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# HABITAT USE AND FOOD HABITS OF KASHMIR RED DEER OR *HANGUL* (*Cervus elaphus hanglu*) AT DACHIGAM NATIONAL PARK, KASHMIR, INDIA

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**Abstract**

We investigated the habitat use and food habits of Kashmir Red deer or *Hangul* (*Cervus elaphus hanglu*) at Dachigam National Park, Kashmir, India, from April 2007 to June 2009. We characterized *Hangul* habitats based on vegetation plots (n= 98) along 13 transects / trails that systematically covered Lower Dachigam (*ca.* 90 km$^2$), our intensive study area. We classified five *Hangul* habitats *viz.,* Riverine (1,600-1,900 m), Lower Temperate Mixed (*Celtis australis, Morus alba, Aesculus indica, Juglans regia* and *Parrotiopsis jacquemontiana,* 1,800-2,200 m), Lower Temperate Pine Mixed (*Pinus wallichiana* and others, 1,800-2,400 m), Mid Temperate Mixed (*Ulmus wallichana, C. australis, A. indica* and *P. jacquemontiana*, 2,300-2,600 m), and Temperate Grassland and Scrubland (*Parrotiopsis jacquemontiana, Themeda anethra*, 1,900-2,900 m). We recorded 404 visual encounters and signs of *Hangul* and found that the habitat use was significantly different across seasons ($\chi^2$= 32.33 df= 4, $P$< 0.001). Maximum number of sightings and evidences (39%) were recorded in Temperate grassland/scrub habitat followed by Riverine (26%) and Lower Temperate pine mixed (9%). Temperate grassland/scrub habitat was used more than its availability (0.36 ≤ $P$ ≤ 0.487) in all seasons. Based on 404 *Hangul* use plots and 121 available plots, we found that there was a significant difference in the use of elevation zones by *Hangul* between seasons ($\chi^2$= 12, df= 12, $P$< 0.01). In spring, *Hangul* used the elevation categories 1,901-2,100 m (0.123 ≤ $P$ ≤ 0.321) and 2,101-2,300 m (0.245 ≤ $p$ ≤ 0.473) more than availability. In summer and autumn, maximum proportion of sightings and signs were recorded in the elevation ranges 1,901-2,100 m and 2,101-2,300 m and in winter *Hangul* used valley areas with elevation category of 1,700-1,900 m more than its availability (0.521 ≤ $P$ ≤ 0.766). Most (40%) of the sightings and signs were recorded in Eastern aspect and *Hangul* use of aspect differed significantly ($\chi^2$= 96.33, df= 18, $P$= 0.00) in different seasons. Slope use by *Hangul* have differed significantly ($\chi^2$= 25.09, df= 9, $P$= 0.003) and the maximum percentage of sightings and signs (37%) were recorded in slope category of 10°-20°. Based on dung analysis (n= 67) and direct feeding observations (n= 38), we found a seasonal variation in diet composition of *Hangul* and it was mostly composed of Grass/herbs (60%) in summer, forbs/fern (46.66%) in spring and autumn, and bark of trees (57%) mostly *Salix alba* during winter. Twenty food plant species were observed in the diet of *Hangul*. Some of these include: *Berberis* sp.*, Geranium* sp.*, Aesculus indica,*

*Poa annua, Rumax nepalensis, Hedera nepalensis, Smilax vaginata*, and *Rosa* sp.

Key words: *Cervus elaphus hanglu*, Dachigam, habitat use, food habits, management.

## Resumen

*Uso del habitat y habitos alimenticios del hangul (*Cervus elaphus hanglu*) en el Parque Nacional de Dachigam, Cachemira, India*

Se investigaron el uso de hábitat y los hábitos alimenticios del Hangul (*Cervus elaphus hanglu*) en Parque Nacional Dachigam, Cachemira, India, entre abril de 2007 junio de 2009. Hemos caracterizado los hábitats usados por el hangul sobre la base de parcelas de vegetación (n=98) a lo largo de 13 transectos que sistemáticamente cubren el Lower Dachigam (ca 90 km$^2$), nuestra área intensiva de estudio. Hemos clasificado cinco hábitats: fluvial (1.600-1.900 m), bosque mixto templado bajo (*Celtis australis*, *Morus alba*, *Aesculus indica*, *Juglans regia* y *Parrotiopsis jacquemontiana*, 1.800-2.200 m), bosque templado de pinos mixto bajo, (*Pinus wallichiana* y otros , 1.800-2.400 m), bosque mixto templado medio (*Ulmus wallichana*, *C. australis*, *A. indica* y *P. jacquemontiana*, 2.300-2.600 m) y los pastizales templados y matorrales (*Parrotiopsis jacquemontiana*, *Themeda anethra*, 1.900 - 2.900 m). Se registraron 404 encuentros visuales y signos de hangul y encontramos que el uso del hábitat fue significativamente diferente entre estaciones ($\chi^2$= 32,33 g = 4, P<0,001). El número máximo de avistamientos y evidencias (39%) se registraron en los pastizales templados / matorrales, seguido por el hábitat ribereño (26%) y por el bosque templado de pinos mixto bajo (9%). El hábitat compuesto de pastizales templados/matorral se utilizó más de su disponibilidad (0,3 ≤ P≤ 0,487) en todas las estaciones. Sobre la base de 404 parcelas de uso hangul y 121 parcelas disponibles, se encontró que había una diferencia significativa en el uso de zonas de elevación por hangul entre las estaciones ($\chi^2$= 12, df= 12, P<0,01). En primavera el hangul utiliza altitudes de entre 1.901-2100 m (0,123≤P ≤0,321) y 2.101-2.300 m (0,245≤p≤0,473) más de la disponibilidad. En verano y otoño, la proporción máxima de avistamientos y señales se registraron entre los rangos de altitud 1.901-2.100 y 2.101-2.300 m y m y en invierno el hangul utilizan los valles entre 1.700-1.900 m más que su disponibilidad (0.521≤P≤0.766). La mayoría (40%) de los avistamientos y señales se registraron en zonas orientadas al Este, apareciendo diferencias significativas ($\chi^2$= 96.33, df= 18, P= 0.00) en las diferentes estaciones. Las pendientes usadas por el hangul difieren significativamente ($\chi^2$= 25.09, gl= 9, P= 0,003) y el porcentaje máximo de los avistamientos y señales (37%) se registraron en pendientes de entre 10º-20º. Basándonos en análisis de excrementos (n= 67) y observaciones directas de alimentación (n= 38) se encontró una variación estacional en la composición de la dieta del hangul, la cual está compuesta en verano de pasto/hierbas (60%), en primavera y otoño de hierbas/helechos (46,66%) y de corteza de árboles en invierno (57%) fundamentalmente de Salix alba. Veinte y dos especies de plantas se han observado en la dieta del hangul, entre las que destacan: *Berberis* sp., *Geranium* sp., *Aesculus indica*, *Poa annua*, *Rumax nepalensis*, *Hedera nepalensis*, *Smilax vaginata* y *Rosa* sp.

Palabras clave: *Cervus elaphus hanglu*, Dachigam, uso del hábitat, hábitos alimenticios, manejo.

## Introduction

The Kashmir Red deer or *Hangul* (*Cervus elaphus hanglu*) is the one of the four eastern most distributed subspecies of red deer that inhabits the temperate coniferous forests in the western Himalayas of Jammu and Kashmir State in India. Historically, it was widely distributed in the mountains of Kashmir valley and some parts of Chamba district of Himachal Pradesh State (Schaller 1969). The distribution of *Hangul* is an arc of 40 miles from north to east of Jhelum and lower Chenab valley from Shalurah in North to Ramnagar in South (Lydekker 1924, Holloway 1972, Charoo *et al.* 2009). Due to increasing rate of fragmentation of forested habitats and poaching, there was a drastic decline in the population and as well reduction in the distribution range of *Hangul*. Today, the only viable population of *Hangul* is restricted to Dachigam National Park (NP) and adjoining protected areas (Kurt 1978, Iqbal *et al.* 2005, Ahmad *et al*. 2005, Ahmad 2006). As per the IUCN Red List of threatened species assessment 1996, the subspecies is categorized as EN. *Hangul* is placed under schedule I in the Jammu and Kashmir State Wildlife Protection Act, 1978 and in Indian Wildlife (Protection) Act, 1972, and LC in IUCN 2010.

Anthropogenic pressures and disturbances in the form of movement of people and operations by the security forces are some of the major threats to *Hangul* population. The population decline could be attributed to low recruitment rate of fawns to adults due to predation pressure. The major predators in Dachigam NP are Leopard *Panthera pardus* and Asiatic black bear *Ursus thibetanus* (Gee 1965, Schaller 1969, Iqbal *et al.* 2005; Ahmad *et al.* 2005). *Hangul* forms a major proportion (*ca*. 25%) of the leopard diet (Iqbal *et al.* 2005) and it forms almost 5% of black bear diet (Sharma *et al.* 2009).

Habitat for a species is an area that provides food and cover and is central to its survival and reproductive success (Johnsingh *et al.* 1999). Thus the study on habitat use is important for the conservation and management of any species. Habitat use of ungulates in the Himalayas depend on various factors such as altitude, aspect, and slope which determine the vegetation of the area in addition to availability of water, shelter and escape cover (Schaller 1977, Green 1985,

Putman 1986, Beirer & Mc Cullough 1990, Chundawat 1992, Sathyakumar 1994, Vinod & Sathyakumar 1999).

As like the Red deer, *Hangul* move to the higher elevations during summer *i.e.*, the alpine and sub-alpine habitats of Upper Dachigam area in the past. However, in the recent past, they have been confined to the middle and lower elevations of the Lower Dachigam due to the large scale livestock grazing and biotic interferences in its summer range (Ahmad *et al.* 2005). But in winter and autumn, their distribution is restricted to riverine habitats (Gee 1965, Schaller 1969, Charoo *et al.* 2009). *Hangul* being a generalist feeds mostly on herbs, grasses, forbs and some times feeds on fruits of species such as *Aesculus indica* (Shah *et al.* 1983, Ahmad *et al.* 2005). This paper presents the habitat use, and food and feeding habits of *Hangul* at Dachigam NP during the period April 2007 to June 2009.

## Study Area

The Dachigam NP is located in Kashmir Valley, 21 km northeast of Srinagar, capital of Jammu and Kashmir State of India (Figure 1). It covers an area of 141Km$^2$ which extends between 34$^0$05'-34$^0$11'N and 74$^0$54'E-75$^0$09'E in Zanskar mountain range of Northwest Himalayan biogeographic zone (2A) of India (Rodgers *et al.* 2000). This NP is bounded by Dara block of the Sindh Forest Division (FD) in the north; by Brain block, Khrew and Tral ranges of Forest Plantation Divisions in the South; by Harwan village and Harwan reservoir in the west; and by Lidder FD in the east. The Overa-Aru Wildlife Sanctuary (WS) is connected to the south-eastern portion of Dachigam NP. The Lower Dachigam encompasses areas that fall in the altitudinal range from 1,650 m to 3,950 m (Mahadev peak) and the altitudinal range of upper Dachigam ranges from 2,000 m to 4,400 m. Dachigam NP has a temperate climate with cool summer and harsh winter. The mean temperature recorded in summer is maximum 27.3$^0$C and minimum in winter of 2.0$^0$C. Average rainfall recorded is 660mm but there is no definite rain season as like other parts of the country (Ahmad *et al.* 2005).

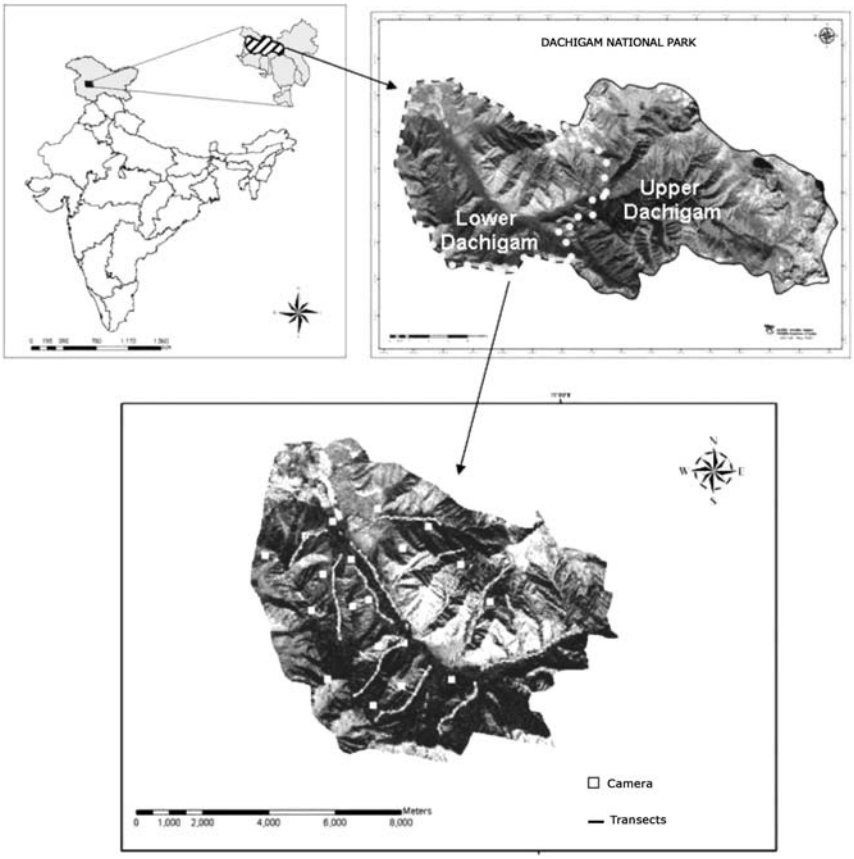


Figure 1. (a) Maps showing the location of Dachigam National Park in India; (b) the Lower Dachigam (Intensive Study Area) in Dachigam National Park; and (C) the locations of transects/trials and camera trap stations in Dachigam National Park.

The vegetation of Lower Dachigam NP is classified as Himalayan Moist Temperate Forest (Champion & Seth, 1968). The middle altitude of the park is typical of the west Himalayan upper broad leaved conifer mixed forests that is replaced by subalpine birch forests and alpine scrub and meadows above 3,000 m. The vegetation of the valley is very patchy. The tree species such as *Ulmus wallichiana*, *Salix alba* and *Populus cilia* are found along the streams, *Prunus armeniaca* is found in open scrub areas, and *Quercus robur* and *Robina pseudoacacia*

in distinct pure patches which show evidence of having been planted. Shrubs species are quite evenly distributed throughout the valley. Common shrub species in the lower parts of Dachigam are four species of *Prunus,* two species each of *Rubus, Berberis, Vibernum* and *Rosa, Indigofera* and *Parrotiopsis* (Sharma *et al.* 2007). The vegetation on the southern aspects is characterized by grassy slopes with *Prunus armenica*, *Rosa webbiana* and *Rubus niveus*. The *nullahs* (streams) have reasonable tree cover, including species such as *Aesculus indica* and *Juglans regia*. The northern aspects have more tree and shrubs cover with species such as *Pinus griffithi*, *Aesculus indica*, *Prunus armenica* and *Parrotiopsis jacquemontiana* (Sharma *et al.* 2007).

## Methods

Investigations on habitat use and food habits of *Hangul* were carried out in Lower Dachigam area (90 km$^2$), from April 2007 to June 2009. The study period was divided into four seasons: winter (December to February), spring (March to May), summer (June to August) and autumn (September to November). A total of 193 field days of effort was made by the research team.

A total of 121 circular plots were laid systematically transects/trails (n=13) at every 250 m and along the main Dachigam stream at every 500 m interval in the intensive study area to quantify habitat availability. At each sampling plot (availability plot), we sampled tree species using 10 m radius plots, shrubs in 5 m radius plots and 1x1 m square for ground layer vegetation. The phenology was recorded in all these plots once in a fortnight. The vegetation data was analyzed using TWINSPAN analysis (Hill 1979) to classify plant communities. This along with field observations was used to classify *Hangul* habitats (Figure 2).

The transects/trails represented all the habitat types and elevation categories of the intensive study area. They were sampled twice a month to record visual encounters /signs of *Hangul*. For every visual encounter/sign, we laid a 'animal focal plot' (used plot) to quantify habitat use by *Hangul*. Habitat parameters such as habitat type, altitude, aspect, slope, canopy and ground cover were recorded. *Hangul* signs included: dung, hoof marks, debarking (feedings) signs on trees, and antler rubbing signs on trees. In case of a combination of visual encounters

and signs, only visual encounters were considered for quantification of habitat use. Similarly, in case of a combination of many signs, only one type of evidence (fresh/recent) was considered.

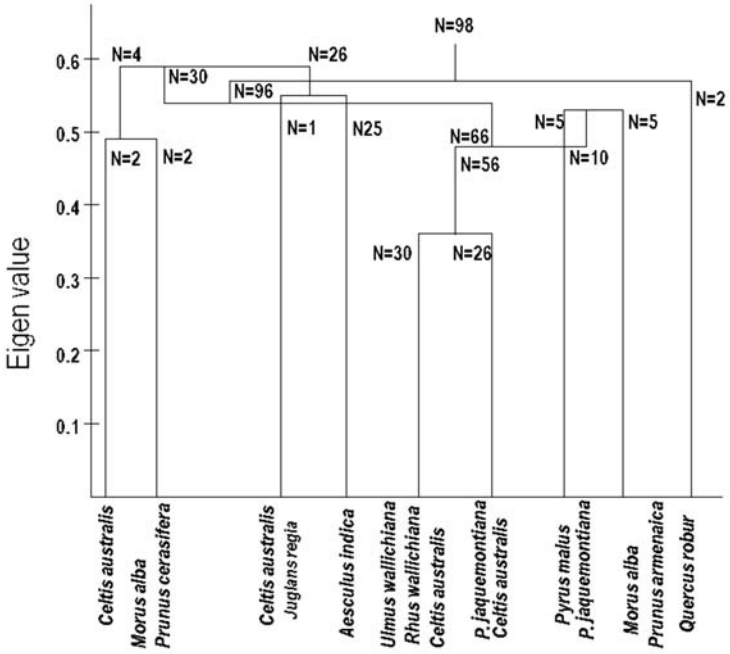


Figure 2. Dendrogram showing the results of TWINSPAN analysis with Eigen values for plant community classification of vegetation data collected from vegetation plots (n=98) at Dachigam NP.

The data from the availability and use plots was pooled and compared for habitat availability-utilization in different seasons. The Chi-square statistic ($\chi^2$) was used to statistically test for significant use of different habitat variables. To understand the preference among the habitat types, we calculated the available area of habitat types from the habitat map that was generated. Bonferroni

confidence intervals (95%) were computed based on Neu *et al.* (1974) to determine preference for habitat categories in terms of habitat used more than availability (UMA), in proportional to availability (UPA), and used less than availability (ULA) in terms of area.

To understand *Hangul* food habits, micro histological analysis of pellet groups that were collected in the intensive study area was carried out. Opportunistic direct feeding observations were recorded to confirm the utilization of various grasses and forbs by *Hangul*. From each pellet group 5-10 pellets were collected and preserved for analysis (Sabins 1981, 2004). Collected Pellet samples were dried and grinded using grinding machine which were later processed by the Sparks and Malechek (1968) method so that at least three slides were prepared from each pellet group sample and number of species were estimated on these three slides of each pellet group (Shrestha *et al.* 2005, Wegge *et al.* 2006). Epidermal tissue fragments were identified and recorded from each slide and percentages of each species were calculated following Sparks and Malechek (1968) and compared with the reference slides of plant species (Holecheck *et al.* 1982) collected from the study area and also form the information based on the opportunistic direct feeding (n=38) observations. SPSS 16.0 and MINITAB 13 computer programs were used for data analyses.

## Results

Of the five major vegetation types in Lower Dachigam NP, Temperate grasslands and scrublands covered 35.6% of the study area, followed by riverine (24.9%), Lower temperate pine mixed (16.9%), Mid-temperate (12.9%) and Lower temperate (9.71%). The characteristics of these habitats are presented in Table 1. Habitat map was prepared based on plant community structure. The Global landsat data was used for the false color classification of the habitat. Habitat map was generated by adopting hybrid method of classification using GIS domain software ArcGIS 9.1 ERDAS 9.4 with an accuracy of 91% (Figure 3).

TABLE 1
Characteristics of *Hangul* Habitats in Dachigam National Park.

| Habitat type | Total area ($km^2$) | Elevation Zone (m) | Dominant plant species with mean Densities/ha | #/ha SE |
|---|---|---|---|---|
| Riverine Habitat | 17.36 | 1600-1900 | *Morus alba* | 88.05 ± 18.43 |
| | | | *Quercus robur* | 23.38 ± 6.19 |
| | | | *Aesculus indica* | 47.82 ± 11.33 |
| | | | *Prunus cerasifera* | 78.31 ± 23.41 |
| | | | *Prunus tremantosa* | 36.56 ± 9.21 |
| Temperate grassland & Scrubland | 24.81 | 1900-2900 | *Paraotiopsis jacquemontiana* | 12 ± 4.10 |
| | | | *Prunus armeniaca* | 6.43 ± 1.09 |
| Lower temperate mixed | 6.77 | 1800-2200 | *Celtisaustralis* | 29.29 ± 7.28 |
| | | | *Juglans regia* | 19.48 ± 3.97 |
| | | | *Aesculus indica* | 13.63 ± 3.07 |
| Mid temperate mixed | 9.07 | 2300-2600 | *Ulmus wallichana* | 22.30 ± 8.62 |
| | | | *Rhus wallichiana* | 12.78 ± 3.07 |
| | | | *Celtis australis* | 4.78 ± 0.52 |
| Lower temperate pine mixed | 11.81 | 1800-2400 | *Pinus wallichiana* | 69.01 ± 19,06 |
| | | | *Prunus armeniaca* | 7.65 ± 1.85 |
| | | | *Pyrus malus* | 2.54 ± 0.18 |

### *Habitat use*

A total of 404 *Hangul* encounters were recorded which included: 319 sightings and 40 feeding signs, 32 dung, 13 hoof marks and 10 antler rubbing signs on trees. All signs were independent. Based on our observations on transects/trails on *Hangul* habitat use, we found that about 39% of the visual encounters and

signs were recorded in temperate grassland/scrubland, 25% in riverine forests, and 9% in lower temperate habitat. *Hangul* habitat use was significantly different across seasons ($\chi^2$= 32.33 df= 4, p<0.001). Temperate grassland/scrub habitat was used more than its availability ($0.36 \leq p \leq 0.487$) in all seasons. Riverine and lower temperate mixed habitats were used in proportion to availability (Table 2) whereas lower temperate pine mixed and mid-temperate habitats were used less than availability.

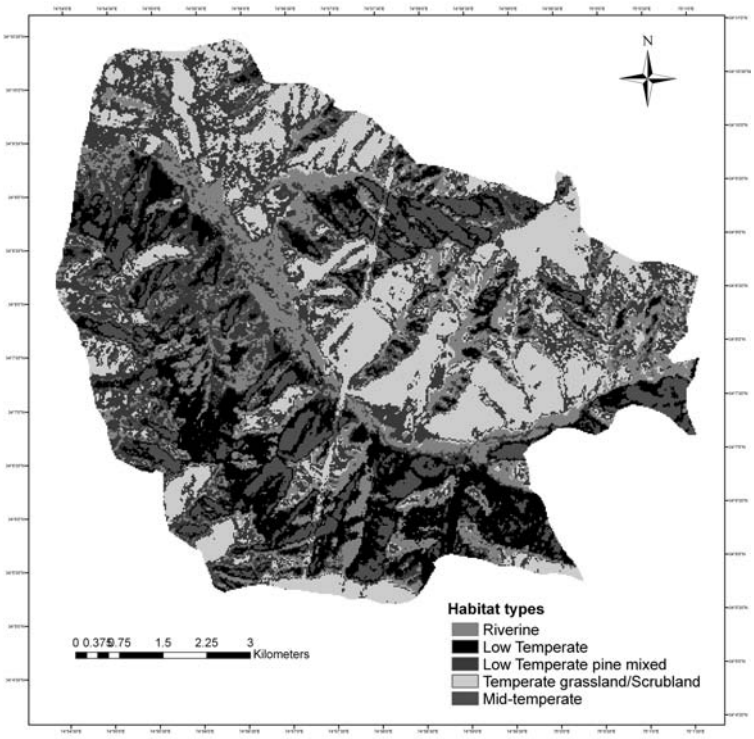


Figure 3. *Hangul* Habitats characterized at Lower Dachigam, Dachigam National Park, Kashmir, India.

TABLE 2
*Hangul* Habitat Availability-Utilization Analysis at Dachigam National Park, April 2007 to June 2009. Utilization based on 404 *Hangul* visual encounters and signs. Availability calculated from the habitat map of the intensive study using GIS.

| Habitat type | Total area ($km^2$) | Relative area | Observed usage | Confidence intervals |
|---|---|---|---|---|
| Riverine | 17.36 | 0,249 | 118 | $0.234 \leq p \leq 0.350$ |
| Temperate grassland & Scrub | 24.81 | 0,356 | 171 | $0.360 \leq p \leq 0.487$* |
| Lower Temperate mixed | 6.77 | 0,097 | 46 | $0.073 \leq p \leq 0.155$ |
| Mid-Temperate Mixed | 9.01 | 0,129 | 35 | $0.051 \leq p \leq 0.123$* |
| Lower Temperate pine mixed | 11.81 | 0,169 | 34 | $0.049 \leq p \leq 0.120$* |
| Total | 69.76 | 1,000 | 404 | |

* Indicates a difference at the 0.05 level of significance

On examining the availability and utilization of the elevation categories (Table 3), a significant difference in the use of elevation zones by *Hangul* between seasons ($\chi^2$= 12, df= 12, $P< 0.01$) was recorded. In spring, *Hangul* used the elevation categories 1,901-2,100 m ($0.123 \leq P \leq 0.321$) and 2,101-2,300 m ($0.245 \leq p \leq 0.473$) more than their availability, but used higher elevations (2,501-2,700 m) less than their availability, and used medium elevation categories in proportion to their availability (Figure 4a). In summer and autumn, maximum percentage of sightings and signs were recorded in the elevation range from 1,901-2,100 m and 2,101-2,300 m and in winter *Hangul* used the valley areas with elevation zones 1,700-1,900 m more than their availability ($0.521 \leq P \leq 0.766$).

The maximum proportion of *Hangul* visual encounters and signs were recorded in eastern aspect (40%). Aspect use by *Hangul* differed significantly ($\chi^2$= 96.33, df= 18, $P< 0.01$) in different seasons. In spring, *Hangul* used western and northern aspects less than their availability, but in summer used north-eastern

aspect ($0.067 \leq P \leq 0.274$) more than their availability and south-eastern aspects less than their availability. In autumn, *Hangul* used western aspect ($-0.014 \leq P \leq 0.122$) less than their availability and used all remaining seven aspects categories in proportion to their availability. In winter, *Hangul* used eastern aspect more than its availability ($0{,}256 \leq P \leq 0{,}484$) and used areas with south, north and south-eastern aspects less than their availability (Figure 4b).

Slope use by *Hangul* differed significantly ($\chi^2 = 25.09$, df= 9, $P = 0.003$) but the maximum percentage of visual encounters and signs (37%) were recorded in slope category of 10°-20°. In spring, *Hangul* used areas with steeper slopes (>40°) more than their availability ($0{,}304 \leq P \leq 0{,}553$) and all other slope categories in proportion to their availability. In summer, areas with gentler slopes were used less than their availability ($0{,}023 \leq P \leq 0{,}137$) but in autumn, *Hangul* did not show any preference for slope and used all categories in proportion to their availability. In winter, *Hangul* used less steeper slopes (10°-20°) and flat areas more than their availability (Figure 4c).

***Food Habits***

In total, 67 fresh pellet groups were collected from different seasons and n= 38 direct feeding observation were made. Out of total pellet groups collected, 23.9% were from Riverine, 13.4% from Low temperate, 17.9% from low temperate pine ,10.4% from mid-temperate and 34.3% from temperate habitat. Results of the micro histological examination of *Hangul* dung samples revealed that there was seasonal difference in the food habits of *Hangul* in different seasons ($\chi^2 = 50.46$, df= 12, $p<0.001$). In summer, *Hangul* diet was dominated by grasses and herbs (60.8%), (38.7%) tree and (25.8%) shrubs contributed maximum in winter, but in spring and autumn, forbs/ferns contributed the most (46% each). Out of total direct feeding observations (n= 38), most of them were on herbs and grasses (Figure 5a).

The frequency of occurrence of food plants in the diet of *Hangul* were: *Poa annua* (14.1%), *Hemerocallis fulva* (6.1%), *Hedera nepalensis* (8.1%), *Rosa* sp, (5.3%), *Berberis lycium* (2.2%), and *Bromus japonicus* (6.8%). The overall diet composed of forbs 27.6%, shrubs 11.4%, grasses 21.9%, climbers 9.5% and

TABLE 3
Hangul Habitat Factors Availability - Utilization at Dachigam National Park, April 2007 to June 2009. Availability based on 121 available plots and use based on 404 hangul visual encounters and signs.

| Habitat Variable | Relative Proportion | Observed Usage | Bonferroni Confidence Interval | | Chi Square Values & Significance of Usage |
|---|---|---|---|---|---|
| | | | Lower | Upper | |
| Elevation(m) | | | | | $\chi^2$=12, df= 12, p=0.00 |
| 1700-1900 | 0.347 | 0.384 | 0.321 | 0.446 | Used in proportion |
| 1901-2100 | 0.122 | 0.218 | 0.165 | 0.271 | Preferred |
| 2101-2300 | 0.224 | 0.255 | 0.199 | 0.311 | Used in proportion |
| 2301-2500 | 0.133 | 0.052 | 0.024 | 0.080 | Avoided |
| 2501-2700 | 0.173 | 0.092 | 0.055 | 0.129 | Avoided |
| Aspect | | | | | $\chi^2$=96.33, df=18, p=0.00 |
| E | 0.122 | 0.218 | 0.144 | 0.291 | Preferred |
| SE | 0.184 | 0.134 | 0.056 | 0.211 | Used in proportion |
| S | 0.173 | 0.116 | 0.027 | 0.205 | Used in proportion |
| SW | 0.153 | 0.126 | 0.018 | 0.235 | Used in proportion |
| W | 0.224 | 0.166 | 0.026 | 0.306 | Used in proportion |
| NW | 0.061 | 0.067 | -0.040 | 0.173 | Used in proportion |
| N | 0.051 | 0.139 | -0.026 | 0.303 | Used in proportion |
| NE | 0.031 | 0.035 | -0.062 | 0.131 | Used in proportion |
| Slope angle (deg,) | | | | | $\chi^2$ =25.09, df=9, p=0.003 |
| <10 | 0.214 | 0.260 | 0.007 | 0.512 | Used in proportion |
| 11-20 | 0.245 | 0.371 | 0.069 | 0.674 | Used in proportion |
| 21-30 | 0.245 | 0.265 | -0.033 | 0.563 | Used in proportion |
| >40 | 0.296 | 0.104 | -0.117 | 0.325 | Used in proportion |

trees 29.5% (Table 4). Major contributors to *Hangul* diet during summer were *Poa annua, Morus alba, Carex cernua,* and *Solanum nigrum*. During spring, forbs were the major contributors (46.6%), followed by trees (13.3%), grasses (20%)

and shrubs (6.6%). In autumn, the major components of the *Hangul* diet were: *Indigofera* sp., *Aesculus indica*, *Rosa sp,*, and *Hedera nepalensis*. Shrubs accounted for 10.7% of the diet, trees 21.4% and forbs 46.4% and grasses 14.2%. The major dietary items in the winter were: *Aesculus indica*, *Rosa babiliana*, *Hedera nepalensis* and *Salix alba*. Trees accounted for 38%, shrubs 25.8%, forbs 16%, grasses 7% and climbers 12.9% (Figure 5b).

Table 4
Percent frequency of occurrence and plant types of food items in dung samples (N= 67) of *Hangul* in Dachigam National Park, April 2007 to June 2009.

| Plant species | Percent occurrence | Plant type |
|---|---|---|
| *Poa annua* | 14.1 | Grass |
| *Portulaca oleracea* | 10.3 | Forb |
| *Aesculus indica* | 9.0 | Tree |
| *Hedera nepalensis* | 8.1 | Climber |
| *Rumex nepalensis* | 7.4 | Forb |
| *Hemerocallis fulva* | 6.1 | Forb |
| *Indigofera* sp. | 5.5 | Shrub |
| *Rosa* sp. | 5.3 | Shrub |
| *Jasminum humile* | 4.6 | Shrub |
| *Geranium* sp. | 3.9 | Grass |
| *Bromus japonicus* | 3.4 | Grass |
| *Prunus tomentosa* | 3.3 | Shrub |
| *Salix alba* | 3.2 | Tree |
| *Smilax vaginata* | 3.1 | Grass |
| *Heraculum* sp. | 3.0 | Forb |
| *Carex* sp. | 2.2 | Forb |
| *Berberis lycium* | 2.2 | Shrub |
| *Ophioglosum* sp. | 1.8 | Forb |
| *Solanum nigram* | 1.6 | Forb |
| *Arctium lappa* | 1.5 | Forb |

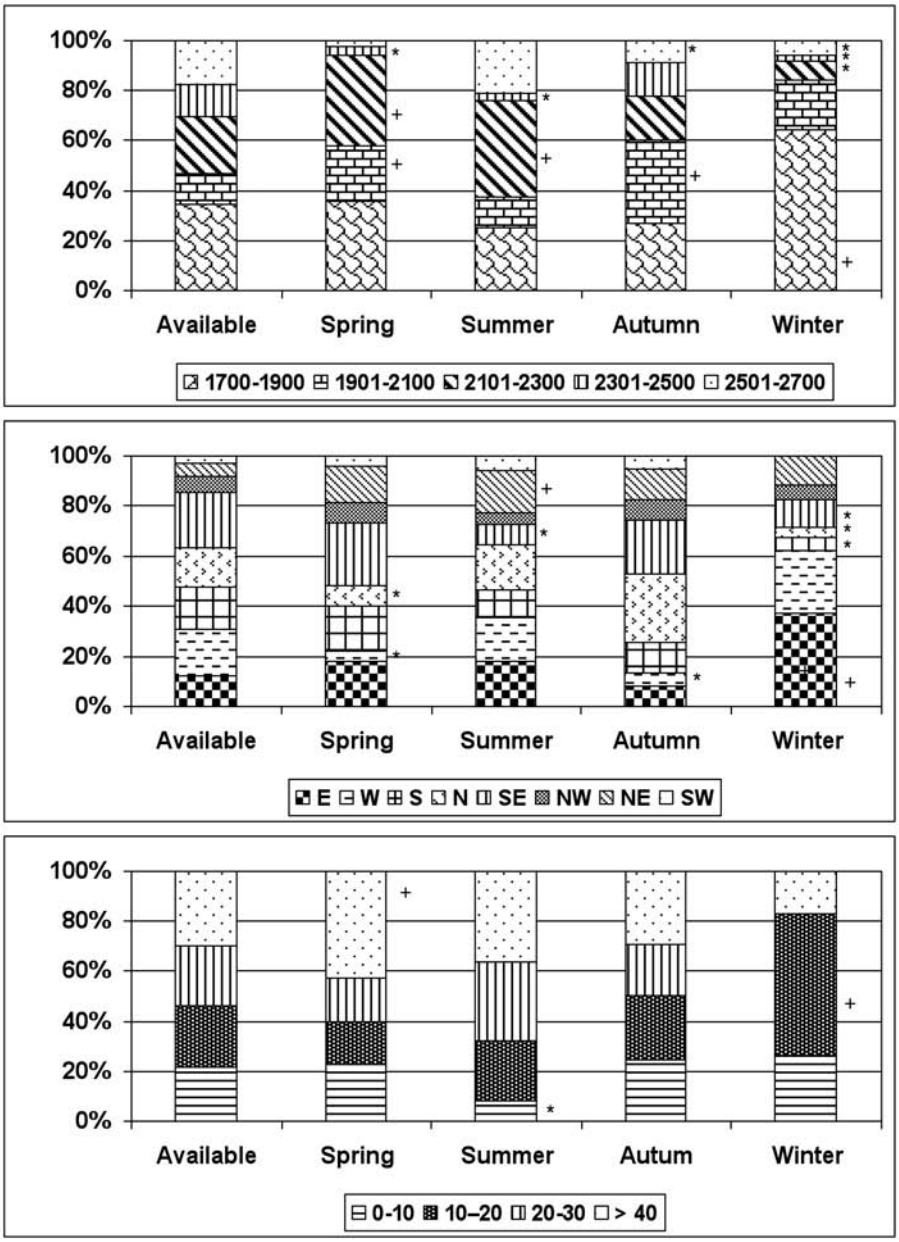


Figure 4. Availability and use of (a) Elevation, (b) Aspect, (c) Slope by *Hangul* in Dachigam National Park, April 2007 to June 2009 based on 121 availability plots and 404 used plots . (+ used more than availability; * used less than availability; unmarked - used in proportion to availability; significance level maintained at 0.05).

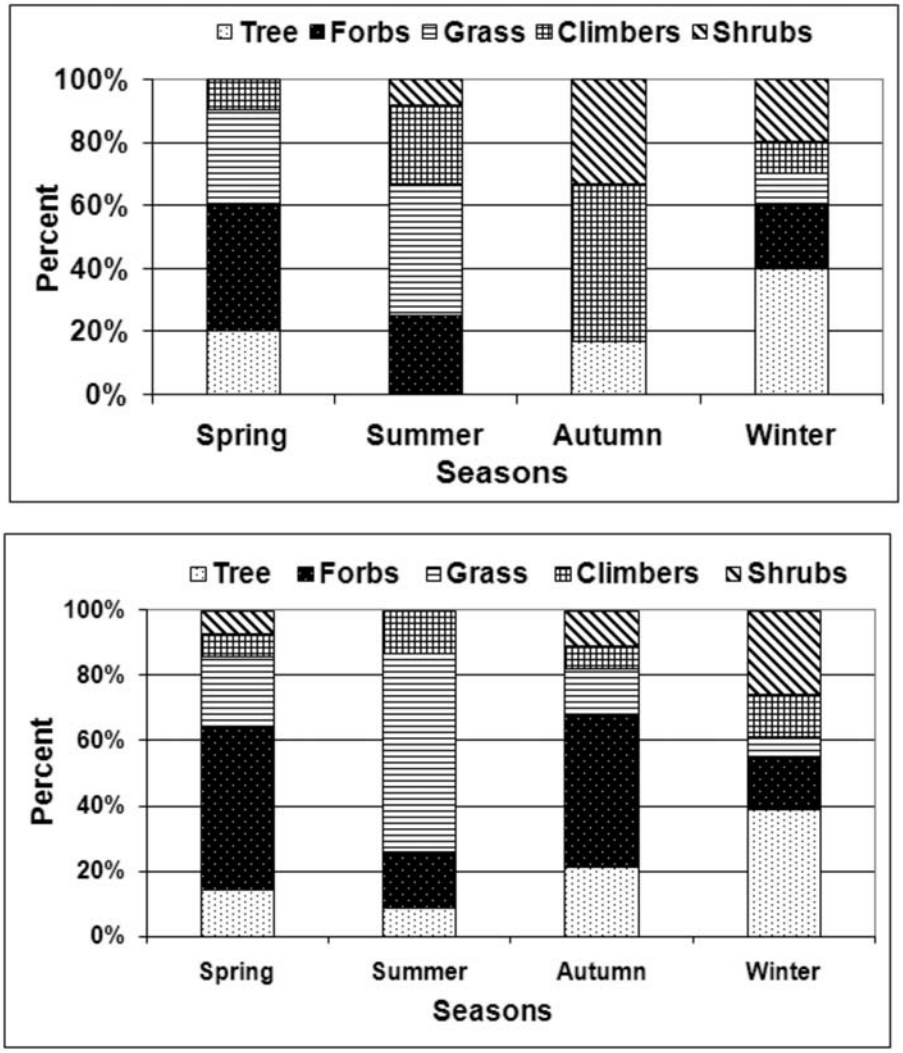


Figure 5. Diet composition of *Hangul* in Dachigam National Park, based on (a) direct feeding observations (n= 38) and, (b) dung sample analysis (n= 67), April 2007 to June 2009.

## Discussion

Habitat use is a critical facet for the wildlife species. Habitat provides food and cover essential for the survival of wild animal population. To understand habitat selection it is important to explain the major habitat components and their seasonal changes. The use of different habitat types by *Hangul* in Dachigam NP shows a seasonal shift in utilization patterns which can be associated with the changes in habitat structure and abiotic factors such as temperature and snowfall. Some of the major factors that affect habitat use by ungulates in the Himalaya include altitude, aspect, slope, habitat type, food availability-abundance and quality, escape terrain, escape cover and cover against extreme of weather and biotic pressures (Schaller 1977, Green 1985, Chundawat 1992, Sathyakumar 1994).

There was a significant difference in the habitat use patterns by *Hangul* in Dachigam NP. In winter and spring, the maximum sightings and signs were recorded in the Valley with flat areas which provide shelter to *Hangul* from extreme cold and heavy snowfall in its distribution range and fulfill the requirement of food (Table 4) since valley or stream has been considered to provide a better shelter (Staines 1976). The preferential use of riverine habitat by *Hangul* in winter and spring was due to the fact that riverine habitat were close to water and being provided with artificial food (salt lick) by the park management (Ahmad 2006). The movement of *Hangul* population from upper elevations to valley areas in winter and spring can be attributed with extreme cold weather conditions in upper elevation (Ahmad 2006). This kind of temporary movement of *Hangul* was found to be similar to Red deer (Clutton-Brock & Albon 1989). The availability of food and shelter has shown impact on the distribution and foraging behavior of deer (Staines 1977). The preference of eastern and steeper slopes was due to the fact that eastern slopes get more exposed to sunlight that provides relief from harsh cold winds. But in summer, maximum *Hangul* sightings and signs were recorded in the altitudinal range of 2,500-2,700 m because of the fact they do segregate, *i.e.*, females forming smaller groups and males separated from each other establishing social hierarchy and moving in different areas (Ahmad *et al.* 2005) which was similar to other Red deer (Clutton-Brock *et al.* 1982, Main *et*

*al.* 1996, Kie *et al.* 1999). In summer, the southern slopes provide good forage, but the valley areas were warmer and were not suitable for *Hangul* so they migrate to higher reaches of the Dachigam NP. The availability and quality of forage in Dachigam varies seasonally which leads to changes in diet of *Hangul* among seasons. The variation in the diet of deer is influenced by the availability of different food items in the habitat used by the roe deer (Jackson 1980, Holisova *et al.* 1986, Tixier & Duncan 1996). *Hangul* is also a generalist feeder as other Red deer and its diet was composed of grasses, herbs, tree bark and browse. The diet of *Hangul* in winter and autumn season was largely composed of tree bark (38.7%) and shrubs (25.8%) possibly as a strategy for complementing their diet when other forage is scarce. In winter, diet of *Hangul* tends to be more dependent on availability than on their foraging selection. The diet of *Hangul* was largely composed of forbs (46.7%) in spring season and a similar pattern as shown by other Red deer (Clutton-Brock & Albon 1989). In summer, *Hangul* diet was dominated by grasses and herbs (60%).

***Management implications***

The results of this study dealing with important aspects such as habitat use and food habits of *Hangul* will be helpful in (a) a better understanding of the ecology of this species and consequently its management in Dachigam NP; (b) habitat restoration in relic habitats outside the Dachigam NP; and (c) improvement in the habitats in the summer range (Upper Dachigam) by reducing livestock grazing and other anthropogenic pressures and carrying out habitat restoration activities.

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