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DISTRIBUTION AND RELATIVE ABUNDANCE OF KASHMIR RED DEER OR *HANGUL* (*Cervus elaphus hanglu*) AT DACHIGAM NATIONAL PARK, KASHMIR, INDIA

Samina Amin Charoo, Lalit Kumar Sharma & Sambandam Sathyakumar

Wildlife Institute of India, P.O. Box 18, Chandrabani, Dehradun 248 001, Uttarakhand, India. (ssk@wii.gov.in)

Abstract

We assessed the distribution and relative abundance of Kashmir Red deer or *Hangul* (*Cervus elaphus hanglu*) in Lower Dachigam (*ca.* 90 km^2), Dachigam National Park, Kashmir, India from April 2007 to June 2009. Line transects/trails (n=13) representing all the habitats of Lower Dachigam were used to record sightings and signs of *Hangul*. The study area was divided into 23 (2x2 km) grids and in each grid a camera trap was deployed. The distribution pattern and relative abundance of *Hangul* varied seasonally. In spring and autumn, *Hangul* sightings and signs were distributed uniformly in the study area whereas in winter, they were clumped in the riverine valley. During summer, we recorded low number of sightings and signs and most of these were distributed in the upper reaches of the study area. The overall encounter rates (#±SE) based on scan and transect sampling were 3.01±0.49 individuals/hr and 1.37±0.22 individuals/km, respectively. The encounter rate was highest in spring followed by winter, autumn and summer. The overall *Hangul* density (/km^2) was 3.09±0.66. The density was highest in spring (16.91±5.2) followed by winter (12.55±3.32), autumn (10.31±2.8) and summer (4.15±1.35). *Hangul* group sizes ranged from 1- 52 and the mean group size changed across seasons. Females formed the largest proportion of individuals that could be put into different age categories (52%). Adult males accounted for 27% of the population while fawns accounted for 21%. *Hangul* presence and the human disturbance, calculated in the form of photo capture rates were negatively correlated (R^2=0.41), P=0.084.

Key words: *Cervus elaphus hanglu*, distribution, group size, relative abundance

Resumen

*Distribución y abundancia relativa del hangul (*Cervus elaphus hanglu*) en el Parque Nacional de Dachigam, Cachemira, India*

Hemos evaluado la distribución y abundancia relativa de Hangul, una subespecie de ciervo rojo (*Cervus elaphus hanglu*), en el Bajo Dachigam (ca. 90 km^2) Parque Nacional de Dachigam, Cachemira, India, entre abril 2007 y junio 2009. Utilizamos el método de transecto lineal/ recorrido de senderos (n=13) en todos los hábitats presentes en el área de estudio registrando todos las observaciones y señales de Hangul. El área de estudio se ha dividido en 23 cuadrículas (2x2

km) instalándose una cámara trampa en cada una de ellas. La distribución y la abundancia relativa del Hangul varía estacionalmente. En primavera y otoño, los rastros de Hangul se distribuyen uniformemente por toda el área de estudio, mientras que en invierno se concentran en el valle del río. Durante el verano, hemos registrado un bajo número de señales y observaciones y la mayoría de estas se distribuyen por la zona superior del área de estudio. Las tasas globales de encuentro (±ES) basadas en barridos visuales y recorridos de transectos fueron de 3,01±0,49 ejemplares/hora y 1,37±0,22 ejemplares/km recorrido respectivamente. La tasa de encuentro fue la más alta en primavera seguida del invierno, otoño y verano. La densidad global fue de 3,09 ±0,66 (ind/ km^2). La densidad fue la más alta en primavera 16,91±5,2, seguida del invierno 12,55±3,32, otoño 10,31 ±2,8 y verano 4,15 ±1,35. Los grupos oscilan entre 1 y52 individuos, variando estacionalmente el tamaño medio de los mismos. Las hembras representan la más alta proporción de ejemplares clasificables en categorías de edad (52%). Los machos adultos representaban el 27% de la población y las crías el 21%. La presencia de Hangul y las perturbaciones humanas, calculadas a través de los índices de foto captura, está correlacionada negativamente (R^2= 0,41), P=0,084.

Palabras clave: Abundancia relativa, *Cervus elaphus hanglu*, distribución, tamaño de grupo.

Introduction

Quantifying the relationships between the distributions of species and their biotic and abiotic environments has a long history in ecological research. This is particularly in the case of endangered species, where knowing how the species are distributed and their habitat requirements are important in management and conservation. The Kashmir Red deer or *Hangul* (*Cervus elaphus hanglu*) is one of the four easternmost subspecies of red deer that has a restricted distribution unlike other red deer species which are widely distributed. According to Schaller (1969) the *Hangul* was once widely distributed in the mountains of Kashmir and was confined to a stretch of 65 km in width to the north and east of Jhelum and lower Chenab rivers. During the recent past, the distribution range of *Hangul* appears to have been drastically reduced possibly due to poaching, habitat fragmentation and degradation. Some small or relictic populations are also reported to be present in the neighboring areas of Shikargarh Conservation Reserve and Overa-Aru Wildlife Sanctuary. Within Dachigam National Park (NP) there has been a drastic decline in *Hangul* population during the last three decades. The recent population estimate reported a population of 175 ± 23 individuals (Charoo *et al*. 2009b). There have been a few studies on *Hangul* (Schaller 1969, Holloway *et al.* 1971, Kurt 1979, Shah *et al*. 1984, Ahmad *et al.* 2005, Ahmad 2006). Information on the

distribution, abundance and densities and also factors influencing the abundance and density are crucial requirements for the conservation and management of the species of restricted distribution such as the *Hangul*. This study was aimed to understand the distribution and abundance of this unique surviving viable population of *Hangul* in Dachigam NP.

Area of Study

This study was carried out in Lower Dachigam of Dachigam National Park (Dachigam NP) which is located in Kashmir Valley, 21 km northeast to Srinagar - the capital of Jammu and Kashmir State of India. It lies in Zanskar mountain range of Northwest Himalayan biogeographic zone (2A) of India (Rodgers *et al.* 2000) with an area of 141 km^2. 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. Dachigam NP has a temperate climate with cool summer and harsh winter. The mean temperature recorded in summer is maximum 27.3^0C and minimum in winter of 2.0^0 C. Average rainfall recorded is 660 mm but there is no definite rain season as like other parts of the country (Ahmad *et al.* 2005).

Based on altitudinal and vegetation categories Dachigam NP is divided into two parts (Lower Dachigam and Upper Dachigam). The Lower Dachigam encompasses areas that 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. 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. 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 on abandoned

agricultural fields. Shrubs species are quite evenly distributed throughout the valley. Common shrub species in the lower parts of Dachigam NP are four species of *Prunus,* two species each of *Rubus, Berberis, Vibernum* and *Rosa, Indigofera* and *Parrotiopsis*. The vegetation on the southern aspects is characterized by grassy slopes with *Prunus armenica*, *Rosa webbiana* and *Rubus niveus*. The *nullahs* 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* (Charoo *et al.* 2009a). Human use and disturbance to wildlife and their habitats in Dachigam NP includes grazing in higher altitudes in summer by nomadic pastoralists; collection of firewood and fodder by local people and tourism.

Material and Methods

The surveys were carried out in lower part of Dachigam NP during April and May 2007 and an area of 90 km² was selected as an intensive study area with elevations ranging from 1,960 m to 3,000 m.

Habitat characterization

To generate a habitat map of the study area, 121 permanent vegetation plots were marked along transects (n=98) at an interval of 250 m and (n=23) around the main Dachigam river at every 500 m. Within each sampling plot, a 10 m circular plot was laid to quantify tree density, 5 m circular plots for shrub density, and four 1x1 m quadrats for ground cover (herb, grass, bare ground, rock and litter) estimation. Habitat parameters such as altitude (using GPS), slope (ocular) and aspect were also recorded for each sampling plot. Aspect was measured on eight point scale of North, South, East, West, Northeast, Northwest, Southeast, and Southwest using a compass. For the habitat characterization and community classification TWINSPAN analysis (Hill 1979) was used.

Abundance

Line transect method (Thomas *et al.* 1980) was used for the estimation of distribution and relative abundance of *Hangul* in the study area. Curvilinear transects have been used to estimate abundance of mountain ungulates in different

parts of the Himalaya (Sathyakumar 1994, Vinod & Sathyakumar 1999). In total 13 transects were laid (Figure 1) and regularly monitored for *Hangul* presence twice a month. Habitat parameters such as habitat type, altitude, aspect and slope were recorded for every *Hangul* sighting and sign. *Hangul* signs included: dung, hoof marks, feeding signs (graze, browse, debarking), and antler rubbing signs on trees. For every sighting, in addition to the habitat parameters, data on time sighting distance, sighting angle, group size, age and sex were also recorded. We used four vantage points to monitor the animals. Opportunistic scan sampling was carried out between 06:00h-07:00h and 17:00h-18:00h during different seasons. Group structure, group size, activity, age and sex were recorded for each sighting.

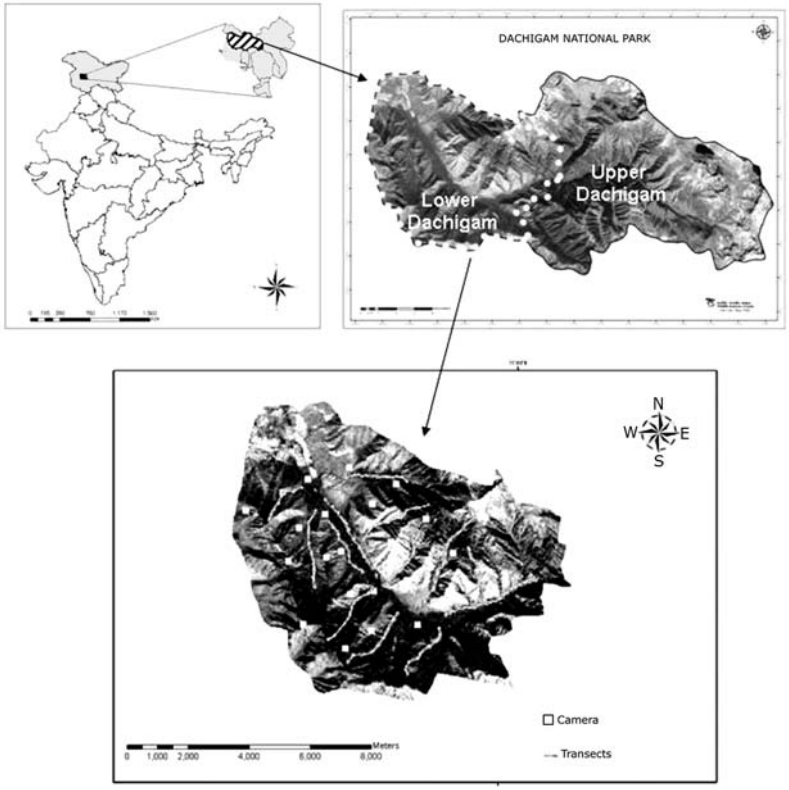

Figure 1. (a) Location of Dachigam National Park in India; (b) the Lower Dachigam (Intensive Study Area) in Dachigam National Park; and (C) the locations of transects/trials and camera trap stations in Dachigam National Park.

The density estimates of *Hangul* were calculated using DISTANCE 5.0. Post stratification procedure was used to get the seasonal density from the pooled dataset and the data was subjected to interval classes but not truncated (Thomas *et al.* 2002). Kruskal Wallis test was used to test the significance in variation of *Hangul* densities across the seasons. Hayne's estimator was used to calculate overall *Hangul* density based on the angular distances of the direct sightings on transects (Hayne 1949).

Distribution pattern

The GPS location of each sighting and sign of *Hangul* in the study area was recorded and the locations were plotted on the habitat map to understand the distribution pattern of *Hangul* in the study area. ArcGIS 9.3 was used to plot all the GPS locations of different *Hangul* evidences for each season on the habitat map of the study area.

Site occupancy and detection probability

The study area was divided into 23 grids (2x2 km) for a systematic sampling (MacKenzie & Royle 2005) and in each grid a camera trap (*Wildview*) was deployed. Camera trapping was carried out in three seasons, spring (April-May), summer (June-September) and autumn (October-December) during 2008-2009. During winter, camera trapping was not carried out due to the technical inadequacy of the camera to perform at low temperatures. Each trap was regularly checked after 2-3 days for the photo captures. Camera trapping data has been used to estimate the density of ungulates (Datta *et al*. 2008).

Hangul photo capture rate (/100 trap nights) was calculated for each camera site (Carbone *et al*. 2001). Disturbances in the form of human photo capture rates were also calculated and a Pearson correlation between *Hangul* and human capture rates was carried out for forested areas and grassland habitats to understand the effect of human disturbance on *Hangul* distribution. For assessing the proportion of site utilization and detection probability based on camera trap captures PRESENCE 2.3 (Hines 2006) was used. To test statistically the difference in site occupancy and detection probability estimates across the seasons, t- test for means and standard deviation, NCSS 2007 was used.

Results

Relative abundance of Hangul

A total of 414 *Hangul* encounters were recorded based on 326 km of transect walk and 49 scans. This included: 319 sightings, 40 feeding signs, 32 dung, 13 hoof marks and 10 antler rubbing signs on trees. The overall encounter rates (±SE) based on scan and transect sampling were 3.01±0.49 individuals/hr and 1.37±0.22 individuals/km, respectively. The overall *Hangul* density (#/km²) was 3.09±0.66. Density was highest in spring (16.91±5.2) followed by winter (12.55±3.32), autumn (10.31±2.8) and summer (4.15±1.35) (Figure 2). The detection probability and effective strip width varied seasonally (Table 1). Although densities varied across seasons but the difference was not statistically significant (H=1.64, P=0.65).

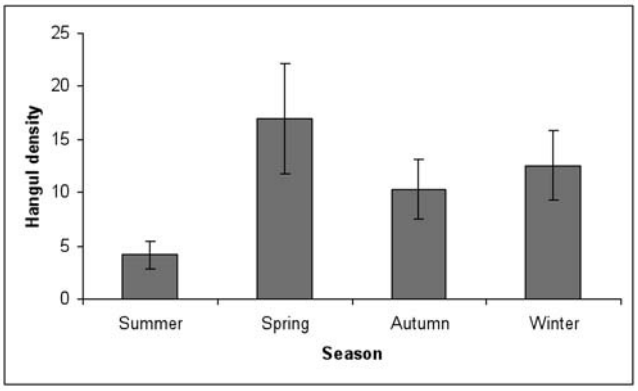

Figure 2. *Hangul* densities (groups/km²+SE) in different seasons in Dachigam National Park, 2007- 2009.

The overall *Hangul* group density was 0.43/km². The group size of *Hangul* ranged from 1- 52 and the mean group size was 5.3±1.05 individuals per group. *Hangul* group size was maximum in spring (7.04±2.00) followed by winter (6.75±1.04), autumn (4.15±0.96) and minimum in summer (3.78±0.55) (Figure 3). Females formed the largest proportion of individuals (52%) of *Hangul* population. Males accounted for 27% while as fawns accounted for 21% (Figure 4).

TABLE 1
Detection probability (p), effective strip width (ESW) and encounter rates (ER) with respective variances (CV) of *Hangul* in different seasons at Dachigam National Park, 2007-2009.

Season	p	CV (%)	ESW	ER	CV
Autumn	0.2	18	24.55	0.24	24%
Winter	0.2	12	24.89	0.45	22%
Spring	0.18	18	21.35	0.55	22%
Summer	0.22	12	26.53	0.45	20%

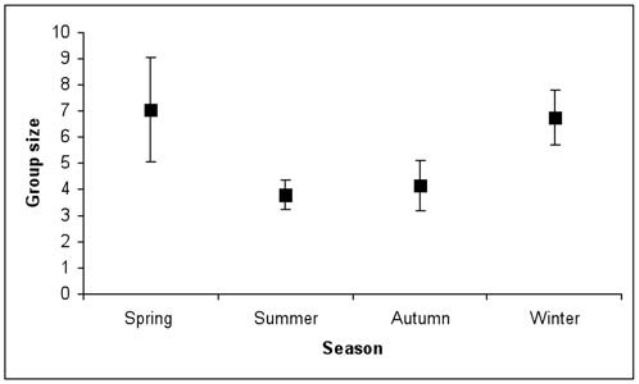

Figure 3. Mean group size of *Hangul* at Dachigam National Park, 2007- 2009.

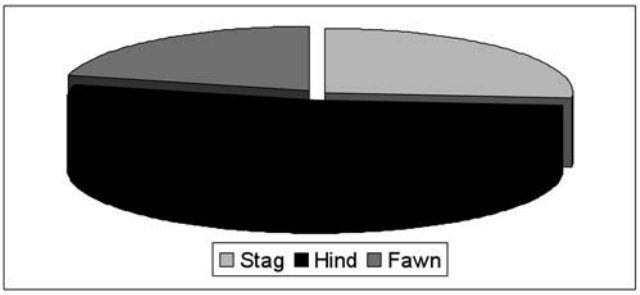

Figure 4. Group structure of *Hangul* at Dachigam National Park, 2007- 2009.

Distribution pattern

The distribution of *Hangul* in Dachigam NP showed a seasonal pattern. The distribution of *Hangul* signs and sightings was uniform in autumn (October-November) and spring (March-May). During summer (June-September) the animal evidences were more distributed towards the higher elevation ranges. In winter (December-February), *Hangul* sightings and evidences were clumped in riverine habitats of the study area (Figure 5).

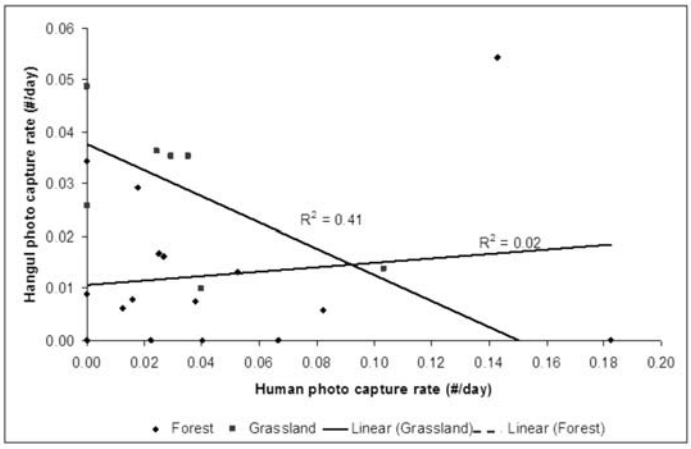

Figure 5. Correlation between *Hangul* and human capture rates in two (Grassland and Forest) habitats in Dachigam National Park, 2008-2009.

The overall detection probability and site utilization based on the camera trap captures was 0.88±0.09 and 0.15±0.02 (Table 2). The site utilization did not vary significantly when compared between the seasons, spring and summer (t=0.29, P=0.77) or for autumn and summer (t=1.45, P=0.22).

The mean capture rate (/100 trap nights) for *Hangul* in the study area was 1.74±0.34. In grassland habitats the *Hangul* capture rate was negatively correlated (R^2=0.41) with the human photo capture rate but the correlation was not statistically significant (P=0.084). In forested habitat (Figure 6), the photo capture rates of *Hangul* and human did not show any correlation (R^2=0.02).

TABLE 2
Proportion of site utilization and detection probability of *Hangul* based on Camera captures in different seasons at Dachigam National Park, 2008- 2009.

Season	Proportion of site utilization	SE	Detection probability	SE
Spring	0.71	0.21	0.25	0.09
Summer	0.64	0.12	0.24	0.05
Autumn	0.38	0.17	0.2	0.09
Overall	0.88	0.09	0.15	0.02

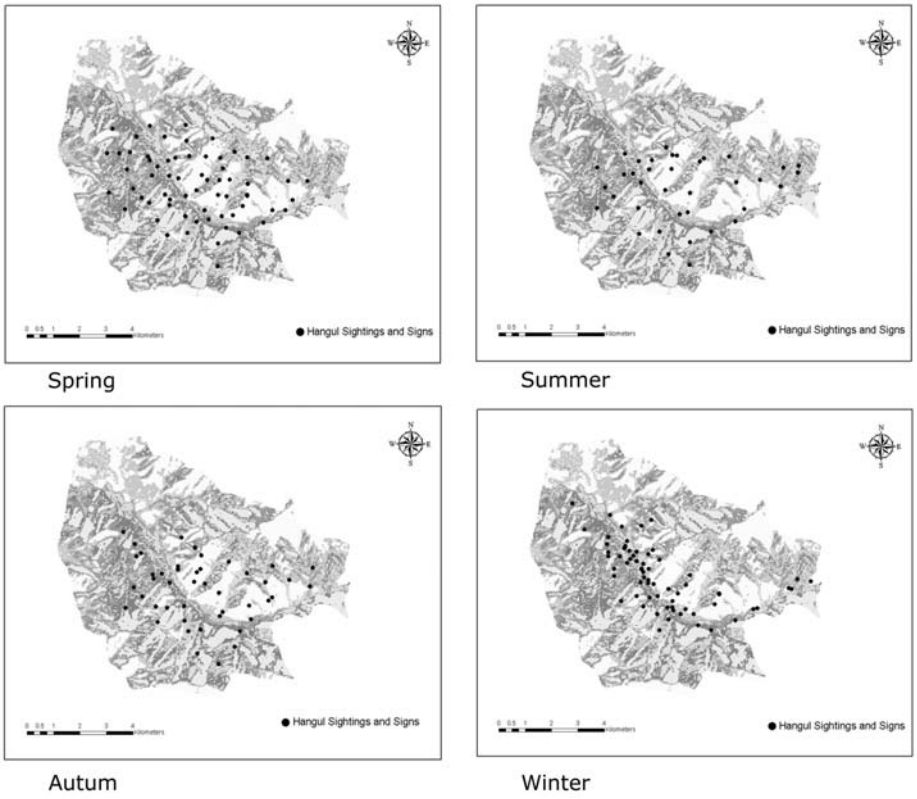

Figure 6. Distribution pattern of *Hangul* at lower Dachigam during different seasons in Dachigam National Park, 2007- 2009.

Discussion

The Kashmir Red deer or *Hangul* has had a restricted distribution that was confined to the mountainous areas of Kashmir valley particularly in Dachigam NP and adjoining protected areas. A gradual decline in *Hangul* population during the last 3-4 decades in Dachigam NP and adjoining areas has been correlated to various factors such as poaching and habitat degradation. In this study, the Lower Dachigam of Dachigam NP was selected as study area as this area is now the only habitat with a viable *Hangul* population. The distribution and relative abundance of *Hangul* in the study area showed a seasonal pattern as already documented in earlier studies. The relative abundance of *Hangul* in the study area is comparable with an earlier study (Ahmad 2006). Density of *Hangul* was found to be highest in spring, followed by winter, autumn and summer. The overall distribution and local abundance of many wildlife species are related in time and space and particularly for the migratory ones. However, distribution patterns in an area would be dependent on various other factors and the ones best understood in the present study included the presence of forage, breeding season and climatic conditions. The presence of forage, water and comparative favorable conditions leads to the clumped congregation of *Hangul* around riverine forest areas. During spring, food availability has been described to be an important factor in *Hangul* distribution (Kurt 1979). In spring season the movement of deer coincided with the change in climatic conditions and sprout of fresh forbs and grasses. The local migrations to higher elevations during summer possibly meant for exploitation of quality forage, as recorded in many other deer species. The migration leads to dispersal of *Hangul* to upper parts of Dachigam NP and to other adjoining protected areas. The proportion of site utilization based on an additional effort of camera trapping was relatively high in spring as the animal was evenly distributed through out the study area whereas during autumn, in the advent of winter, *Hangul* start congregating in low elevation areas with ample forage and resting places resulting in less proportion of site utilization but with uniform distribution.

The group size and structure changed for *Hangul* in different seasons. Congregated male- female groups are seen during spring. Separate male and

females groups were also observed during summer. Rutting season (autumn) again congregates the male- female groups while in case of winter the animals get clumped in the riverine habitat of Dachigam NP.

Human disturbance can be an important factor that influences distribution of any wildlife species. Mountain ungulates once thought to be protected for their rugged terrain habitats are increasingly vanishing by human encroachment and disturbance (Geist 1971). Human activities on the landscape often modify habitats which result in ungulate distribution and later on to species substitution also. The disturbances in the summer ranges of *Hangul* in the form of presence of grazers, their sheep dogs and local villages that use such areas for resource dependency alter their summer range which may have reduced the habitat range available to *Hangul* and the habitat quality. In this study, the human disturbance in the form of human photo capture rate showed a negative correlation with *Hangul* presence, particularly in the grasslands which is an important habitat for *Hangul.* The current levels of human disturbances in Lower Dachigam is a matter of serious concern as this is the only area currently available for *Hangul* for use in all seasons. Therefore, the management authorities have to make efforts to reduce livestock and anthropogenic pressures in Upper Dachigam to restore the *Hangul's* natural summer habitat range through participatory approach by involving the grazers and local village communities. Similarly, the current levels of disturbances in Lower Dachigam have to be reduced. These would enable the recovery of Hangul population not only in the Dachigam NP but also in the potential habitats in the adjoining protected areas.

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