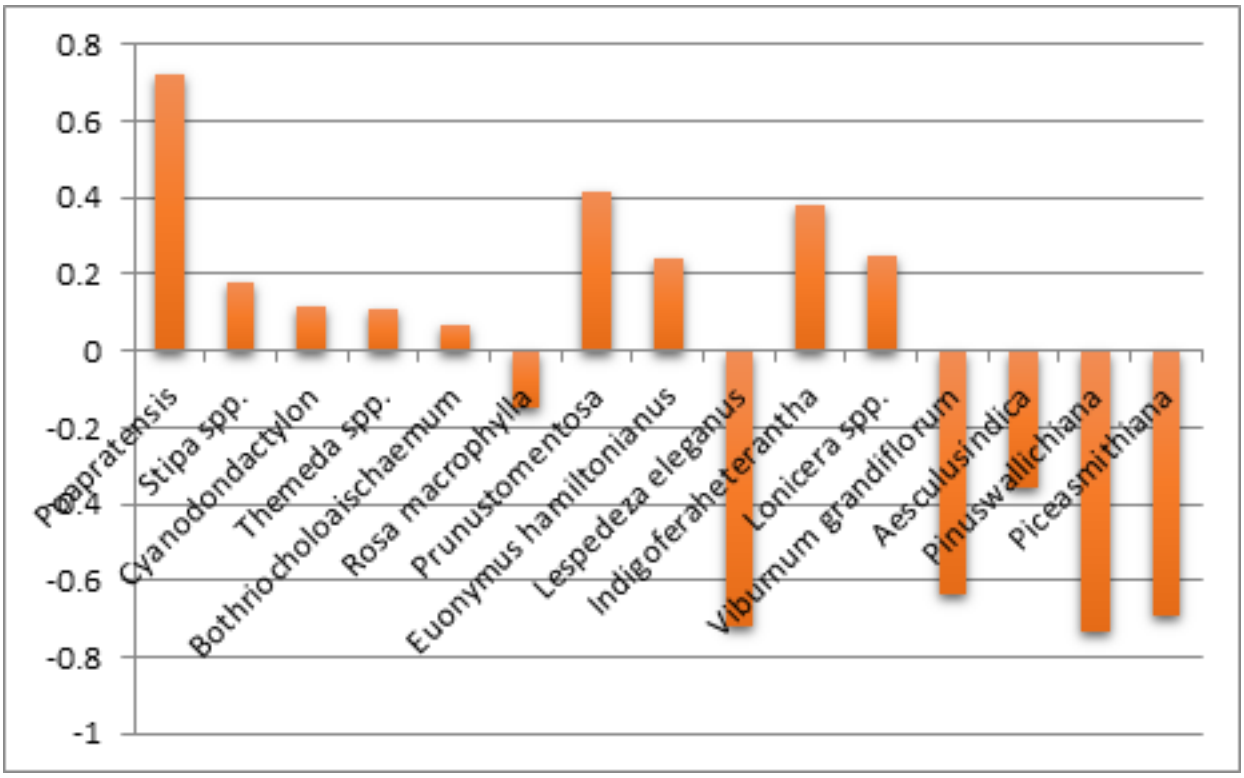

Fig 3. Ivlev's Electivity Index (IEI) values for various dietary items of markhor during winter

5 Discussion

Food and its availability have fundamental impact on the physical health and fertility of an animal. Utilization of nutritious diet helps a faunal species to combat diseases and reproduce successfully, what is actually the basic requisite for a species to coup up in the competition for existence and in continuing its race. Knowing feeding strategies of wild ungulates is vital for sound management of a species especially in protected areas [38,39]. Each species prefers a particular type of food and shows peculiar type of foraging behavior. Feeding in markhor occurred early in the morning during hot months, with occasional day feeding [21,40,41]. Early morning and evening foraging and midday rest during hot days of summer, as observed in the current study, was also observed in other wild ungulates [27,42,43]. But during winter, food was short and scarce, hence, feeding occurred intermittently throughout the day. Continuous day feeding during winter could be because of limited availability of forage during this season [40].

The ratio of different categories of plants in herbivore diet represents their dietary diversity and composition [44,45] .Consumption of grasses in all four seasons suggests that markhor is primarily a grazer. Same has been observed in a number of wild ungulates. Grasses make an important and major dietary part of Himalayan goral [46], which mostly consumed grasses 84% [47–49], with browse to graze ratio of 12: 88 [50].

In Kazinag National Park, during winter, shrubs and grasses constitute important components of the markhor diet. The ratio of browse to graze (36.28%:42.23%) clearly indicates that, markhor shows a browsing strategy during winter. The reason behind such changed strategy of feeding during winter could be due to environmental conditions as also evidenced in grey goral in Pakistan [51]. Similarly, Bighorn sheep of British Columbia mostly browsed during winter and shrubs contributed the greatest proportion of its diet [52].The present study clearly concludes that markhor strongly prefers shrubs (Figure 3) during win-

ter with *Indigofera heterantha* and *Prunus tomentosa* alone contributing 21.22% of the whole diet. These results are supported by earlier results. It was reported that the shrubs constitute the main component of the grey goral diet during winter with *Berberis vulgaris* and *Viburnum nervosum* as the most common dietary shrubs [28].

We also reported that some grasses were available in markhor habitat and their relative percentage in the markhor diet was significant during winter. Our findings are substantiated by the earlier findings for goral in various protected areas in India [50,53,54].This also implies that markhor is primarily a grazer but also browse whenever required. Thus its diet changes with the season and availability [22,55]. Moose has been described to modify its rumen physiology and rate of dietary intake as a response to scarcity of nutritive diet during fall [9]. Kazinag National Park experiences heavy snowfall during winter that covers the entire area. Deep layers of snow are probably the reason for the low utilization of grasses in winter as most of grasses remain under snow cover. However, grasses in certain areas with less snow depth and also around the cliffs are available to markhor but not in a sufficient quantity due to over grazing by livestock of herders during the previous autumn season. The negative impact of livestock grazing on availability of forage particularly in winter was also speculated by many authors [14,55,56]. Some herbs although available in markhor habitat during winter but did not appear in fecal samples. Herbs being fugacious and appear for a shorter duration, have limited availability and hence, low consumption [57]. Another reason for very low representation of herbs in the markhor feaces is perhaps their high digestibility. They have softer tissues, hence, expected to face higher digestion and lower representation as identifiable pieces in fecal samples [57,58].

Three species of trees (*Aesculus indica*, *Picea smithiaina* and *Pinus wallichiana*) were also reported as lean-winter food of markhor. The conifer species viz. *Picea smithiana*, *Cedrus deodara* and *Abies pindrow* were also recorded as diet of goral in Pakistan during winter season [28]. Due to limited dietary choice during winter, herbivores consume food of low nutritive quality like conifer needles [59–61] but in other seasons they are avoided as they are low in energy content [62,63]. Consumption of needles of some conifers shows unfavourable foraging and may affect health and reproductive condition of herbivores [10,11]. Although trees were abundant (32.14%) in the habitat, but contributed only 6.68% of the winter diet (Table 1), hence, reflected that the utilization of trees by markhor was primarily due to availability rather than selection. The utilization of conifers by high altitude temperate ungulates during winter signify dietary compromise when preferred forage availability is limited [22] and serves as an emergency winter forage when deep snow makes other forages unavailable [64]. Moreover, the rugged geomorphology of the study site, covered by snow, acts as severe bottlenecks during cold and snowy winter [6].

Our findings revealed that, the winter nutrition of markhor was dominated by shrubs and grasses contributing 72.37% of the consumption. These observations were authenticated by the other findings. The winter forage of mule deer was reported to be dominated by browse species (74%) followed by graze species (26%) in North America [65]. During winter, browse provides major proportion of nutrients, especially proteins, during critical times of the season when grasses were low in nutritional value & digestibility and with ample fiber content [66,67]. Markhor utilizes grasses and herbs during other seasons but shifts to browsing mode in winter for nourishment has also been documented earlier [16]. The dietary shift of markhor to browsing mode may be owing to decline in availability of graze species in winter with increasing snow depth. During winter, snow cover limits the access of ungulates to ground forage thus they suffer from dietary deficiency [68]. There occurs an increased shrub use and decreased forb & grass consumption during winter with increased snowpack [69].

6 Conclusion

Although a mixed feeder with more tendencies towards grazing, the results confirmed that, markhor shows a browsing strategy during winter season, thus shows high adaptability in feeding habit. Conifers are consumed by markhor during winter as an emergency food rather than selection and shrubs were critical to the dietary composition and consumed at relatively high rates. The snowfall during winter acts as a major limiting factor and has a drastic impact on the survival of this animal as almost all ground forage remains covered and hence, unavailable for consumption. Nutritive value of dietary species of wild herbivores has hardly been evaluated; hence, need to be studied to ascertain the reason of their avoidance or preference [(49)]. We also recommend that the species of plants consumed by the markhor during winter must be protected and propagated [(55)] and supplementary feed must be provided to this wild goat during resource-lean period of winter. The anthropogenic activities inside the National Park must be strictly curbed for the continued survival of markhor in its distribution range in Kashmir.

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References

1) Burles DW and Hoefs M. Winter mortality of Dall sheep, Ovis dalli dalli. *Canadian Field-Naturalist*. 1984;98:479–484.
2) Parker KL, Robbins CT and Hanley TA. Energy Expenditures for Locomotion by Mule Deer and Elk. *The Journal of Wildlife Management*. 1984;48(2):474–474. Available from: https://dx.doi.org/10.2307/3801180.
3) Dailey TV and Hobbs NT. Travel in alpine terrain: energy expenditures for locomotion by mountain goats and bighorn sheep. *Canadian Journal of Zoology*. 1989;67(10):2368–2375. Available from: https://dx.doi.org/10.1139/z89-335.
4) Cornelis J, Casaer J and Hermy M. Impact of season, habitat and research techniques on diet composition of roe deer (Capreolus capreolus): a review. *Journal of Zoology*. 1999;248(2):195–207. Available from: https://dx.doi.org/10.1111/j.1469-7998.1999.tb01196.x.
5) Zweifel-Schielly B, Kreuzer M, Ewald KC and Suter W. Habitat selection by an Alpine ungulate: the significance of forage characteristics varies with scale and season. *Ecography*. 2009;32(1):103–113. Available from: https://dx.doi.org/10.1111/j.1600-0587.2008.05178.x.
6) Zweifel-Schielly B, Leuenberger Y, Kreuzer M and Suter W. A herbivore's food landscape: seasonal dynamics and nutritional implications of diet selection by a red deer population in contrasting Alpine habitats. *Journal of Zoology*. 2012;286(1):68–80. Available from: https://dx.doi.org/10.1111/j.1469-7998.2011.00853.x.
7) Mysterud A, Iversen C and Austrheim G. Effects of density, season and weather on use of an altitudinal gradient by sheep. *Applied Animal Behaviour Science*. 2007;108(1-2):104–113. Available from: https://dx.doi.org/10.1016/j.applanim.2006.10.017.
8) Regelin WL, Schwartz CC and Franzmann AW. Seasonal Energy Metabolism of Adult Moose. *The Journal of Wildlife Management*. 1985;49(2):388–388. Available from: https://dx.doi.org/10.2307/3801539.
9) Hofmann RR. Evolutionary steps of ecophysiological adaptation and diversification of ruminants: a comparative view of their digestive system. *Oecologia*. 1989;78(4):443–457. Available from: https://dx.doi.org/10.1007/bf00378733.
10) Anderson E and Koivisto I. White tailed deer's winter food and diurnal rhythm. *SuomenRiista*. 1980;7:84–92.
11) Wishart WD and Canada. White tailed deer: ecology and management. K HL, editor. Harrisburg, PA. Stackpole Books . 1984,.
12) Bhattacharya T, Bashir T, Poudyal K, Sathyakumar S and Saha GK. Distribution, Occupancy and Activity Patterns of Goral (Nemorhaedus goral) and Serow (Capricornis thar) in Khangchendzonga Biosphere Reserve, Sikkim, India. *Mammal Study*. 2012;37(3):173–181. Available from: https://dx.doi.org/10.3106/041.037.0302.
13) Shukla R. An ecological study of interactions between wild animals and vegetation in Pench Sanctuary and environs. vol. 249. Sagar, India . 1990,.

14) Arshad M, Qamer FM, Saleem R and Malik RN. Prediction of Kashmir markhor habitat suitability in Chitral Gol National Park, Pakistan. *Biodiversity*. 2012;13(2):78–87. Available from: https://dx.doi.org/10.1080/14888386.2012.684206.
15) Schaller GB and Khan SA. Distribution and status of markhor (Capra falconeri. *Biological Conservation*. 1975;7(3):185–198. Available from: https://dx.doi.org/10.1016/0006-3207(75)90014-2.
16) Ranjitsinh MK, Seth CM, Ahmad R, Bhatnagar VY and Kyarong SS. Goats on the border: A rapid assessment of the PirPanjal markhor in Jammu and Kashmir: Distribution, status and threats. Wildlife Trust of India. Wildlife Trust of India . 2007,. .
17) Ahmad R, Haq S, Qureshi S, Puri M and Kaul R. The lost markhor of Pirpanjal: Assessing the distribution of markhor (Capra falconeri) and other important fauna along the southern slopes of Pirpanjal with special reference to resource competition with local grazier communities in Hirpora WLS. Delhi. Jammu and Kashmir. Wildlife Trust of India . 2011,.
18) Bhatnagar YV, Ahmad R, Kyarong SS, Ranjitsinh MK, Seth CM, Lone IA et al. Endangered markhor Capra falconeri in India: through war and insurgency. *Oryx*. 2009;43(03):407–407. Available from: https://dx.doi.org/10.1017/s0030605309001288.
19) Roberts TJ . 1969,.
20) SCHALLER GB and MIRZA ZB. ON THE BEHAVIOR OF KASHMIR MARKHOR (CAPRA FALCONERI CASHMIRIENSIS). *Mammalia*. 1971;35(4):548–566. Available from: https://dx.doi.org/10.1515/mamm.1971.35.4.548.
21) Ahmad R, Mishra C, Singh NJ, Kaul R and Bhatnagar YV. Forage and security trade-offs by markhor (Capra falconeri) mothers. *Current Science*. 2016;110:1559–1564.
22) Ahmad R, Sharma N, Mishra C, Singh NJ, Rawat GS and Bhatnagar YV. Security, size, or sociality: what makes markhor (Capra falconeri) sexually segregate? *Journal of Mammalogy*. 2018;99(1):55–63. Available from: https://dx.doi.org/10.1093/jmammal/gyx155.
23) Rodgers WA and Panwar HS. Planning a Protected Area Network in India. vol. 1. Dehra Dun . 1988,.
24) Champion H and Seth S. Forest types of India. and others, editor. Dehra Dun: Forest Research Institute . 1968,.
25) Holechek JL and Gross B. Training Needed for Quantifying Simulated Diets from Fragmented Range Plants. *Journal of Range Management*. 1982;35(5):644–644. Available from: https://dx.doi.org/10.2307/3898655.
26) Haleem A, Ilyas O, Sayed Z, Arya SK and Imam E. Distribution, status and aspects of ecology of mammalian species in Kedarnath Wildlife Sanctuary. *Journal of Materials and Environmental Science*. 2014;5(3):683–692.
27) Nayak BK and Patra AK. Food and feeding habits of Indian Bison, (Bos gaurus, Smith, 1827) in Kuldiha Wildlife Sanctuary, Balasore, Odisha, India and its conservation. *International Research Journal of Biological Science*. 2015;4(5):73–79.
28) Ashraf N, Anwar M, Oli MK, Pine WE, Sarwar M, Hussain I et al. Seasonal variation in the diet of the grey goral (Naemorhedus goral) in Machiara National Park (MNP), Azad Jammu and Kashmir, Pakistan. *Mammalia*. 2017;81(3):235–244. Available from: https://dx.doi.org/10.1515/mammalia-2015-0075.
29) ASHRAF N, ANWAR M, HUSSAIN I and NAWAZ MA. Competition for food between the markhor and domestic goat in Chitral, Pakistan. *TURKISH JOURNAL OF ZOOLOGY*. 2014;38:191–198. Available from: https://dx.doi.org/10.3906/zoo-1306-6.
30) Schemnitz SD. Wildlife management technique manual. Washington, D.C. Wildlife Society . 1980,.
31) Panthi S. Feeding ecology, habitat preference and distribution of red panda (Ailurus fulgens fulgens) in Dhopatan Hunting Reserve. Pokhara, Nepal . 2011,.
32) Panthi S, Aryal A, Raubenheimer D, Lord J, Adhikari and B. Summer diet and distribution of the red panda (Ailurus fulgens fulgens) in Dhorpatan hunting reserve, Nepal. . *Zoological Studies*. 2012;51(5):701–709.
33) Aryal A, Panthi S, Barraclough RK, Bencini R, Adhikari B, Ji W et al. Habitat selection and feeding ecology of dhole (Cuon alpinus) in the Himalayas. *Journal of Mammalogy*. 2015;96(1):47–53. Available from: https://dx.doi.org/10.1093/jmammal/gyu001.
34) Latham ADM, Latham MC, Knopff KH, Hebblewhite M and Boutin S. Wolves, white-tailed deer, and beaver: implications of seasonal prey switching for woodland caribou declines. *Ecography*. 2013;36(12):1276–1290. Available from: https://dx.doi.org/10.1111/j.1600-0587.2013.00035.x.
35) Jnawali SR. Population ecology of greater one-horned rhinoceros (Rhinoceros unicornis) with particular emphasis on habitat preference, food ecology, and ranging behavior of a reintroduced population in Royal Bardia National Park in lowland Nepal (thesis). Aas, Norway . 1995,.
36) Koirala RA, Shrestha R and Wegge P. Grasslands in the Damodar Kunda Region of Upper Mustang, Nepal. In: and others, editor. In Grassland ecology and management in protected areas of Nepal. Technical and status papers on grasslands of mountain protected areas . 2000,. p. 53–69.
37) Ivlev VS. Experimental ecology of the feeding of fishes. New Haven, Connecticut, USA. Yale University Press . 1961,.

38) Berwick SH. The community of wild ruminants in Gir forests . 1974,.
39) Martin C. Status and ecology of the Barasingha (Cervus duvauceli branderi) in Kanha National Park. (India). *Journal of Bombay Natural History Society*. 1977;74:60–132.
40) Roberts TJ. The mammals of Pakistan. and others, editor. London. Ernest Benn . 1977,.
41) Bhatnagar YV, Mathur VB and Carthy TM. A regional perspective for Snow Leopard conservation in the Indian Trans-Himalaya. Presented at the National Workshop on Regional Planning for Wildlife Protected Area. In: part of GEF-India Eco-development Project Initiative . 2001,. .
42) and CZ. Nemorhaedus canbrooki Hayman. In: Soma HH, editor. The biology and management of Capricorns & related mountain antelopes. London. Croom Helm . 1987,. p. 213–223.
43) Fedosenko AK and Blank DA. Capra sibirica. *Mammalian Species*. 2001;675:1–13. Available from: https://dx.doi.org/10.1644/1545-1410(2001)675<0001:cs>2.0.co;2.
44) Omphile UJ, Aganga AA, Tshireletso K and Nkele R. Foraging strategies of sheep and goats under semi-intensive management in Botswana. *South African Journal of Animal Sciences*. 2004;34:120–122.
45) Prins HHT, de Boer WF, van Oeveren H, Correia A, Mafuca J and Olff H. Co-existence and niche segregation of three small bovid species in southern Mozambique. *African Journal of Ecology*. 2006;44(2):186–198. Available from: https://dx.doi.org/10.1111/j.1365-2028.2006.00619.x.
46) Green MJB. Ecological separation in Himalayan ungulates. *Journal of Zoology*. 1987;1:693–719.
47) Anwar M. Development of a management plan for grey goral: lessons from Black buck and Cheer pheasant re-introduction attempts . 1989,.
48) Anwar M and Chapman JA. Distribution and population status of grey goral in the Margalla hills National Park. *Pakistan Journal of Agricultural Research*. 2000;16(2):43–46.
49) Awasthi A, Uniyul SK, Rawat GS and Sathyakumar S. Food plants and feeding habits of Himalayan ungulates. *Current Science*. 2003;385(6):719–723.
50) Ilyas O and Khan JA. Food habits of barking deer (Muntiacus muntjak) and goral (Naemorhedus goral) in Binsar Wildlife Sanctuary, India. *Mammalia*. 2003;67(4):521–531. Available from: https://dx.doi.org/10.1515/mamm-2003-0406.
51) Abbas F. A study on ecobiology of grey goral (Naemorhedus goral) with reference to Pakistan. Lahore, Pakistan . 2006,.
52) Wikeem BM and Pitt MD. Diet of California bighorn sheep (Ovis canadensis californiana) in British Columbia: assessing optimal foraging habitat. *Canadian Field Naturalist*. 1992;106:327–335.
53) Mishra C. Habitat use by goral (Nemorheaedus goral bedfordi) in Majhatal Harsang Wildlife Sanctuary, Himachal Pradesh, India. Himachal Pradesh, India; Dehradun . 1993,.
54) Mishra C and Johnsingh AJT. On habitat selection by the goralNemorhaedus goral bedfordi(Bovidae, Artiodactyla). *Journal of Zoology*. 1996;240(3):573–580. Available from: https://dx.doi.org/10.1111/j.1469-7998.1996.tb05307.x.
55) Ali S. Conservation and status of markhor (Capra falconeri) in the Northern parts of North West Frontier Province, Pakistan . 2008,. Available from: https://scholarworks.umt.edu/10919.
56) Harris RB and Miller DJ. Overlap in summer habitats and diets of Tibetan Plateau ungulates. *Mammalia*. 1995;59(2):197–212. Available from: https://dx.doi.org/10.1515/mamm.1995.59.2.197.
57) i Abbas FF, Akhtar T and Mian A. Food and feeding preferences of Himalayan gray goral (Naemorhedus goral bedfordi) in Pakistan and Azad Jammu and Kashmir. *Zoo Biology*. 2008;27(5):371–380. Available from: https://dx.doi.org/10.1002/zoo.20202.
58) Rogerson SJ, Stevens EJ and Hughes JG. An improved preparation technique for identification of plant cuticle in animal faeces. *New Zealand Journal of Botany*. 1976;14(1):117–119. Available from: https://dx.doi.org/10.1080/0028825x.1976.10428658.
59) Homolka M. The diet of Cervus elaphus and Capreolus capreolus in deforested areas of Moravskoslezske Beskydy mountains. *Folia Zoologica*. 1995;44:227–236.
60) Mysterud A. Diet overlap among ruminants in Fennoscandia. *Oecologia*. 2000;124(1):130–137. Available from: https://dx.doi.org/10.1007/s004420050032.
61) Sauve DG and Cote SD. Winter forage selection in white tailed deer at high density: balsam fir is the best of a bad Choice. *Journal of Wildlife Management*. 2007;171:911–914.
62) Cederlund G, Ljunquist H, Markgren G and Stalfelt F. Food of moose and roe deer at Grimso in Central Sweden- results of rumen content analysis. *Swedish Wildlife Research*. 1980;11:171–247.
63) Prieditis A. Influence of dry food and needles on body weight and consumption of food substances in roe deer, Capreolus capreolus L. *Acta Zoologica Fennica*. 1984;171:213–215.
64) Adams LG and Bailey JA. Winter Forages of Mountain Goats in Central Colorado. *The Journal of Wildlife Management*.

1983;47(4):1237–1237. Available from: https://dx.doi.org/10.2307/3808202.
65) Kufeld RC, Wallmo OC and Feddema C. Foods of the Rocky Mountain mule deer. and others, editor. U.S. Department of Agriculture Forest Service Research . 1973,.
66) Schaller GB. Wildlife of the Tibetan Steppe. Chicago. The University of Chicago Press . 1998,.
67) Wagner GD and Peek JM. Bighorn sheep diet selection and forage quality in Central Idaho. *Northwest Science*. 2006;80:246–258.
68) Kamler J and Homolka M. Needles in faeces: an index of quality of wild ungulate winter diet. *Folia Zoologica*. 2011;60(1):63–69. Available from: https://dx.doi.org/10.25225/fozo.v60.i1.a10.2011.
69) Carpenter LH, Wallmo OC and Gill RB. Forage density and dietary selection by wintering mule deer. *Journal of Range Management*. 1979;32(3):226–229.