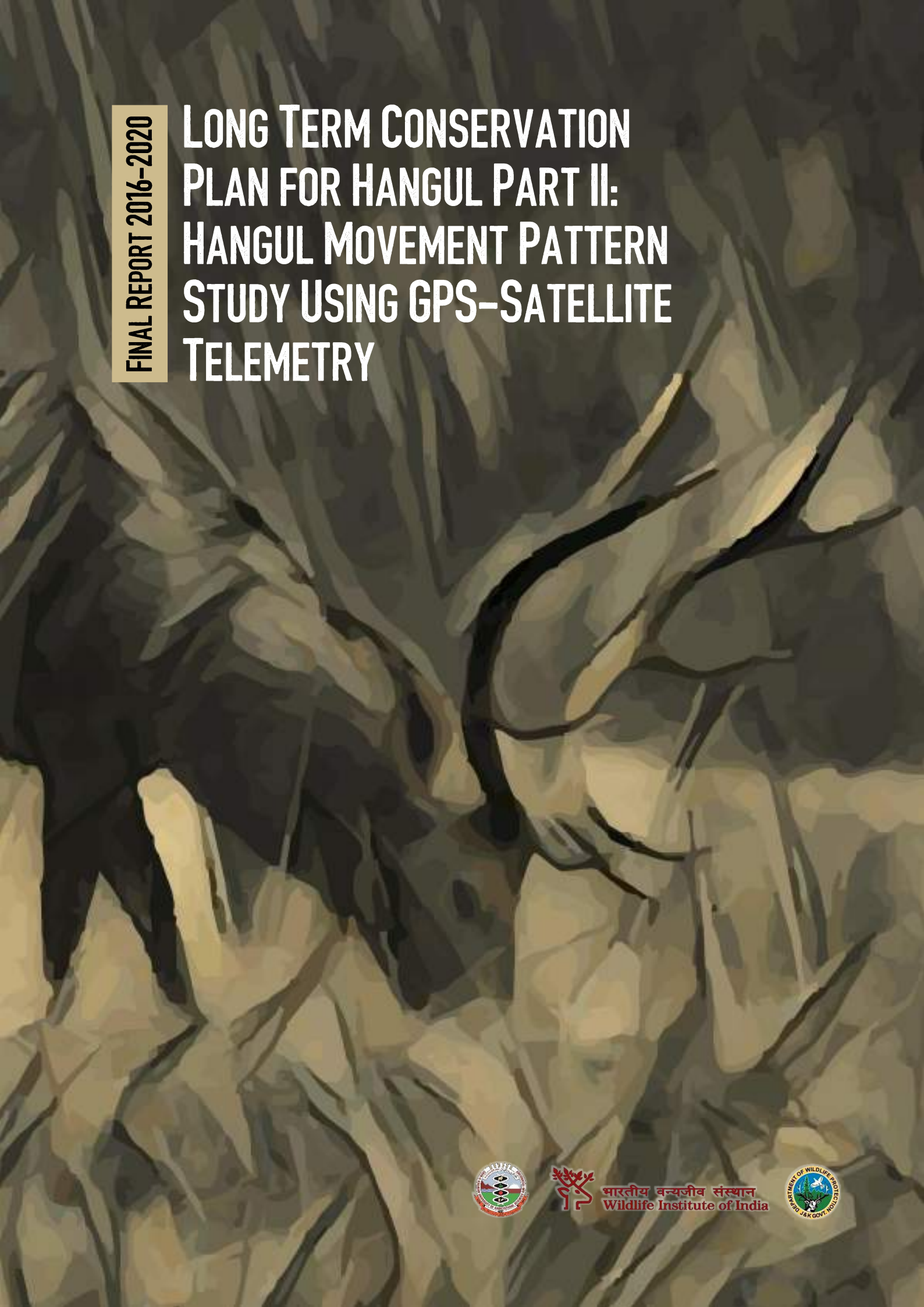
FINAL REPORT 2016-2020

LONG TERM CONSERVATION PLAN FOR HANGUL PART II: HANGUL MOVEMENT PATTERN STUDY USING GPS-SATELLITE TELEMETRY



भारतीय वन्यजीव संस्थान
Wildlife Institute of India

Long Term Conservation Plan for Hangul Part II: Hangul Movement Pattern Study Using GPS-Satellite Telemetry

Investigator(s)
Dr. Khursheed Ahmad
Senior Scientist & Head,
Div. of Wildlife Sciences
Faculty of Forestry, SKUAST-Kashmir

Dr. Parag Nigam
Scientist F, Dept. of Wildlife Health Management
WII, Dehradun

Prof. Qamar Qureshi
Scientist G, Dept. of Population Management, Capture and Rehabilitation, WII, Dehradun

Sh. Rashid Y. Naqash
Regional Wildlife Warden,Kashmir
Wildlife Protection Department
J & K Govt.

Research Team
Sh. Gh. Mohi-ud-Din Dar, JRF
Sh. Mohsin Munshi, JRF
Sh. Shabir Ahmad Lone, Field Assistant

Support Team
Dr. Iqram ul Haq, Research Scholar
Sh. Inayat Ullah Lone, JRF SERB Waterfowl Project
Sh Khursheed Alam Khan, Project Fellow, Grassland Project
Dr. Zaffar Mir, N-PDF-SERB Fellow
Sh.. Mohsin Javid, JRF

Partners:

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

Division of Wildlife Sciences
Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir
Shalimar 190025, Srinagar, Jammu & Kashmir, India
Website: www. skuastkashmir.ac.in

Wildlife Institute of India
Post Box # 18, Chandrabhani 248001
Dehradun, Uttarakhand, India
Email: wii@wii.gov.in; nigamp@wii.gov.in
Telephone: +91 135 2640219

Department of Wildlife Protection, Jammu & Kashmir Government
Office of the Chief Wildlife Warden, Jammu & Kashmir Government
Boulevard Road (near Grand Lalit), 19001
Srinagar, Jammu & Kashmir, India
Telephone: +91 194 250

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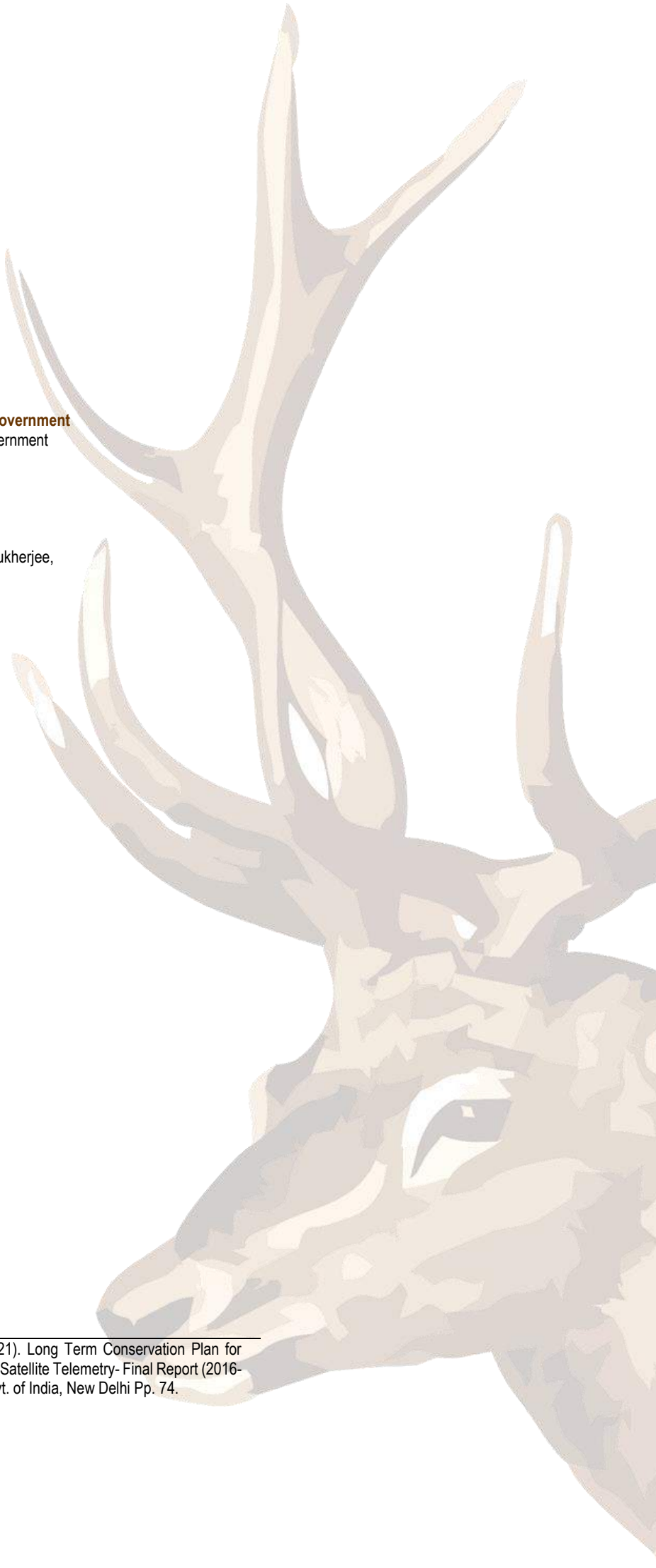
Dr. Khursheed Ahmad, Sh. Intesar Suhail, Sh. Dhritiman Mukherjee, Dr. Parag Nigam

Layout and Design
Ritesh Vishwakarma



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Sh. Suresh K. Gupta, IFS PCCF (Wildlife)/ CWLW, Dept. of Wildlife Protection
Sh. Imtiyaz A. Lone, Sh. Rauf A Zargar
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Wildlife Institute of India
Dr. S. P. Yadav, Director Wildlife Institute of India
Dr. Y.V. Jhala, Dean, Faculty of Wildlife Sciences
Dr. S. Sathyakumar, Scientist G, Endangered Species Deptt.

Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir
Prof. S. A. Wani Director Research SKUAST-KASHMIR
Prof T.H. Masoodi, Register SKUAST-KASHMIR
Prof S. A. Gangoo Dean Faculty of Forestry
Prof. A. H. Mughal, Prof P. A. Khan, Dr Javed A. Moglu, Dr Aflaq Wani, Er. M. R.
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Dr. G.S. Rawat, Former Dean, Faculty of Wildlife Sciences
Dr. Pradeep K Mathur, Former Dean, Faculty of Wildlife Sciences
Dr. Pradeep K Malik, Former Head, Dept. of Wildlife Health Mgmt.
Dr. S.P. Goyal, Former Professor, Animal Ecology & Conservation Biology

Prof. (Dr.) Nazeer Ahmed
FIDS,FTHS,FSHD & FOHI
Vice-Chancellor

Sher-e-Kashmir
University of Agricultural Sciences & Technology of Kashmir
www.skuastkashmir.ac.in

Message

I am happy to endorse the Field Technical Report "Capture and Collaring of Hangul" being published by the Division of Wildlife Sciences, of this University under the Ministry of Environment, Forests and Climate Change Government of India funded research project entitled " Long Term Conservation of Hangul: Study of Hangul Movement Patterns using GPS-Satellite Telemetry".

The Kashmir red deer or Hangul, the state animal of Jammu & Kashmir has recently been classified as a separate species by IUCN and included as part of central Asian red deer (Cervus hanglu), with the Kashmir stag listed as a separate sub-species, Cervus hanglu hanglu. This critically endangered deer endemic to Kashmir Mountains with a genetically viable population restricted largely to 141 Km2 Dachigam National Park in Kashmir can go extinct if necessary scientific measures are not taken immediately. Since threat of biodiversity degradation and species extinction looms large in the country including State of Jammu & Kashmir, the ways to mitigate the responsible factors requires in depth scientific approach and management application as well.

It is under this backdrop that this management oriented research project being conducted by SKUAST Kashmir in collaboration with the Department of Wildlife Protection, Jammu & Kashmir Government and Wildlife Institute of India, Dehradun is of ecological significance as the information generated through this research is expected to provide in-depth knowledge on lesser known aspects of Hangul biology, behavior and ecology that would further support the management interventions for long-term survival of the species in Dachigam National Park and in its erstwhile range areas from Gurez to Kishtwar.

I am glad to know that the investigating team have been able to successfully capture and satellite collar two female Hangul in a record time in Dachigam National Park during 03-07 May 2018 which has been a milestone achievement in the field of satellite telemetry.

I hope the research findings presented in this report have provided significant scientific information on the behaviour, movement patterns and habitat use by the two collared female Hangul in and outside Dachigam National Park which shall go long way in helping the department to concentrate the management intervention in the identified and now scientifically validated Hangul corridors in Sindh Forest Division to ensuring safe passage for the Hangul to erstwhile range area in Gurez.

I complement the team leader Dr. Khursheed Ahmad, Scientist & Head, Wildlife Division, SKUAST Kashmir, Dr. (Cap.) Parag Nigam, Wildlife Institute of India, Dehradun and Shri Rashid Y. Naqash Regional Wildlife Warden, Kashmir region, project researchers and the frontline staff of Dachigam for this remarkable scientific achievement and for bringing out this technical report.

(Nazeer Ahmed)

Shalimar Srinagar-190025, J&K, India
Phone: (O) 0194-2462159, 2464028 Fax: 0194-2462160 (R) 0194-2463655, 2436700 Fax: 0194-2461543
E-mail: vc@skuastkashmir.ac.in, skuastvc@gmail.com

Manoj Kumar Dwivedi, IAS
Commissioner/Secretary to Govt.
Forests, Environment & Ecology Department, J&K
Tel. No.s: 0194-2506055 (May – Oct)
0191-2546793 (Nov to Apr)

MESSAGE

I am happy to learn that the Division of Wildlife Sciences, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (SKUAST Kashmir) in collaboration with the Department of Wildlife Protection, Jammu & Kashmir Government and Wildlife Institute of India, Dehradun is bringing out Field Technical Report on "Capture and Collaring of Hangul" under the pioneering research programme on Hangul Movement Patterns Using Satellite Telemetry funded by the Ministry of Environment, Forests and Climate Change Government of India.

Kashmir Red deer or Hangul the State Animal of Jammu & Kashmir is the most spectacular deer endemic to Kashmir Mountains. The conservation of this heritage animal has always been the priority of the State as well as Central Government and requires the support of all other stakeholders especially the scientific Institutions for an ensured long-term survival.

It gives me immense pleasure to know that the SKUAST Kashmir in collaboration with the Wildlife Institute of India, Dehradun has contributed largely towards the science based conservation of the species and has been helping the department of Wildlife Protection in strategizing policies and measures towards effective management and conservation of Hangul and its habitats both under in-situ and ex-situ conditions.

I am sure that the findings presented in the technical report will be useful in taking further management and policy level measures in recovery of the Hangul population in Dachigam National Park and relic range areas.

I compliment SKUAST Kashmir especially Dr. Khursheed Ahmad and the Department of Wildlife Protection and Wildlife Institute of India for undertaking this important scientific study.

Manoj Kumar Dwivedi, IAS

Government of Jammu and Kashmir

Department of Wildlife Protection

Ravi Kumar Kesar (IFS)
Principal Chief Conservator of Forests (HoFF)
Chief Wildlife Warden, J&K Government.
Forest Complex, Rajbagh, Srinagar-190008 Ph.: 0194-2312847 (O) 2310315 (Fax)

Message

I am glad to know that the Division of Wildlife Sciences, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (SKUAST Kashmir) in collaboration with the Department of Wildlife Protection, Jammu & Kashmir Government and Wildlife Institute of India, Dehradun is bringing out Field Technical Report with significant research findings on "Capture and Collaring of Hangul" under our collaborative Ministry of Environment, Forests and Climate Change Government of India funded research project entitled " Long Term Conservation of Hangul: Study of Hangul Movement Patterns using GPS-Satellite Telemetry".

The State Government with active support and collaboration of Govt. of India has always been sensitive towards biodiversity conservation particularly conservation of threatened species and has taken several measures towards population recovery of threatened species particularly the Kashmir Red deer or Hangul and its habitats under both in-situ and ex-situ environment in the State. However the species has been constantly under threat of extinction and requires immediate scientific measures towards species recovery and its population growth.

It gives me immense pleasure to place on record the role of the SKUAST Kashmir and especially Dr. Khursheed Ahmad for his great scientific and leadership contribution towards classifying Hangul as a separate species by IUCN and included as part of central Asian red deer (*Cervus hanglu*), with the Kashmir stag listed as a separate sub-species, *Cervus hanglu hanglu*. Furthermore the consistent scientific efforts by SKUAST through conducting of research in active collaboration of the department on the management and conservation- oriented aspects of wildlife biodiversity, especially the threatened fauna and their habitats under *in-situ* and *ex-situ* conditions which has largely helped the department in various aspects of their conservation is highly appreciable.

I acknowledge the consistent but highly challenging efforts put in by the Investigators in successfully capturing and satellite collaring of two female Hangul individuals in Dachigam in a record time during May 3-7, 2018 which has been a milestone achievement in the field of Satellite telemetry.

I understand that the research findings presented in this technical bulletin is expected to provide in-depth knowledge on lesser known aspects of Hangul biology, behavior and ecology that would further support the management interventions for long-term survival of the species in its erstwhile range from Gurez to Kishtwar. The tracking of movement patterns of one of the collared Hangul doe towards Surfrao/Akhal and Kangan blocks of Sindh Reserve forest which proved and validated the information published during earlier studies by SKUAST is of great ecological significance and has helped the department to take necessary management measures to ensure safe passage of the Hangul through this corridor habitats in Sindh Forest Division.

I compliment Dr. Khursheed Ahmad, Dr. Parag Nigam and Shri Rashid Y. Naqash, the authors of this publication and everyone else involved for initiating this pioneer research programme of great management significance and wish for the successful accomplishment of the project objectives by the investigators.

Ravi Kumar Kesar IFS

CONTENT

PROJECT ANTECEDENTS

December 2011: The project submitted in June 2010 was placed before the Thematic Group on Conservation and Management of Wildlife and Animal Welfare" of the MoEF & CC and subsequent to the project presentation made by the PI in the 8th meeting of the Thematic Group on 28th December, 2011, the project was recommended by the Thematic Group for financial support by MOEF & CC, Govt. of India.

February 2012: The approval and recommendations of the Thematic Group on Conservation and Management of Wildlife and Animal Welfare" of MOEF for financial support of the project by MOEF & CC were conveyed to the University vide MoEF & CC (WL) Division's letter No. 15- 19/2010-WL-1 dated 8th February 2012.

February 2015: The project was further placed before the Apex Committee of the MOEF & CC and the Apex Committee during its meeting held on 11 February 2015 accorded final approval to the project for financial assistance by MOEF & CC to the tune of Rs. 37,23,840/- for three years.

August 2015: Project Sanction issued by the MOEF & CC (WL Division) vide sanction orders No. 15-19/2010-WL-1 dated 17 August 2015 and 19 November 2015.

August 2015: A letter of request made to the Chief Wildlife Warden, Jammu & Kashmir Government, Srinagar, for accord of permission for undertaking study and capture and collaring of Hangul under the project.

October 2015: A power point presentation made by the PI at NIC Dachigam in a meeting scheduled under your chairmanship at on 18.10.2015.

November 2015: Selection of Project JRF/JPF.

December 15, 2016: Permission accorded by the Chief Wildlife Warden, Jammu & Kashmir Government, and Srinagar for initiation of the field work under the project.

December 19, 2015: Project initiation meeting held with the concerned Wildlife Warden, Central and Regional Wildlife Warden, Kashmir Region, Srinagar.

December 28, 2015: Actual project field work started with the construction of Hide at Oak patch for Hangul habituation exercise.

March 2016: Release of First Instalment funds under the project.

The present report highlights major research initiatives taken by us at the SKUAST-Kashmir in collaboration with the Wildlife Institute of India, Dehradun and the Department of Wildlife Protection, J&K to understand the lesser known aspects of movement patterns and other aspects of ecology and biology of the last viable population of the critically endangered Kashmir red deer or Hangul future plan of action adopted in capture and collaring and monitoring of free ranging Hangul at Dachigam National Park under the MOEF & CC funded project.

EXECUTIVE SUMMARY

The globally viable single population of Kashmir Red Deer or Hangul (*Cervus hanglu hanglu*), one of the critically endangered subspecies of the Central Asian Deer is restricted to a confined area of 141 km2 Dachigam National Park (34°05' to 34°32'N; 74°50' to 75°16'E) in the Greater Himalayan mountain range of the Northwest Himalayan biogeographic region zone 2A, with some stray populations occurring in the adjoining relic range areas (Ahmad et al. 2009; Qureshi et al. 2009). Earlier, the species was widely distributed in the mountain of Kashmir Himalayas along the entire Greater Himalayan mountain range (Gee 1965; Schaller 1969; Prater, 1993; Nowak, 1999) declined drastically in the recent past from 5000 Individuals prior to 1947 to less than 200 Individuals at present.

Current trends in the Hangul population indicate that the species could go extinct if necessary serious interventions are not made immediately and as such there was need to undertake urgent measures to hold the declining trends in the Hangul population (Ahmad et.al. 2009: Qureshi et.al. 2009; Ahmad et.al 2013). Therefore, understanding the ecology and biology particularly the movement ecology of this critically endangered deer species with small single population was fundamental to develop better strategies for conservation and management practices.

The present study duly funded by the MOEF & CC, Government of India was as such initiated to understand the lesser known aspects of movement ecology and behaviour of this last viable population of the Hangul for its effective management, conservation planning and species population recovery under the following objectives:

1) Studying the seasonal Home range size and ranging and movement patterns of Hangul in and outside Dachigam National Park vis-à-vis Hangul migration route, important stop-over sites, and barriers and corridors to migration into the Hangul's relic areas.
2) Studying the lesser known aspects of Hangul ecology viz., habitat use, activity patterns, behaviour and predation prerequisite for effective long term management and conservation of Hangul and its habitats.
3) To identify the potential habitats used by Hangul outside Dachigam and assess and evaluate the extent and magnitude of habitat conditions and threats therein.
4) To identify threats, anthropogenic pressures and other factors particularly predation pressure by leopard and meso-carnivores that impact Hangul distribution and movement patterns.

The capture and Satellite collaring of five Hangul (2 males, 3 female) successfully conducted for the first time under this project has been a milestone achievement in the field of satellite telemetry. The findings of this research study indicated that the Home range size varied from 4.98 Km2 in spring to 7.83 Km2 in summer. One of the female collared Hangul showed movement patterns outside Dachigam National Park towards Sindh forest division crossing the river Sindh and covering an area of 137.94 km, with area use of 10.86-12.26 Km2 in summer 2019 to 137.94 km in summer 2020 and a maximum home range of 124.4 km2 in Summer 2020 to colonize and establish its new summer habitat in the erstwhile range area of Wangath-Naranag Conservation Reserve (CR). The data and information generated has enabled us to identify the corridor areas of movement of the Hangul from Dachigam National Park and outside in the

adjoining erstwhile range areas in north and south and habitats assessment therein. The data generated also indicated that Hangul shows two activity peaks in morning and evening hours with significant seasonal variations.

The findings of the study are of great ecological significance as the significant information generated through this research on the lesser known aspects of movement ecology including animal home ranges and habitat use, biology and behaviour of the Hangul deer would go long way in supporting the management interventions for population recovery and long term survival of this endemic deer of India in Dachigam National Park and its erstwhile range areas in Kashmir Himalayas.

Major management and conservation Intervention recommendations

1. The study revealed that major and viable population of Hangul are confined to Dachigam National Park. Despite availability of ideal summer habitats for the Hangul in upper Dachigam, these alpine meadow habitats are not being explored or used by Hangul. The satellite collared Hangul movements indicated that the animals showed upward movements to Dagwan alpine meadows of upper Dachigam but restricted their movements further in to the alpine meadows, possibly due to heavy disturbances of excessive livestock grazing there.
2. Management interventions are as such required towards expansion of Range of Hangul to alpine meadows of Upper Dachigam and potential corridor areas outside Dachigam NP identified through this research, so that these ideal summer habitats are recuperated and used by Hangul in summer as it used to in the past and to ensure gene flow between the Dachigam and adjoining range populations.
3. Hangul conservation breeding-cum- reintroduction programme is imperative to expand the range of Hangul by restocking and augmenting the small isolated Hangul populations in its relic range areas outside Dachigam National Park starting with the Overa Wildlife Sanctuary which has ideal disturbance free habitats available.
4. The Hangul species recovery programme through a project mode by initiation of Project Hangul on the pattern of Project Tiger is crucial to ensure Hangul species recovery and long term survival of the species and its landscapes in the region.
5. This research study as indicated by earlier studies by the Investigator (s) has revealed that besides poaching and continued degradation of Hangul summer habitats in Upper Dachigam, along with biotic interference in winter habitats, low breeding, female biased sex ratio, the problem of survival of the young and inadequate recruitment of calf to adulthood due to factors such as considerable predation by common Leopard, Asiatic Black Bear, dogs and meso-carnivores (Fox and Jackal) are major challenges for the long term survival of the Hangul in the landscape.
6. The study revealed a significant contribution of Hangul in the diet of Golden jackal (9.09%) and Red fox (6.45%). These ecological issues threatening the long term survival of Hangul need to be investigated and addressed further on long term basis through initiating a breeding biology study to better understand the causes of low breeding and fawn/calf survival in the Hangul population in Dachigam National Park and the adjoining landscape.
7. This research study and the earlier studies by the Investigator (s) has indicated that species due to its small population size, restricted range distribution, critically endangered status, ecological threats

and potentially low genetic variation is at the brink of extinction and needs immediate management interventions to reverse the declining trend in the population. The regulated monitoring of the Hangul populations on a long-term scientific basis using latest techniques of satellite collaring, camera trapping and population genomics is imperative.

8. Strengthening Hangul genome sequencing to understand the DNA mitochondrial based phylogeography of the species and Skull based genetic investigations to link the mitochondrial DNA analysis findings with the nuclear genetic analysis to further establish the degree of closeness or divergence between Hangul and the Bactrian deer.

INTRODUCTION

The Kashmir Red deer or Hangul, *Cervus hanglu hanglu*, which was earlier considered as one of six Asian subspecies of European Red deer (*Cervus elaphus*) is endemic to Greater Himalayas of Kashmir. Recently based on the substantial systematic genetic analysis by us and other ecologists and geneticists (Ahmad and Nigam 2014; Lorenzini & Garofalo 2015, Mukesh et al. 2015, Kumar et al. 2017) which resolved the phylogenetic relationship of Hangul and other two Central Asian Red Deer (*C. bactrianus and C. yarkandensis*) in the family Cervidae, the Hangul along with Bactrian and Yarkand deer have been accorded separate species status different from the other "elephine" recognized as the Tarim Red deer (*Cervus hanglu* Wagner, 1844), with hanglu as type species (IUCN 2017; Brook et al. 2017). Of these three subspecies of Tarim red deer, The Kashmir red deer or Hangul has been listed in the "critically endangered" threat category by IUCN (Brook et. al. 2017; IUCN 2017). The Kashmir red deer is endemic to Kashmir Himalayas of the Northwest Himalayan biogeographic region zone 2A (Rodgers & Panwar 1988) where it was once distributed widely along the Zanskar mountain range (Gee 1965; Schaller 1969; Holloway and Wani 1971; Kurt 1978; Prater, 1980; Nowak, 1999).

In India, recognizing the conservation status and declining population trends of this range restricted and endemic deer of Kashmir, it has been officially declared the state and heritage animal of Jammu & Kashmir and listed as a Schedule 1 species in the Indian Wildlife Protection Act 1972 (amended 2002) and erstwhile Jammu & Kashmir Wildlife Protection Act 1978 (amended 2002) (Ahmad et al. 2009).

The population of Hangul deer declined drastically in the recent past due to human interferences owing to excessive livestock grazing in Hangul habitats, poaching, urbanization, habitat degradation and fragmentation and loss of corridors for free movement of the animals (Holloway 1971; Kurt 1978). At present a genetically viable population of ≤ 200 Hangul individuals is confined to the 141 km2 of Dachigam National Park (DNP) although some isolated populations (Fig. 1) also occur in adjoining relic range areas (Ahmad 2006, Ahmad et al. 2009; Qureshi et al. 2009).

Fig. 1. Past and present distribution of Hangul in Kashmir mountains

Fig. 2. Adult Hangul stag and hind in oak patch in DNP

The Hangul population had shown decreasing trend from 1940's till date (Gee 1965, Holloway 1971, Kurt 1969, Department of Wildlife Protection 1970 till 2011, Qureshi and Shah 2004, Qureshi et.al. 2009 Ahmad 2006: Ahmad et.al. 2009, 2013, 2019). (Fig. 3). The latest Hangul population census has put the population of Hangul at 240-280 individuals (Anonymous 2020).

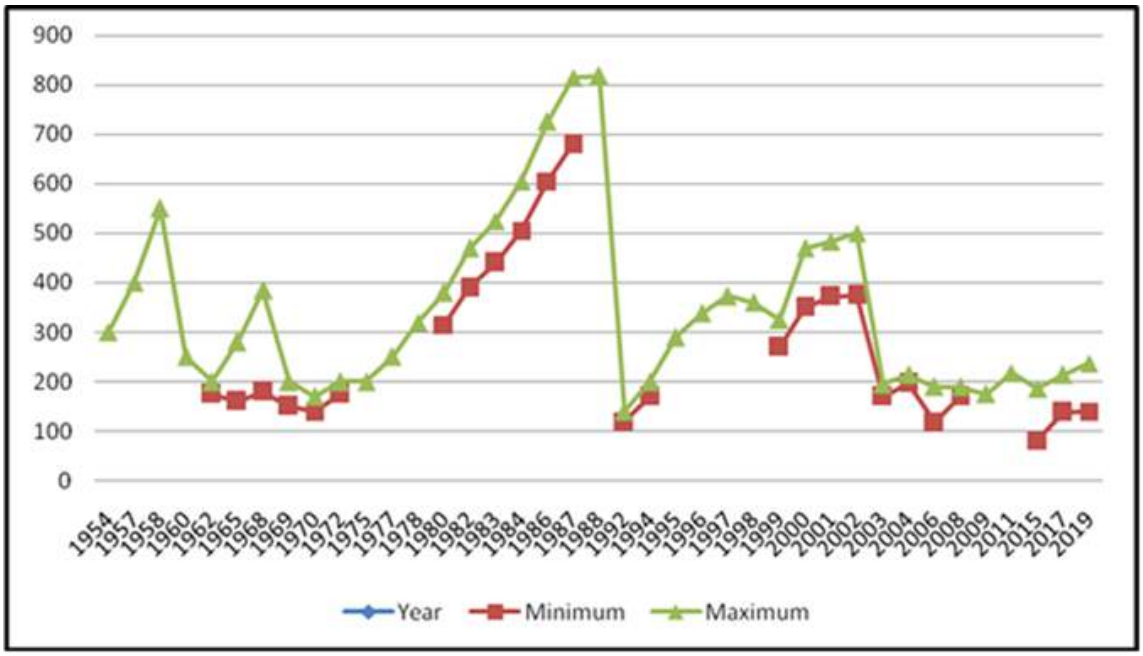


Fig. 3. Hangul population estimates over the years 1954-2019

Threats to Hangul Population

Recent studies on the Hangul (Ahmad 2006 & 2007: Ahmad et.al 2009, 2013, 2015; Ahmad and Nigam 2014; Qureshi et.al 2009) have suggested a dwindling population and have also indicated the restricted movement of Hangul which used to show regular seasonal movement patterns between lower and upper Dachigam are moving outside Dachigam National Park in the Surfrao/Akhal and Kangan blocks of Sindh Reserve forest and Hangul's other erstwhile stronghold areas. Among other major issues such as the declining population trend and the low sex ratio and fawn to female ratio, predation by Common leopard and other meso-carnivores, the movement patterns shown by Hangul into the unprotected areas outside Dachigam National Park, is of great concern and needs to be monitored for the long term conservation and survival of Hangul.

The Hangul population indicates decreased genetic heterozygosity over time, low sex ratio and fawn to female ratio, and predation by Common leopard and other meso-carnivores. Current trends in the Hangul population indicate that the species could go extinct if necessary serious interventions are not made immediately and as such there was need to undertake urgent measures to hold the declining trends in the Hangul population (Ahmad et.al. 2009: Qureshi et.al. 2009; Ahmad et.al 2013).

Notwithstanding, concerted efforts have been made in the past to emphasize the conservation problems of Hangul (Gee 1965; Schaller 1969; Holloway and Schaller 1970, Holloway and Wani 1970; Holloway 1971; Kurt 1978; Inayatullah 1987), and during recent years including initiation of establishment of

Hangul conservation breeding centre at Shikargah Tral, Shifting of Government Sheep breeding farm from Dachigam National Park and research and monitoring of Hangul population in Dachigam National Park (Ahmad 2006; Qureshi et al. 2009; Ahmad et al. 2009, 2013, 2014, 2015; Ahmad and Nigam 2014; Bacha 2015; Mukesh et al. 2015) there had been a lack of information on the ecology, behavior, movement pattern and conservation issues of Hangul which is prerequisite for effective management and long term conservation of the species.

In light of the given background and considering the importance of knowing the seasonal movement patterns of Hangul so as to identify the movement corridors and ensure to delineate and protect the corridor areas used by Hangul outside Dachigam National Park for long term conservation planning, it was mandatory to undertake scientific studies on the movement ecology of Hangul using latest technology of GPS satellite telemetry to understand the lesser known aspects of Hangul movement ecology and behavior.

The Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir (SKUAST-Kashmir), Srinagar (SKUAST-Kashmir) with an initial limited grants and resources made initial successful efforts in capturing and collaring of Hangul in 2013 which has been a milestone in the area of satellite telemetry as for the first time the one male Hangul has been successfully captured and specially fitted with the Vectronics GPS- Satellite collar that has ensured its remote tracking.

This research project entitled "Long Term Conservation Plan for Hangul Part II: Hangul Movement Pattern Study Using GPS-Satellite Telemetry" funded by the Ministry of Environment, Forests & Climate Change (MOEF & CC) envisaged to study the lesser known aspects of Hangul movement ecology and other aspects of ecology and biology of Hangul including the home range and seasonal movement pattern of Hangul in and outside Dachigam National Park and identify potential corridors and habitats used by Hangul in and outside Dachigam using GPS satellite telemetry which would further support the management interventions for long term survival of the species in its erstwhile range from Gurez to Kishtwar.

OBJECTIVES

1) Studying the seasonal Home range size and ranging and movement patterns of Hangul in and outside Dachigam National Park vis-à-vis Hangul migration route, important stop-over sites, and barriers and corridors to migration into the Hangul's relic areas.
2) Studying the lesser known aspects of Hangul ecology viz., habitat use, activity patterns, behaviour and predation prerequisite for effective long term management and conservation of Hangul and its habitats.
3) To identify the potential habitats used by Hangul outside Dachigam and assess and evaluate the extent and magnitude of habitat conditions and threats therein.
4) To identify threats, anthropogenic pressures and other factors particularly predation pressure by leopard and meso-carnivores that impact Hangul distribution and movement patterns.

The project objectives were fulfilled following widely used standard methodologies and technologies including the satellite telemetry and camera trapping. Apart from aforesaid objectives, some other important aspects of Hangul ecology, biology and conservation were also included and assessed during the course of the project and its completion. During the project period, a total of two interim reports were submitted to MOEF & CC (Wildlife Division) and Department of Wildlife Protection, Jammu & Kashmir Government (JKWLPD) for 2016-2017 and 2017-2018 and Hangul conservation breeding and reintroduction programme study and Inspection reports submitted to the JKWLPD in March 2020. The present report is the final technical report, which summarizes the findings/results of all the objectives of the study and is organized into ten different sections as per the envisaged objectives.

STUDY AREA AND LANDSCAPE

The study was conducted largely in Dachigam National Park and the adjoining landscapes in the Kashmir Valley. Dachigam National Park encompassing an area of 141 km² and ranging in altitude from 1700 m. to 4700 m. lies between 34 ° 05' N and 34° 11' N and 74° 54' E and 74° 09' E in the Great Himalayan mountain range of North-West Himalayan Bio-geographic zone (2A). The mountain ranges enclosing Dachigam National Park are a part of the great Himalayan range, which forms the north -west branch of the Central Himalayan axis, bifurcating near Kullu (Himachal Pradesh) and terminating in the in Zanskar Mountain range in the high twin peaks of Nun Kun (7135m).

Dachigam National Park assumes a great ecological, aesthetic and socio-economic significance as it inhabits the last surviving viable global population of the critically endangered Kashmir red deer or Hangul besides the endangered Kashmir Musk deer, Himalayan Serow, Asiatic Black bear and Brown bear (*Ursus arctos*) and diverse flora and fauna. Dachigam National Park is named after ten villages, (Da-meaning ten; chi-meaning are; gam- meaning village), which occupied the area prior its declaration as a game preserve by the then last Maharaja of Jammu & Kashmir- Hari Singh, in 1910, to provide hunting support for himself and his guests as also to support as an undisturbed catchment zone for the Harwan water reservoir that provided city of Srinagar with fresh water.

Dachigam National Park is roughly rectangular in shape approximately 22.5 km. long and 8 km. wide, and covers roughly half of the catchment area of Dal lake (Holloway & Wani 1971). The valley begins as a broad and narrow bent passage at its entrance facing north- west direction and ends at its south eastern end at Nagberan and at its eastern end at Marsar meadows (Fig.4). The Greater Dachigam Landscape comprising Dachigam National Park bounded by Sindh valley to the north east; Tarsar, Lidderwath, Kolhai of Lidder valley and Overa –Aru Wildlife Sanctuary in the far east; Tral range in the

south east and Harwan, Brain and Nishat in the west and south west represents the current distribution range of Kashmir red deer or Hangul (Fig. 4). In this study the intensive study areas was Dachigam National Park and the adjoining areas in the landscape served as peripheral study areas.

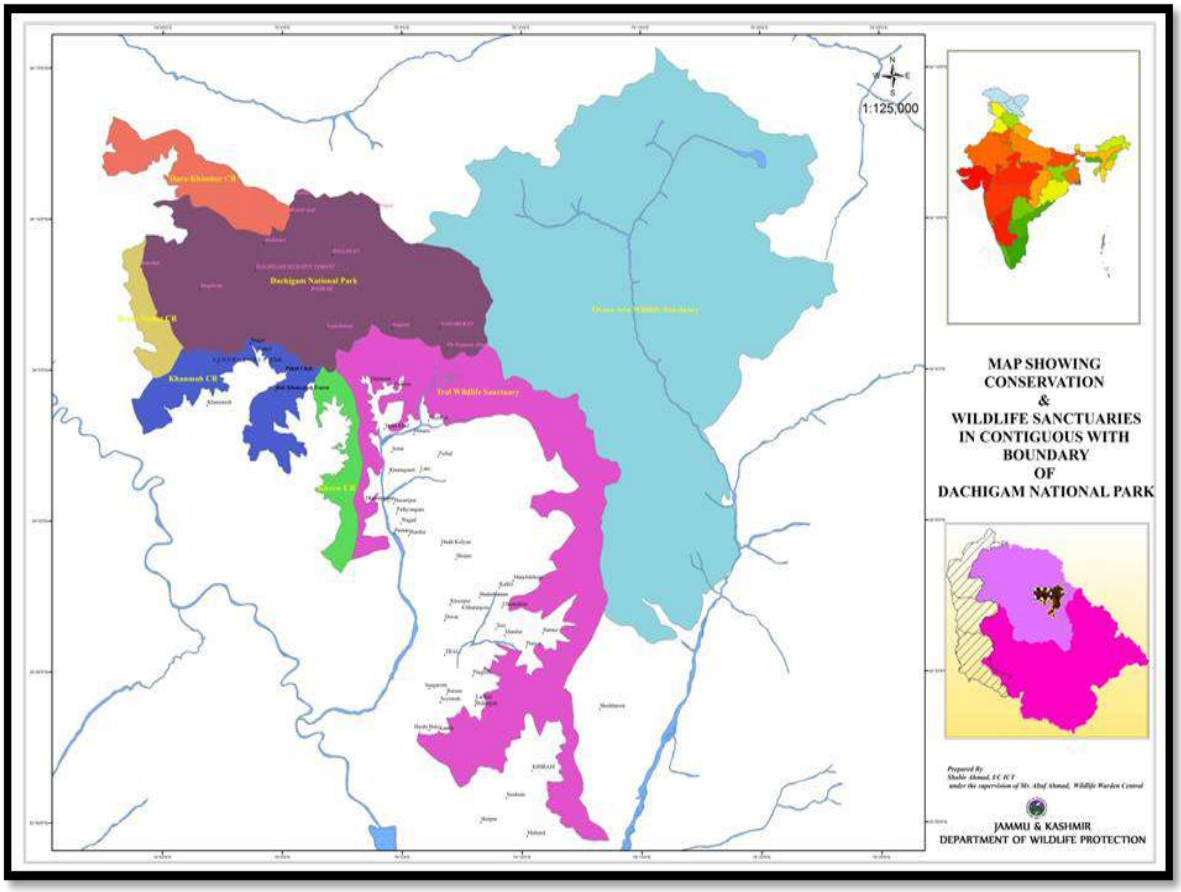


Fig. 4. Map of the study Area (DNP) and the adjoining landscape

Climate

The basic pattern of weather and climate over the Himalayas is governed by the summer and winter monsoon system of Asia (Mani, 1981). In addition, the Himalayas are affected by extra tropical western system (Western disturbance), that move in winter over the north of the sub-continent from west to east. The climate of the area may be described as Sub -Mediterranean to typically temperate with higher degrees of variation in precipitation and dryness. Generally, two spells of dryness are experienced, one in June and another in September to November: Snow is the main source of precipitation and in some parts melts till June. The annual minimum and maximum rainfall of Dachigam have been calculated ranging between 32.60 mm to 546.40 (Bhat 1988).

Four distinct seasons occur in a year: spring (March -May), summer (June-August), autumn (September -November) and winter (December -February) (Ivan1997). The winters are cooler and the summers pleasant. The monthly mean temperatures recorded during the study period ranged between a

maximum of 32.30°C, in August (late summer) 2002, and a minimum of -7.8°C (in Lower Dachigam), in January (midwinter) 2003 (Ahmad et al.2009; Ahmad et al.2015).

Geology

Geologically the Himalayan zone is characterized in bulk by Complex crystalline rocks, granites, gneisses and schists which form the core of the Zanskar range, a fold of which encloses the Dachigam national Park. This complex is partly sedimentary consist of slates, phyllites, schists with embedded crystalline limestone. (Kurt 1969). The region starting from Khrew, Khonmoh, Woyen and extending to near Mahadeo in Dachigam consists of calcareous slate, shale and blue lime stone. Most of the sediments composing these ranges have been laid from Cambrian to tertiary and rigged and folded up during the ages (Wadia 1939).

The crystalline axis of the Himalayan system contains the oldest rocks and on the northern flank of this crystalline axis are found fossiliferous sedimentary of marine origin. Detailed accounts of geology of Kashmir have been given by including among others by Godwin Austin (1864); Lydekker (1878); Oldham (1893) and Middlemiss (1911). Some other studies in connection with geology, geomorphology, palaeo-climatology, palae-ecology and archeology on the Kashmir Himalayas have been done by Geological survey of India and the State Archeology Department. Multidisciplinary Kashmir paleo-climatic research project initiated by Aggarwal (1985), however, is regarded as a pioneering one in this behalf. The soil depth in the study area on the slope from lower to middle reaches is less than 25 cm. and hence falls under the category of very shallow soils (Bhat 1986).

Vegetation of Dachigam National Park and adjoining landscape

Dachigam National park shows a strong vegetation contrast with the outside areas, which are subject to varied types of biotic interferences, and, except for some steeper slopes, largely lack natural tree elements, being replaced in the valley by cultivated elements along roadsides, stream sides and in orchids, and largely determined by the extent and nature of human interference (Kurt 1969).

Dachigam National Park exhibits a variety of vegetation types manifested by habitat, form and density of dominant species and controlled by a number of factors including habitat conditions, exposure, altitude and above all, the degree of biotic interference (Singh and Kachroo 1976).

Dachigam National Park is ecologically and administratively divided into two sectors, the Lower Dachigam and Upper Dachigam. The lower Dachigam altitude ranges from 1700 m to 3500 m (Anonymous 1985) and thus has a complex mixture of vegetation types with broad leaf mesophyll forest of maple (*Acer caesium*), mulberry (*Morus alba*), *Ulmus* spp. *Rhus succidiadiana* and walnut (*Juglans regia)*, Hatab (*Parrotiopsis jacquimontiana*) and a variety of conifers such as deodar (*Cedrus deodara*), blue pine (*Pinus wallichiana*), spruce (*Picea smithiana*), and Fir (*Abies pendrow*) growing in an altitudinal sequence (Rodgers & Panwar1988).

Upper Dachigam altitude ranges from 2000 m to 4700 m (Anonymous 1985). It comprises vegetation gradient of sub alpine community of forest followed by scrub vegetation of birch (*Betula utilis*) and rhododendron (*Rhododendron* spp.) interspersed with meadows of herb rich grass lands over 3300 m. This zone gradually merges in to the zone of permanent snow, which is above 3500 m (Rodgers and Panwar 1988). The vegetation of Dachigam National Park and the adjoining landscape going by Champion and Seth (1968), is typical of Himalayan moist temperate forest; sub-alpine forest and alpine forest type and can be classified into following types.

1. *Moist Temperate deciduous forest (1800 to 2750 m)*
2. *Dry temperate scrub*
3. *Pohu Scrub*
4. *Low level blue pine forest*
5. *Western mixed coniferous forest*
6. *Western Himalayan sub-alpine birch-rhododendron forest*
7. *Dwarf rhododendron scrub*
8. *Deciduous alpine scrub*
9. *Dwarf Juniper Scrub*
10. *Alpine pastures.*

The vegetation of the study area has been described in detail by Singh and Kachroo (1978), Ahmad (2006), Ahmad et al. (2009), Shameem et al. (2012) and Ahmad et. al. (2015). The lower areas 1700–3500 m asl) have a complex mixture of vegetation types, with broad leaf mesophyll forests of Maple (*Acer caesium*), Mulberry (*Morus alba*), *Ulmus spp.*, *Rhus succidiadiana* and Walnut (*Juglans regia*),

Hatab (*Parrotiopsis jacquemontiana*). Conifers are represented by Deodar (*Cedrus deodara*), Blue Pine (*Pinus wallichiana*), Spruce (*Picea smithiana*) and Fir (*Abies pindrow*) growing in an altitudinal sequence (Singh and Kachroo 1978; Ahmad et al. 2009; Qureshi et al.2009). The upper horizons (2000–4250 m asl) are characterized by a vegetation gradient of subalpine communities of forest followed by scrub vegetation of birch (*Betula utilis*) and rhododendron (Rhododendron spp.) interspersed with perennial meadows at 3300 m. Above 3500 m asl there's the zone of permanent snow (Singh and Kachroo 1978; Ahmad 2006; Ahmad et al. 2009; Qureshi et al.2009; Ahmad et al. 2015).

Grassland and scrub forest of lower Dachigam (upper) & Sub-alpine forest of upper Dachigam (below)

This study, however, stratified the study area into nine broad habitats and vegetation communities growing in an altitudinal sequence, *viz.,* 1. Mixed broad leaved riverine forest; 2. Blue pine (*Pinus wallichiana*) forest associated with *Parrotiopsis jaquimontiana*; 3. Grassland and open *Parrotiopsis* scrub; 4. Mixed coniferous forest; 5. Sub-alpine forest of Blue pine and Silver fir (*Abies pindrow*); 6. Birch (*Betula utilis)* – Rhododendron (*Rhododendron compendulatum*) scrub; 7. Alpine – Juniper (*Juniper* recurva) scrub and 9. Alpine meadows. Of these, only the first three vegetation communities represented the flora of lower Dachigam while as, the Mixed forest community represents the edge.

HANGUL POPULATION MONITORING, DEMOGRAPHY & HABITAT USE

Because of the hilly terrain and scarcity of resources it was not possible to undertake a population monitoring programme using standard distance sampling methodology (Buckland et al. 1993) or Line Transect (Burnham et al. 1980) which may have yielded absolute population density estimates for this deer population. In order to achieve the objective of tracking the temporal and spatial demographic patterns, habitat use and behaviour of the confined population of this endemic deer, we used population indexes characterized by a correlation with absolute density at least in some circumstances such as the kilometric abundance index (KAI) (Acevedo et al 2008) or group size (Vander Wal et al 2013). We designed a standard network of transects along trails, *Nullas* (streams) and contours using strip counts and bounded counts methods following Hayne (1949), Holloway (1971) and Rutledge (1982), in seven randomly-laid survey blocks and seven transects in Dachigam NP (Fig. 5) which allowed the observers to move as swiftly as possible in the area. We counted and monitored all deer observed in these seven survey blocks and seven trail transects in Dachigam National Park. Each such transect was monitored on a rotational basis regularly four times a month to collect data on daily activity patterns of the Hangul deer in relation to the resource availability and habitat use parameters. Furthermore, data on indirect evidences of Hangul (dung/pellets) were collected in (2× 20 m) belt transects randomly laid in the survey blocks.

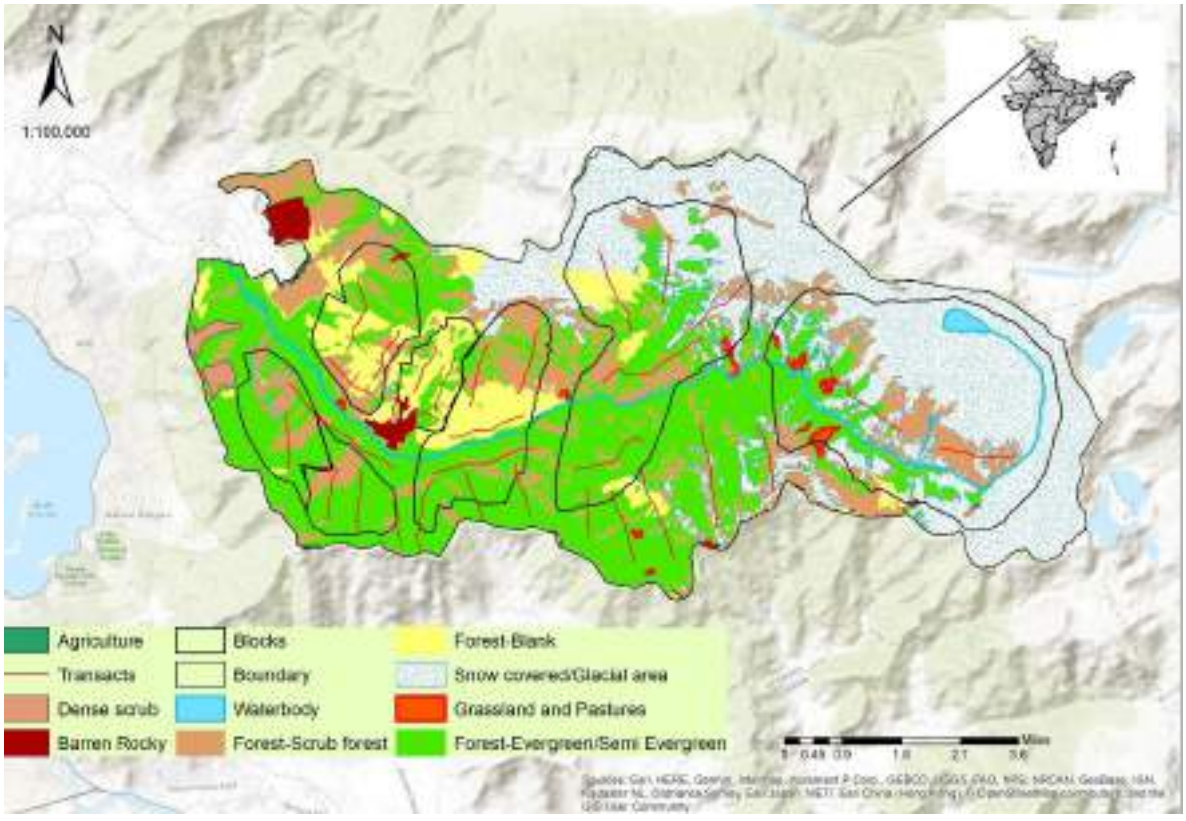


Fig. 5. Map of DNP showing the monitoring blocks and transects

Table 1. Distribution pattern of Hangul over the years in DNP during the study period (January 2016 to December 2020).

Year	No. of Surveys	Hangul Sightings	No. of individuals	Adult Male	Sub Adult Male	Adult Female	Sub Adult Female	Yearling	Fawn/ Calf
2015	228	174	997	95	45	559	196	102	0
2016	177	132	811	86	37	470	163	55	0
2017	271	215	890	98	94	440	112	79	67
2018	423	189	747	81	25	494	65	35	47
2019	335	122	807	85	17	545	96	46	18
2020	132	92	428	64	16	262	32	52	2
Total	**1566**	**924**	**4680**	**509**	**234**	**2770**	**664**	**369**	**134**

Encounter Rate

A total of 1566 surveys conducted involving an effort of 10369 km trail/ transects travelled resulted in recording of 4680 deer in 924 group sightings on these trails during the study period 2016-2020. The Hangul encounter rates or Kilometric Abundance Index (KAI) varied significantly (F=14.561; P=0.000) between the years with an overall mean encounter rate of 0.51 ± 0.86 (S.D) Hangul/Km walk (Fig.6).

Hangul Group size

The mean group size of Hangul was estimated as (Mean ± SE) 5.90 ± 0.77 S.E. The Hangul group size varied between a maximum Hangul groups of 55 Hangul individuals recorded in the grassland habitat in spring to a solitary Hangul stag recorded in the oak patch. The Hangul showed wide sexual segregation which varied over the seasons (Fig. 8)

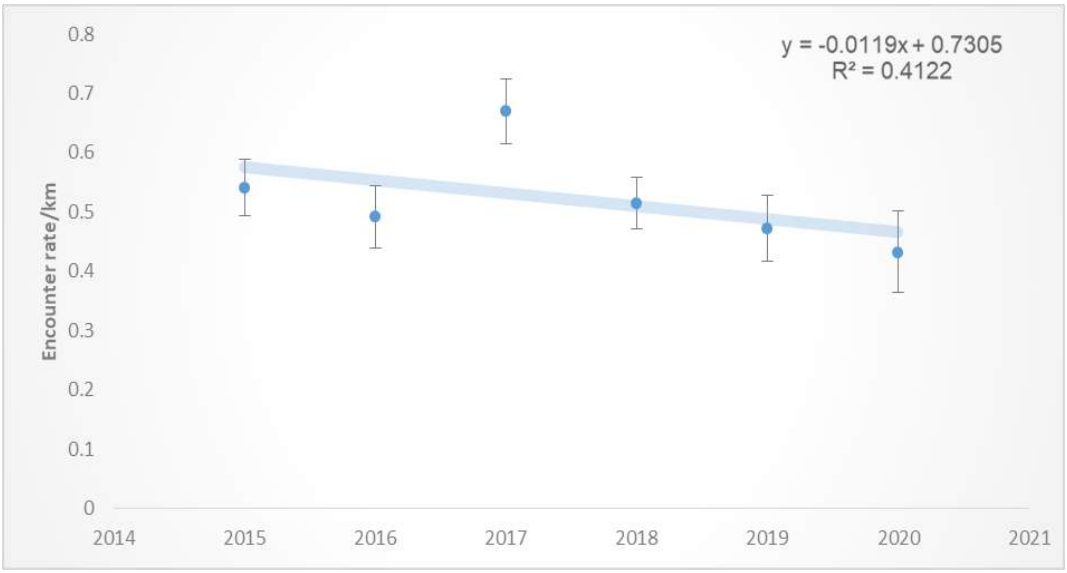
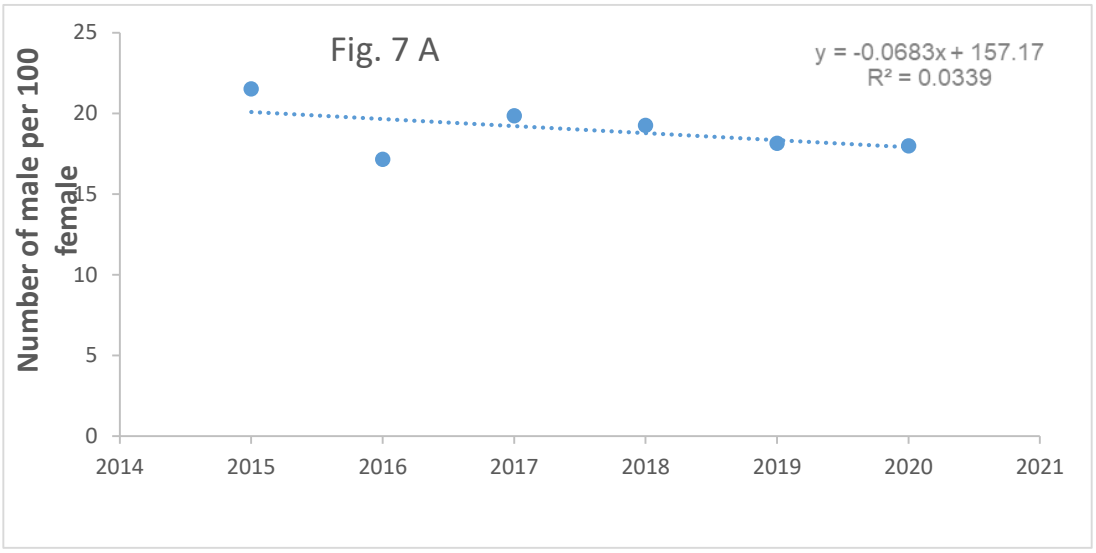


Fig. 6. Hangul encounter rates over the years (2015-2020) n= 4618

Sex ratio and calf female ratio

The sex ratio and calf to female ratio varied and showed a decreasing trend over the years (Fig. 7 A & B). The sex ratio is female biased with a mean of 18.98 male: 100 females and the spring calf-to-female ratio were very low with a mean of 17.44 calves: 100 females (SE= 2.49). Although the sex ratio remained stable (r = 0.0339, $F_{1,16}$ = 1.25, P = 0.27) with large fluctuation from one year to the other, the low adult sex ratio suggests a high mortality of adult males.



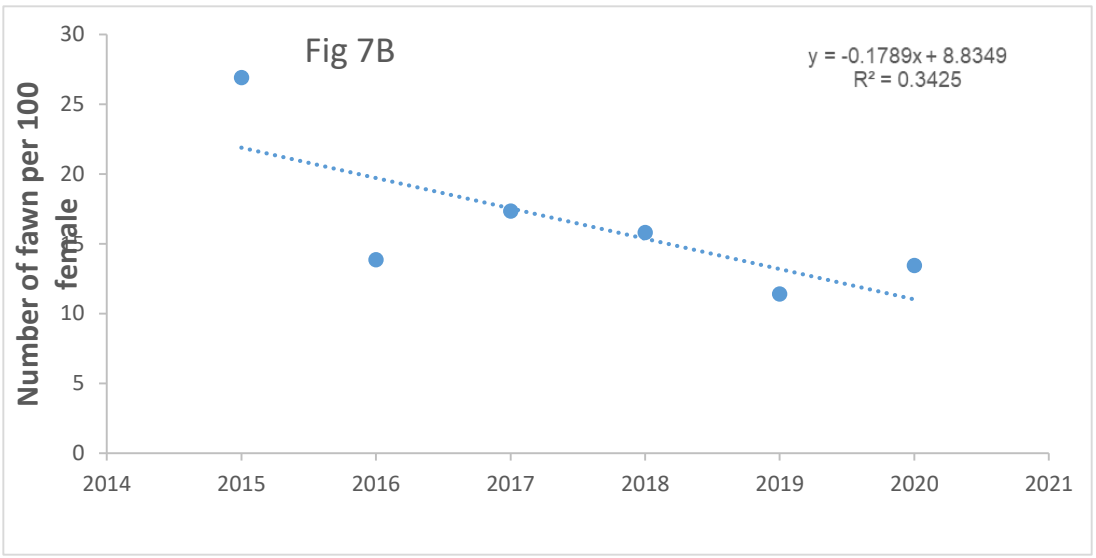


Fig. 7 (A & B). Hangul sex ratio and calf female ratio over the years (2015-2020) in DNP

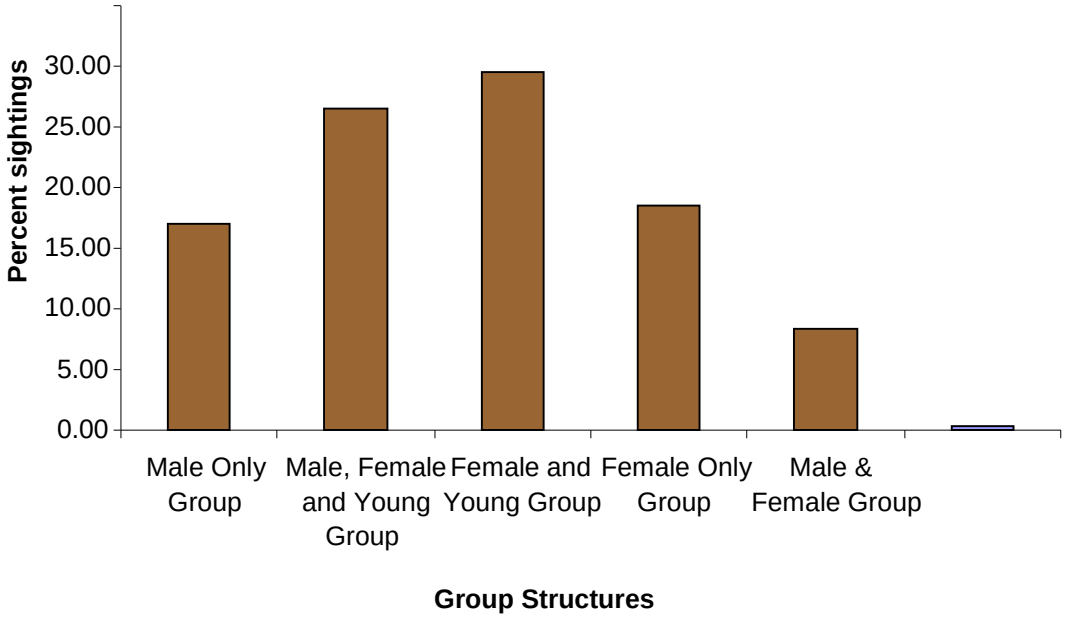


Fig. 8. Proportionate sightings of different Hangul group structures in Dachigam N.P.

Habitat Use and food and feeding habits

The habitat use patterns and food and feeding habits were studied along the designated standard network of itineraries along trails, *nullahs* (streams) and contours and at every animal sighting location. Each itinerary along trails and blocks was monitored on a rotational basis 4 times a month in different time periods to record habitat use by deer following Hayne (1949), Holloway (1971) and Rutledge (1982). At each animal sighting, data on diurnal activity patterns, viz. number and composition of deer groups, time of sighting, browsing, grazing, resting, standing and signs of browsing (thrashing, fraying, bark stripping) of the deer in relation to resource availability, viz. vegetation (trees, shrubs and ground cover in terms of grass, herb, litter, exposed soil/rock, percentage canopy cover and habitat parameters viz., altitude (using a global positioning system, GPS), aspect (compass/GPS), slope, latitude/longitude (GPS) were recorded. In addition to direct sightings, a pellet (dung) count method was also used to assess the habitat occupancy by the deer as the dung may be a reliable indicator of animal presence. Pellets were collected in fixed number of (2 × 20 m) fixed belt itineraries randomly laid in five survey blocks in the intensive study area only as well as at every animal location.

The proportionate (percent) sightings of Hangul recorded varied significantly between the habitats (Fig. 9). Hangul also showed significant differences in the use of different habitat types ($F = 6.49$; $P = 0.001$) between seasons. The Grassland/Scrub habitat was the most frequently used habitat by Hangul during the study period with an average of 32.62%of deer sightings recorded in Grassland/Scrub habitat followed by an average of 23.38% Hangul sightings recorded Mixed Oak/Morus habitat.

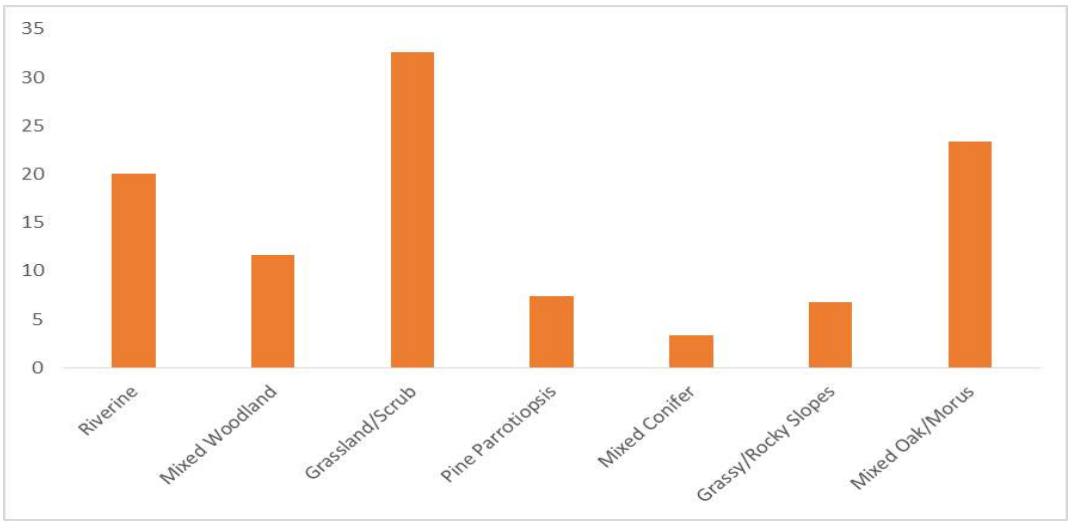


Fig.9. Proportionate Hangul sightings in different habitats in DNP during the study period (2015-2020)

HOME RANGE, RANGING AND MOVEMENT PATTERN OF HANGUL

Capture and Satellite Collaring

For large mammals, understanding animal home ranges is one of the basic fundamentals for understanding the ecology of an animal and crucial for addressing contemporary conservation challenges like predicting extinction risks (Woodroffe & Ginsberg, 2008; Collen *et al.,* 2011). The causes and consequences of the movement patterns of animals within and outside the home range are of great significance to understand several aspects of an animal's ecology like their dispersal (small and Rusch 1989), social interactions (Minta 1993), space use (Kenward et al. 2001) and population distribution (Turchin 1991). Wildlife home ranges can be assessed using various field techniques. However, assessing and monitoring daily animal movements and home range sizes in the wild especially in the rugged terrains like in the Himalayas is very difficult or impossible with the conventional non-invasive method of maintaining re-sighting animals' records. The radio-telemetry which has revolutionized the field of spatial ecology since 1960s is the most widely used technique enabling investigators to obtain high-resolution real-time information on animal movement, behaviour and subsequent home range patterns (Sukumar, 2003). Radio telemetry studies involve capture, collaring and radio-tracking wildlife using very high frequency (VHF) transmitters.

In an attempt to address one of the prime project objectives of understanding the home range, ranging and movement patterns of Hangul, the project required capture and collaring of Hangul using GPS satellite collars. A young-adult Hangul stag was for the first time successfully captured and satellite collared during 2013 (Ahmad & Nigam, 2013) and continuously monitored during Phase I of the project. The information collected during last capture and collaring operation was instrumental in providing some information on ecological aspects however, required data from more individuals to come to meaningful conclusions.

Field Operations for Capture and collaring of Hangul during the second phase under the project

Further to the sanction of the project by the Ministry of Environment, Forests and Climate Change (Sanction order No. 15-19/2010-WL-I dated 17.8.2015) and permission of the chief Wildlife Warden, J&K Govt. vide No. WLP/Res/2015-16/462 dated 15.12.-2015, animal habituation for capture was attempted in Drough area however did not result in positive outcomes. The efforts were continued for animal habituation in the Oak patch following Ahmad and Nigam (2014) with some modification in the plan as under.

Methodology

1. Hangul Habituation and Luring for Hangul Capture

Though there is considerable information available on capture and restraint of Indian wildlife; the information on use of various capture technique in mountain ungulates is limited with no information on

Hangul. The only successful capture and collaring operation carried out in March 2013 has been a milestone in the area of Hangul capture and satellite telemetry and accounts for first successful demonstration of procedures in free ranging Hangul (Ahmad and Nigam 2014).

For capturing very shy Kashmir red deer or Hangul, which being adapted for survival in the mountains differs from other species and requires different approach for capture, effective and safe practices following Ahmad and Nigam (2014).

2. Site Selection and Animal Habituation

The Kashmir red deer or Hangul has been using the vast terrain and habitats in Dachigam National Park particularly the Lower Dachigam. However, in order to ensure safety of the animal and facilitate animal retrieval following darting, it is important that the Hangul capture exercise be done in area that is open. As such prior to the actual field operation and further to the assessments carried out during the previous Hangul capture and collaring operation in 2013 (Ahmad and Nigam 2014), two sites meeting the need were selected which included the Oak patch and the open areas of Drough. The Hangul monitoring studies and habituation process to lure the animals at these select sites for successful darting were initiated subsequent to the Permission accorded by the chief Wildlife Warden, J&K Govt. vide No. WLP/Res/2015-16/462 dated 15.12.-2015 and completion and making functional of a hide at selected located in Oak patch (Fig. 10). However, due to some management issues cited by the department, the open area site at Drough could not be used for Hangul habituation and luring.

Fig 10: Schematic representation of features at Oak Patch, Dachigam National Park

Plate1: Effective Hangul habituation to the hide at the Oak patch during March 2016

Animal habituation for closer approach effective for darting was carried out by using lures including greens, vegetables, rock salt and a mineral mixture. These were placed at the selected sites at Oak patch and the Hangul monitoring studies and habituation process were initiated from January 2016 with the support of Dept. of Wildlife Protection, J&K. A plan of operation was developed and submitted to the department of Wildlife Protection to have better understanding of the whole process and identifying work and individuals. The Hangul habituation exercise conducted at Oak patch proved successful and with the support and cooperation of the department the animal could be successfully lured into the oak patch using varieties of lure including greens, vegetables, rock salt and mineral mixture. There was an increase in the frequency of Hangul sightings at the Hangul habituation site at Oak patch during the last two weeks of March 2016.

Plate 2: Animal feeding on lure provided at the Oak patch site during March 2016

Further to the fresh permission of the Chief wildlife warden, Jammu & Kashmir Government vide letter No WLP/Res/2017/352-55 dated 14th February 2017, the field operation for luring of deer to habituation site at Oak patch for capturing and collaring of Hangul was continued during 3rd to 8th May 2018. Attempts were made to install 02-03 Camera Traps at the luring site to facilitate recording of Hangul movements to the site for further planning.

The animals started using the Oak patch more often and started approaching the habituation site and even getting closer to the hide. Camera traps deployed at the site recorded major activity during the late evenings and night hours with animals moving out during the dawn. Animals however also used the patch during day time with major activity during early mornings; evening and late evenings though were quite sensitive to any kind of vehicular disturbance as well as human movement.

A herd of seven individuals were seen at the habituation site on 3rd May 2018 evening between 1820 to 1940hours. The animals were observed for the entire period till it became dark. The animals were left undisturbed and the team returned to plan for subsequent day.

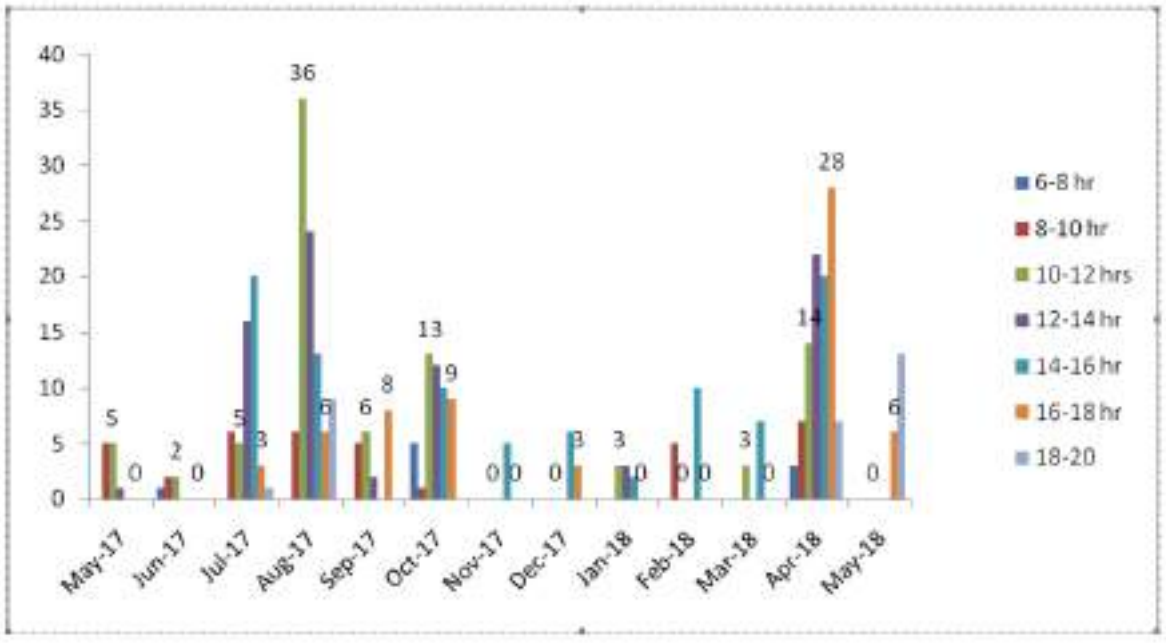


Fig. 11: Number of Individuals using the Oak patch at different time periods (May 2017 to May 2018)

Plate 3: Camera trap images of Hangul using the Oak patch during late evenings and midnight hours

Considering the successful animal habituation to the darting site, the field exercise was initiated on 4th May 2018 with the briefing of the frontline staff of the J&K Wildlife Department and the project research team. Necessary logistics for safe and predictable capture of Hangul were ensured following which the field operation was started in the evening of 4th May 2018.

Team Identification & Responsibilities

Individual teams for defined works as per the Plan of Operation were formed and necessary briefing of the procedures involved in the field operation were given. The specific role and responsibilities of individual team was assigned to all concerned and the field operation was subsequently initiated from 4th May 2018 A/N.

The major field teams included following:

Animal Capture/Darting team *(Dr. Parag Nigam and Dr. Khursheed Ahmad)*: The team was positioned in the darting hide with all logistics in place.

Animal Tracking/Search team I (ATT I) *(Mr. Gh. Mohi-u-Din Dar, Mr. Innyatullah Lone, Sh. Shabir Ahmad Lone, Sh. Nazir Ahmad Mir & Mr. Altaf):* The team was positioned on the metal road at a distance of 150 meters before the Oak patch and were instructed to join the darting team for searching the animal on call.

Animal Tracking/Search team II (ATT II) (Animal Movement restriction team) *(Mr. Khursheed, Sh. Rafiq Ahmad Mir, Gh, Mohd Bhat, Sh. Muzaffar Ahmad Bhat).* The team was positioned on the southern boundary of the oak patch to restrict the animal movement (towards the Dachigam *Nullah)* with clear instructions on search and approach procedures.

Animal Collaring team (Dr. Khursheed Ahmad and Dr. Parag Nigam). The team was same as in Sr. no. 1 and was provisioned with all necessary logistics.

Animal Loading, Weighing and Offloading team (Mr. Iqramul Haque and members of the ATTI & II

Animal monitoring and Biological sampling team (Dr. Parag Nigam and Dr. Omar Nazir).The team was responsible for animal stabilization on approach and for managing any veterinary emergency in case it arises.

Data Recording and documentation (Mr. Gh.Mohiudin Dar, Mr. Iqramul Haque)

Post release monitoring (Project Research Team).

Field Exercise Day 1 (4th May 2018)

The capture efforts were made from 1600 hrs with the darting team positioned in the hide and other teams at respective places. Following section provides details of the sequence of events.

A Hangul stag briefly approached the hide from the western side at 1749 hrs on 4th May but did not provide opportunity for darting. The animal could only be appreciated by the ATT I positioned in Watch tower I and was not visible to the darting team. The animal however returned back into the thicket immediately. Subsequently, a herd of Hangul comprising nine individuals (06 female with 03 yearlings) started approaching the habituation site. The animals were cautious and could sense human presence in watch tower 2. The herd maintained distance and did not come near the hide thereby limiting darting option and returned back. The team however sat in the hide to see the response of animals in case they return. The animals however did not return.

Field Exercise Day 2 (5th May 2018)

The respective teams positioned themselves as per the plan by 0600 hrs with the ATT I in both the watch towers (I & II). As per the information provided by the project research team, the animals were using the Oak patch during the night but moved away as the day broke. The darting team positioned itself in the hide however, no animal movement was noticed during the day till 1849 hrs when a single adult hind approached the habituation site. The ATT I had already vacated the watch towers by then. The animal was cautious alert and shy initially but responded positively to the lure. The animal came on the salt lick and was observed for almost 11 minutes.

Plate 4: Animal on darting site

The team decided not to dart the animal owing to the animal being alone, far from herd and with limited day light for further work. The team sat in the hide till 2000 hrs before returning to the base.

Field Exercise Day 3 (6th May 2018)

The darting team positioned themselves in the hide for 0500 hrs. Herd of seven individual was seen at the habituation site in the morning however, the herd moved away by the time the darting team moved into the hide. Both the watchtowers (1 & 2) were left vacant to avoid any possible disturbance to the animal and the ATT I were positioned on road (150 m before the Oak patch). The darting team remained in the hide for the day, however, no animal movement was noticed till 1800 hrs. Heavy rains and wind all through the afternoon between 1400 to 1700h were encountered. The rains finally settled at around 1700 hrs. By 1800h, a herd of eleven individuals comprising 4 adult females, 01 young male (Spiker) and 06 yearlings started approaching the salt lick. All the animals were however cautious and maintained distance. A single adult female however approached the salt lick and provided opportunity for darting.

Animal was subsequently darted from a distance of 20 m on the left shoulder at 1820 hrs with a drug mixture of medetomidine and ketamine. Dan-inject Model JMDB was used for remote drug delivery.

The animal got startled initially following darting however could be seen moving at a normal pace after a distance of 40 m with continuous vocalization for up to 7 minutes post darting. The animal tracking team II could see the animal from a distance and reported incoordination by 11 minutes and sternal recumbence by 14th minutes post darting. Necessary instructions for keeping check on the animal were given and the animal was approached after 20 minutes post darting. As the animal showed bouncing of head, supplementary doses of ketamine were administered remotely. Levels of sedation were checked and as the animal did not respond to prodding, it was approached and blindfolded. The animal was fitted with Vectronics GPS Plus Iridium Satellite Collar No. 11477.

The animal was re-positioned in sternal recumbency before other procedures were initiated. All the physiological parameters (temperature, pulse and respiration rate, capillary filling time and colour of mucous membrane) were assessed and found to be in tandem with the normal range of conspecific species. Biological samplings were collected for genetic, hemato-biochemical profiling. Additionally, bodily measurements were recorded. Efforts were made to weigh the animal however, as the animal started showing some signs of voluntary movements, further procedures were stopped. The animal was immediately moved back on the ground from the stretcher and postioned in sterna recumbence. Drug reversal was carried out using Atipamezole given intramuscularly. The animal responded effectively to drug reversal and stood up by 1924 hrs. and subsequently moved into the thicket and further up the hill in a normal gate in the Reshiwoodri area. Necessary processing of the biological samples was carried out at the Biochemistry Division of the SKUAST-K Shuhama Campus.

Plate 5: Animal being checked for palpebral reflex

Field Exercise Day 4 (7th May 2018)

On 7th of May 2018, the darting team positioned itself in the morning at 0500 hrs and waited for the animals to reassemble at the oak patch. A fresh herd of 7-8 individuals started approaching the hide by 0600h however waited at a distance. Two of the adult hinds explored further and started coming towards the salt lick. One of the hind came closer and provided a good opportunity for darting.

The animal was darted at 0620h using a drug mixture of Medetomidine HCl and Ketamine HCl remotely delivered using Dan-inject Model JMDB from a distance of about 22m. The animal reacted and ran towards the animal trail along with the other hind. The area was left undisturbed for adequate and proper drug induction. Animal was approached at 20 minutes post darting and was seen in perfect plane of sedation in sternal recumbency.

Plate 6: Animal blindfolded and maintained in sternal recumbency

The animal was blindfolded and further procedures of collaring, biological sampling, weighing and taking bodily measurements were undertaken. Vectronics GPS Iridium Satellite collars GPS Plus 4 (No. 11481) was deployed on the animal.

Plate 7: Collar being fitted on the Hangul

As the animal was lying in a little rough terrain and closer to the Dachigam nullah, it was lifted and moved to a open clear patch. Reversal of drug effect was done using Atipamezole HCl. The animal was left undisturbed till it regained consciousness. The animal got up and moved into the thicket.

Animal could be tracked for some time initially but later moved deep into the thicket and subsequently moved towards the northern slopes.

Plate 8: Animal showing signs of recovery and coming out of sedation

The satellite collared female Hangul provided significant useful information and data on lesser known aspects of home range, ranging and movement patterns and other ecological and behavioral aspects of Hangul however, required data from more individuals to come to meaningful conclusions. Subsequent to the further fresh permission granted by the Chief wildlife warden, Jammu & Kashmir Government vide No WLP/F-101/Res/2019-2020/424-27 dated 14th March 2020, with the successful animal habituation attempts in place, we were successful in capturing and satellite collaring two more Hangul one male and one female on two consecutive days 16th and 17th March 2020 following the same plan of operation, animal habituation and chemical immobilization (Ahmad and Nigam 2014 and Ahmad et al. 2018).

Plate 9: Successful capture and collaring of Male Hangul on 16th March 2020 and female Hangul on 17th March 2020

MONITORING OF SATELLITE-COLLARED HANGUL

The preliminary findings of the satellite-collared animals have provided significant information on the movement patterns, animal home ranges and habitat use by individual Hangul. Radiolocations of both the collared individuals was monitored following deployment. Eleven days post collaring, one of the animals (Collar ID 11477 (female 1 F1) returned to the Oak patch and was captured in the camera trap on 17th May 2018.

Plate 10: A Female Hangul collared in May 2018 captured in the camera trap after seven months & GPS-Satellite collared animal in velvet captured in the camera trap exactly 02 months after it was fitted with the Satellite collar

Plate 11: Collared doe using the Oak Patch and captured on 17th May 2018

One of the hind (Satellite Collar 11481) initially moved in the lower reaches during May and subsequently moved to the middle reaches (altitude of 2400-2900 meters asl) from mid-June onwards. The doe initially moved to the lower reaches of riverine and grasslands, during May, travelling a considerable distance and moving to higher reaches (altitude of 2400-3300 meters *asl*.) in mid-June, outside Dachigam National Park, crossing the river Sindh and covering an area of 137.94 km, with area use of 10.86-12.26 Km^2 in summer 2019 to 137.94 km in summer 2020 and a maximum home range of 124.4 km^2 in Summer 2020 to colonize and establish its new summer habitat in the erstwhile range area of Wangath-Naranag Conservation Reserve (CR). The data and information generated has enabled us to identify the movement corridor areas of Hangul between Dachigam NP and Wangath-Naranag CR and validate the information published during earlier studies (Ahmad 2006 & 2007: Ahmad et.al 2009; Ahmad et. al 2013; Ahmad and Nigam 2014; Qureshi et.al 2009) on the movements of Hangul outside Dachigam National Park. The home range details are given in Table 1.

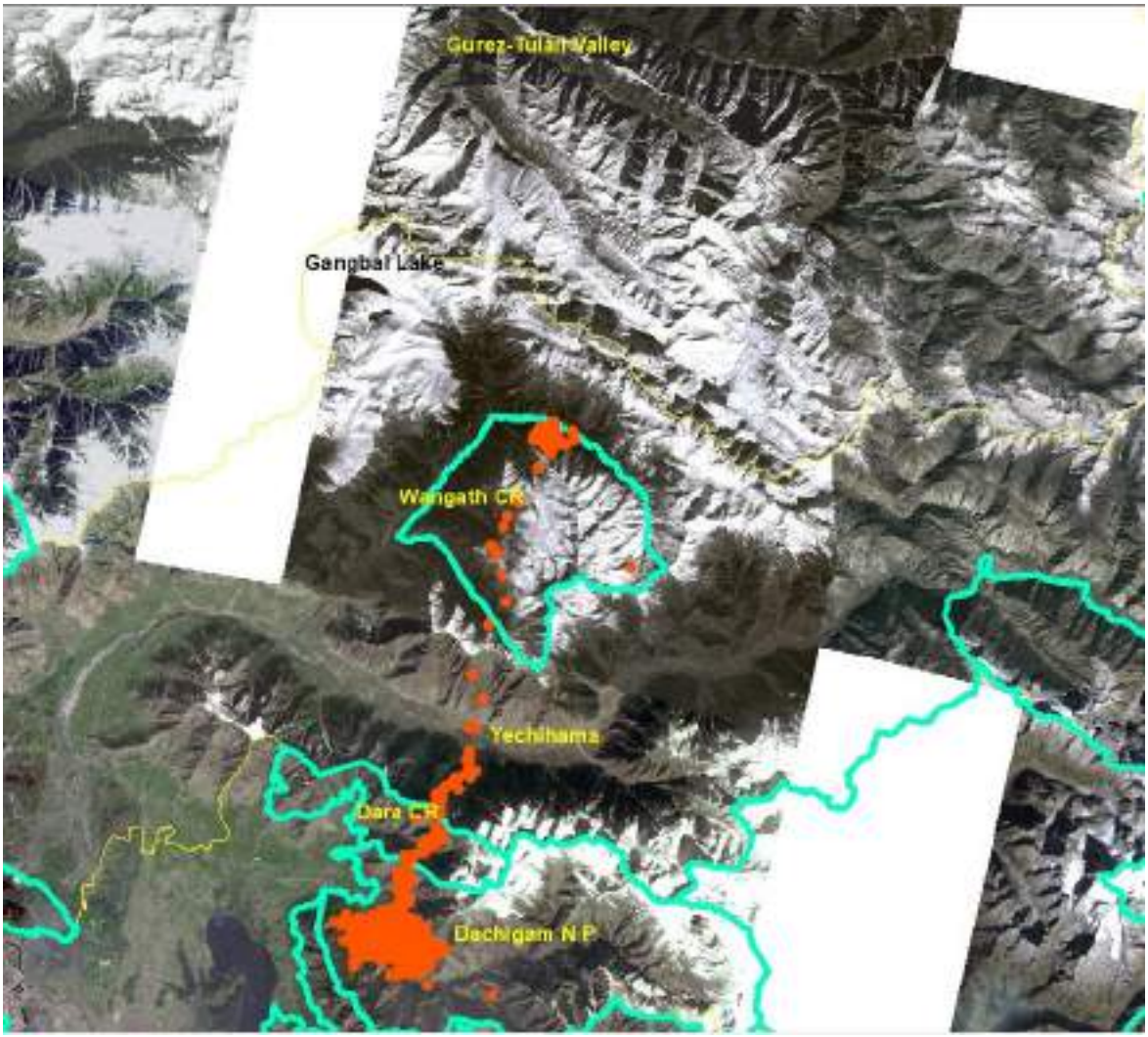


Fig. 12: Movement pattern of female collared Hangul tracked between DNP and Wangath-Naranag Conservation Reserve

Data Analysis

The data generated from four Hangul (Three female and one Male) was filtered in ArcGIS 9.2.1 with the ArcMet tool (Wall, 2014) for estimating Home ranges using Minimum convex polygon (MCP), Kernel density reference bandwidth (href), Kernel density least squares cross validation (LSCV) and BBMM (Brownian bridge movement model) and Net square displacement. The home and core ranges are mentioned as 95 and 50 respectively. 100% home range levels have only been reported for MCP (Table 2). The satellite downloaded data was also analysed using R software.

The Hangul showed great variations in the home range sizes ranging from highest home range of 137. 94 Km 2 MCP recorded in Female Hangul F2 to 5.1 Km 2 MCP recorded in Female Hangul F 3 from Dachigam National Park. The male satellite collared Hangul showed annual home range of 11.44 Km 2 MCP. The 50 and 95% home ranges of Hangul are shown in Table.2. Multiple core zones were utilized by one of the collared female Hangul (F2).

Plate 12: Hangul doe collared in May 2018 photographed using open grassland/scrub in snowy day on 31st January 2020.

Table 2: Home Ranges of Satellite collared Hangul (2 Male and 3 Female) calculated by different methods

Hangul ID	MCP	Kernel KDE (href)	Kernel KDE (LSCV)	BBMM	MCP	Kernel KDE(href	Kernel KDE (LSCV)	BBMM	MCP
	Territory in Km^2				Home-Range in Km^2				
Percent	50	50	50	50	95	95	95	95	100%
Male Hangul M1	3.28	2.2	0.63	1.01	7.89	8.46	3.53	5.64	11.44
Female Hangul F1	2.68	1.8	0.68	1.06	8.67	8.29	2.87	5.64	12.89
Female Hangul F2	28.88	22.61	1.05	0.81	117.78	131.21	8	10.87	137.94
Female Hangul F3	0.77	0.93	0.16	2.73	3.84	4.35	0.95	33.19	5.1
Male Hangul M2	Data Not received								

Plate 13: Hangul doe collared in 17th March 2020 using open grassland/scrub captured in camera trap after one year on 21st March 2021

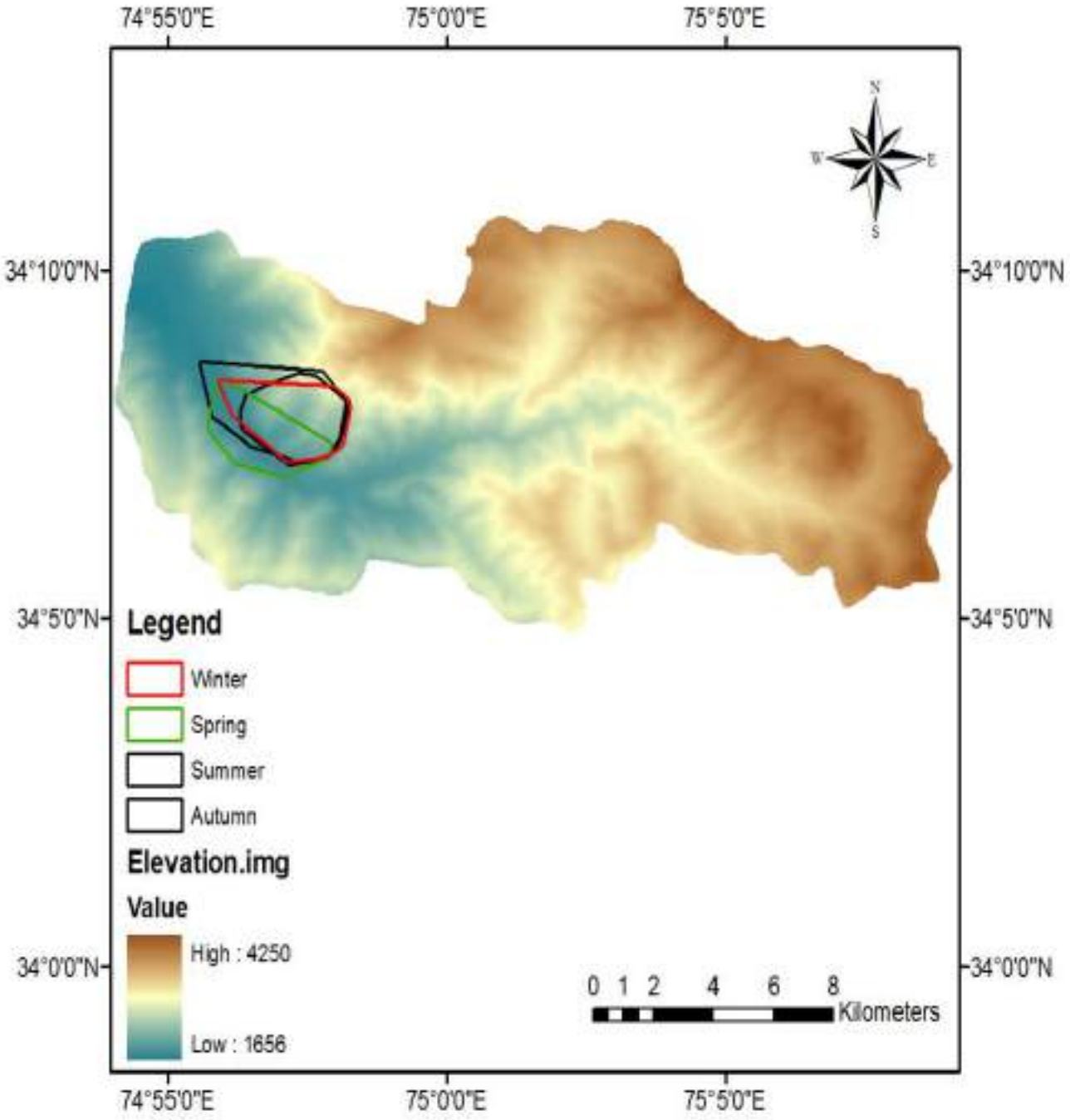
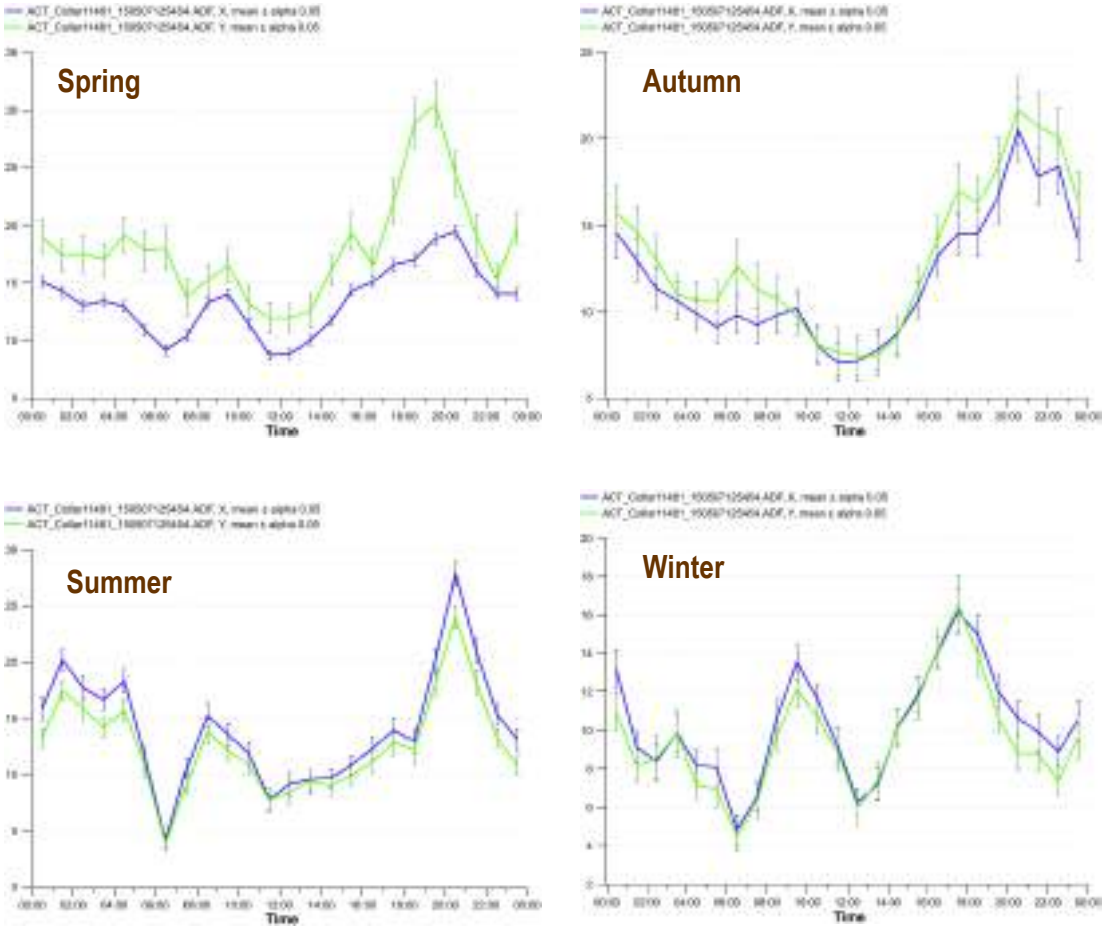


Fig. 13: The Home range size varied from 4.98 Km^2 in spring to 7.83



The animal showed two activity peaks in morning and evening hours with significant seasonal variations

Fig. 14 : Seasonal mean activity of male Hangul – 11481 on X (blue line) and Y (green line) axes representing forward backward and lateral movements experienced by the collar, respectively.

Plate 14: The initial Movement pattern of Hangul outside DNP (Satellite Collar 11481)

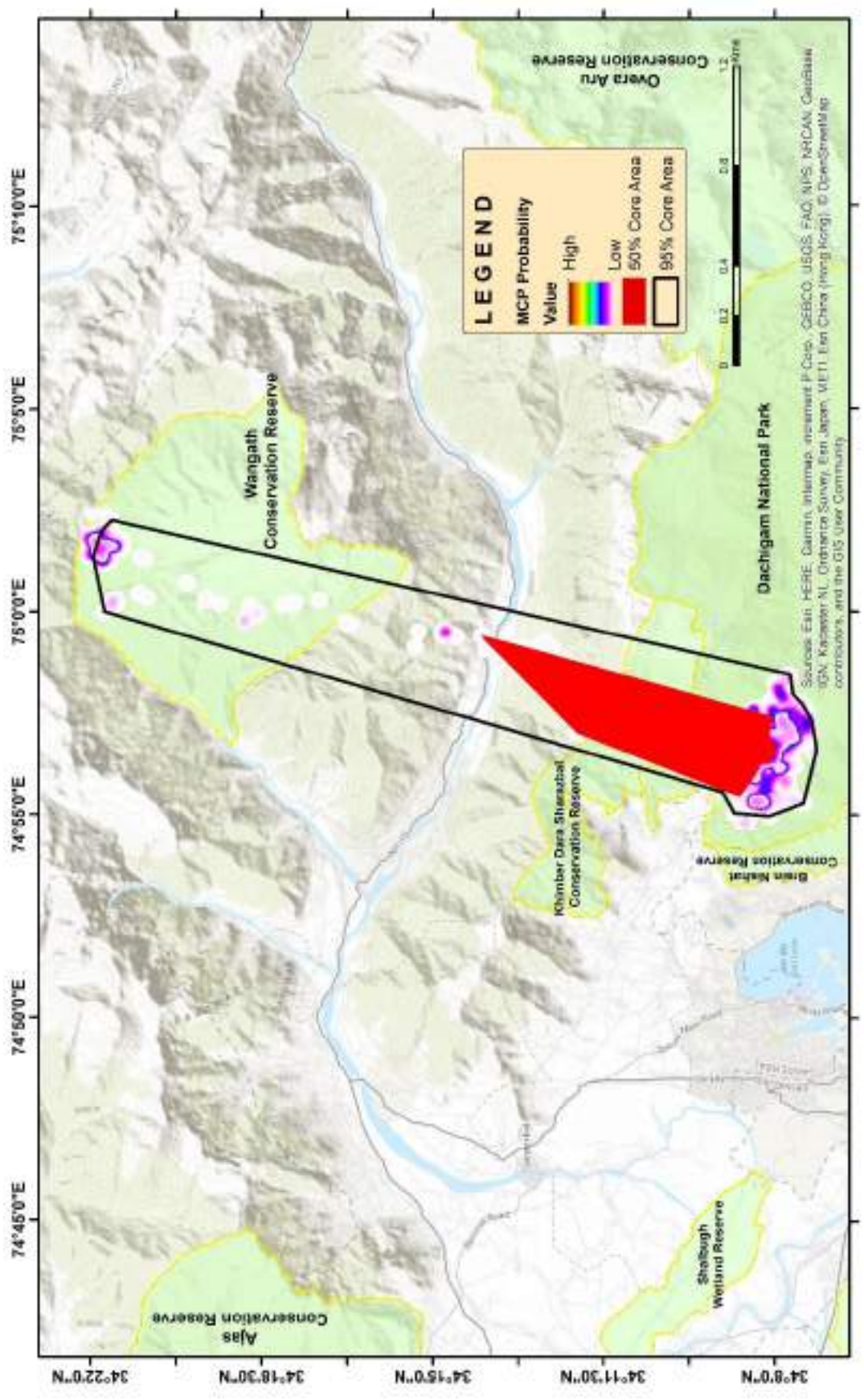


Fig. 15: Annual MCP Home range in and outside DNP of Collared Female Hangul (F2) (May 2018-May, 2021)

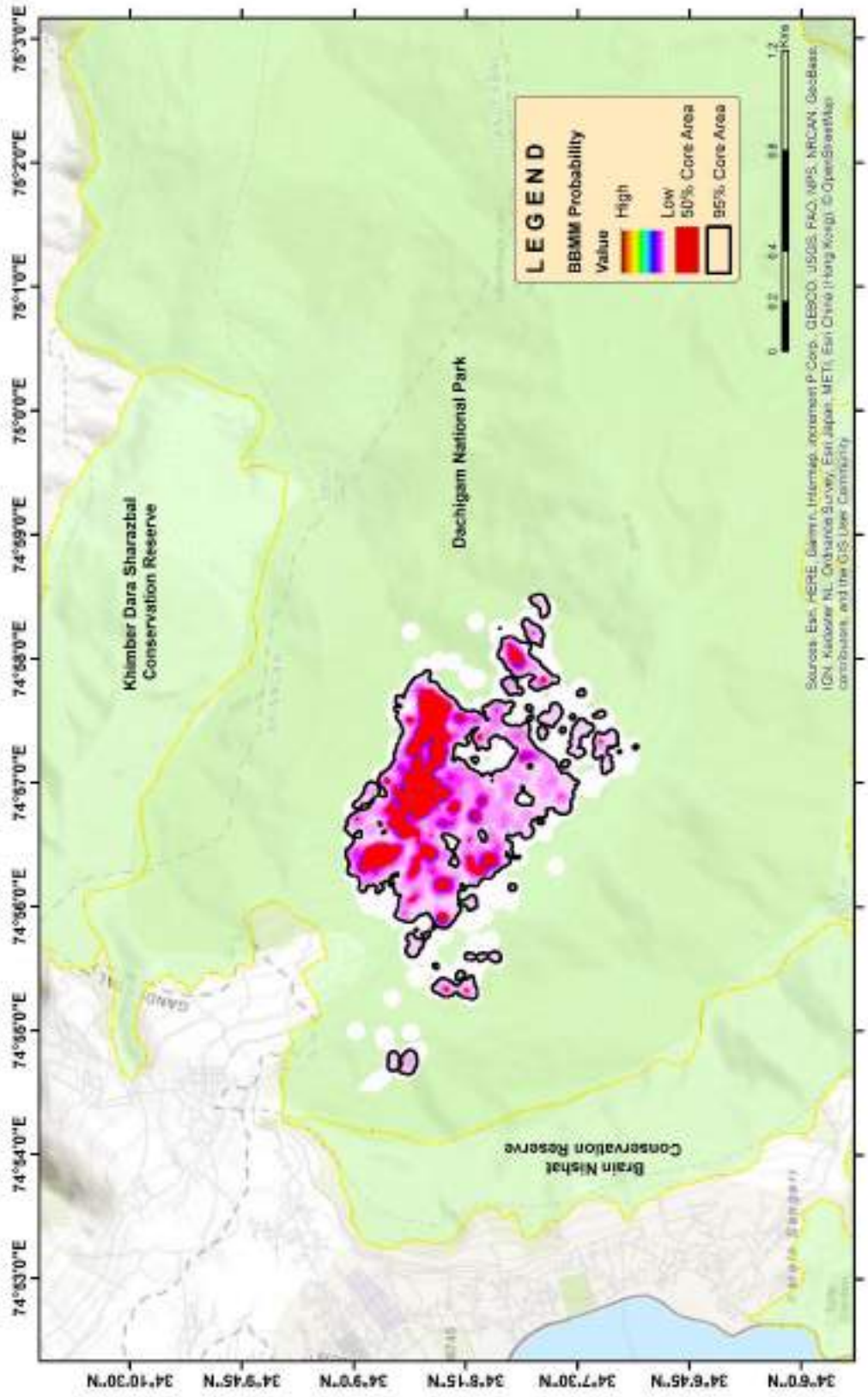


Fig 16: Brownian Bridge Movement Model (BBMM) Home Range (50 and 95 %) of Female (F1) Satellite Collared Hangul in DNP (May 2018-May, 2021)

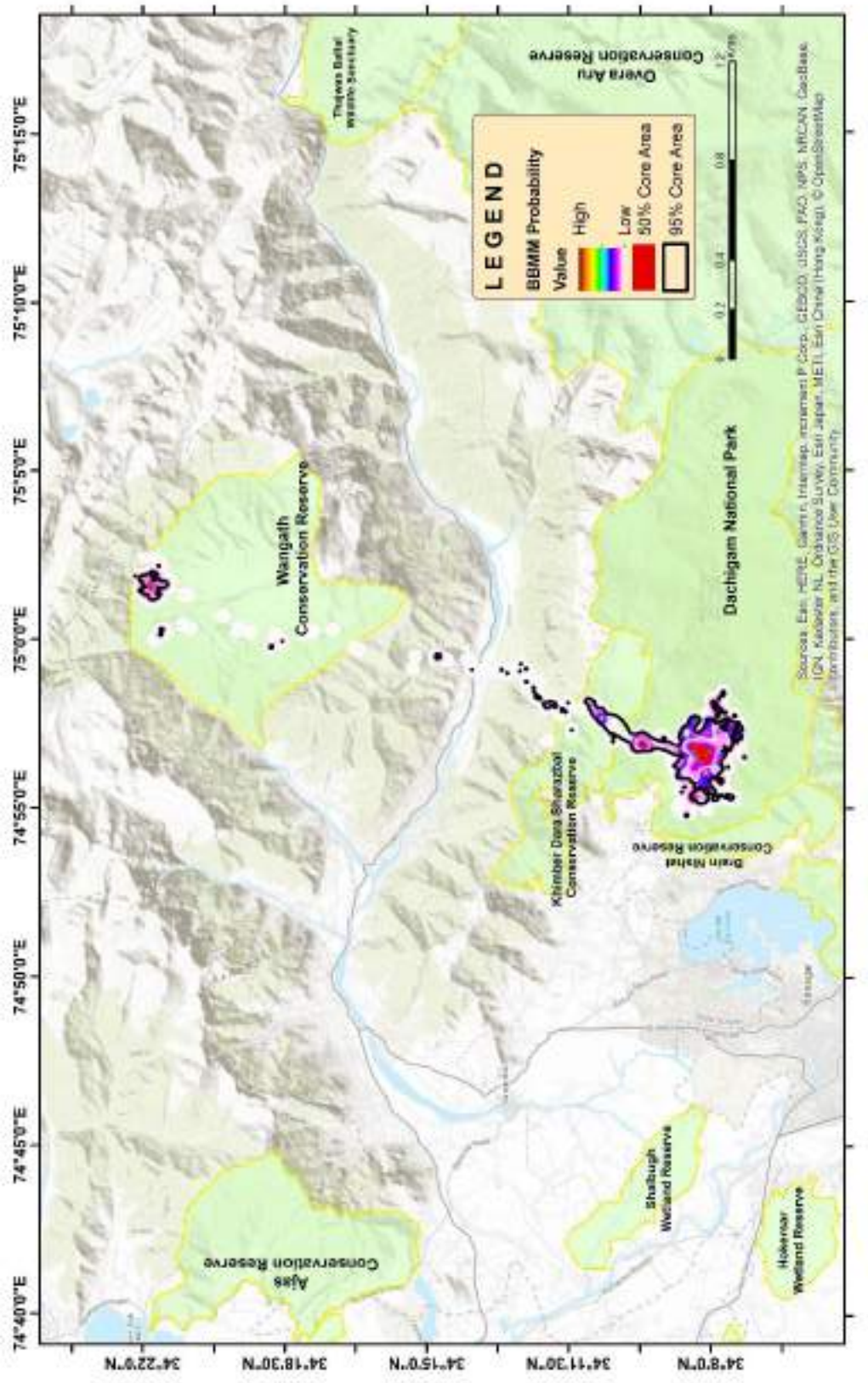


Fig. 17: Brownian Bridge Movement Model (BBMM) Home Range (50 and 95 %) of Female (F2) Satellite Collared Hangul in DNP (May 2018-May, 2021)

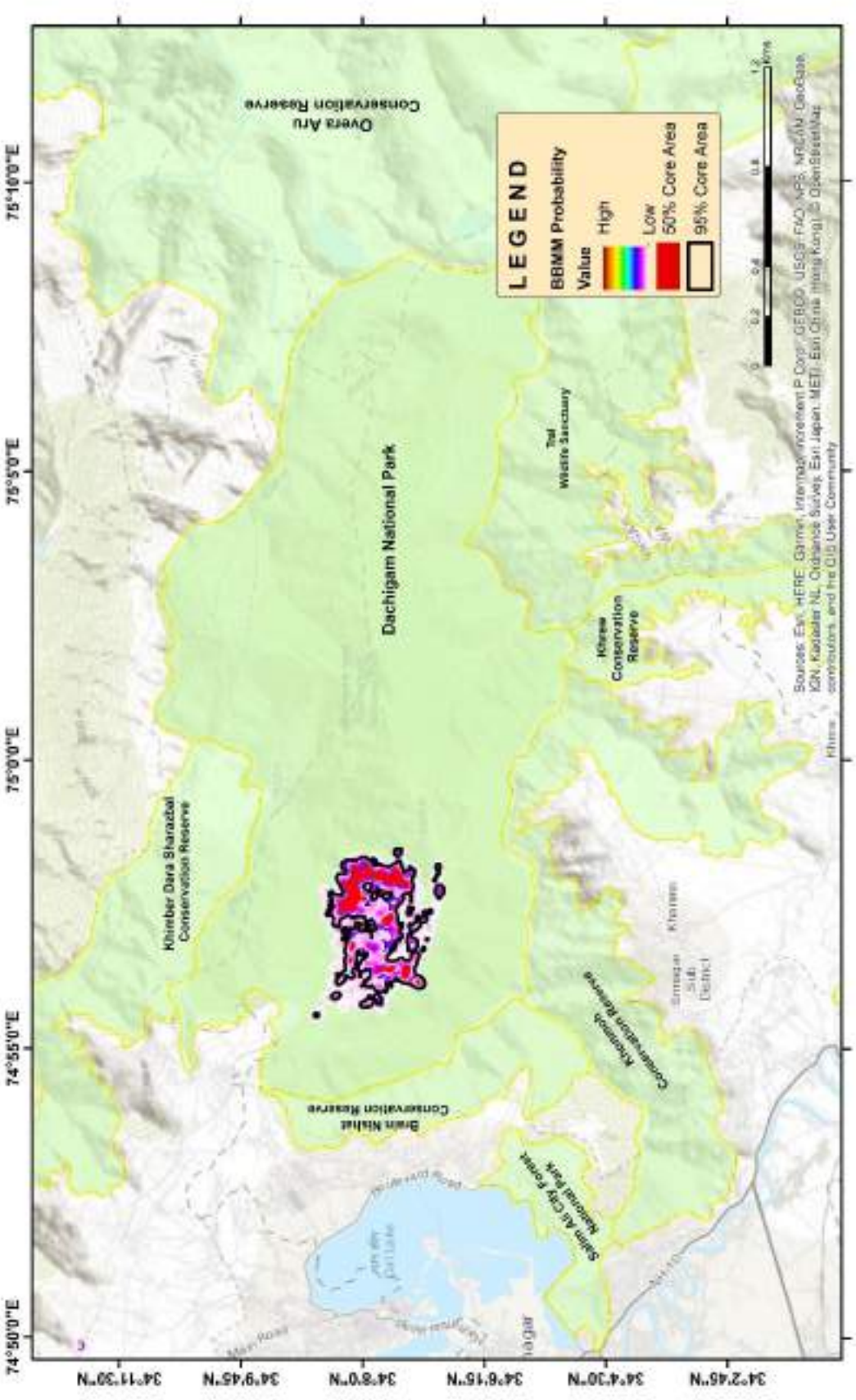


Fig 18: Brownian Bridge Movement Model (BBMM) Home Range (50 and 95 %) of Male Satellite Collared Hangul in DNP (2013-14)

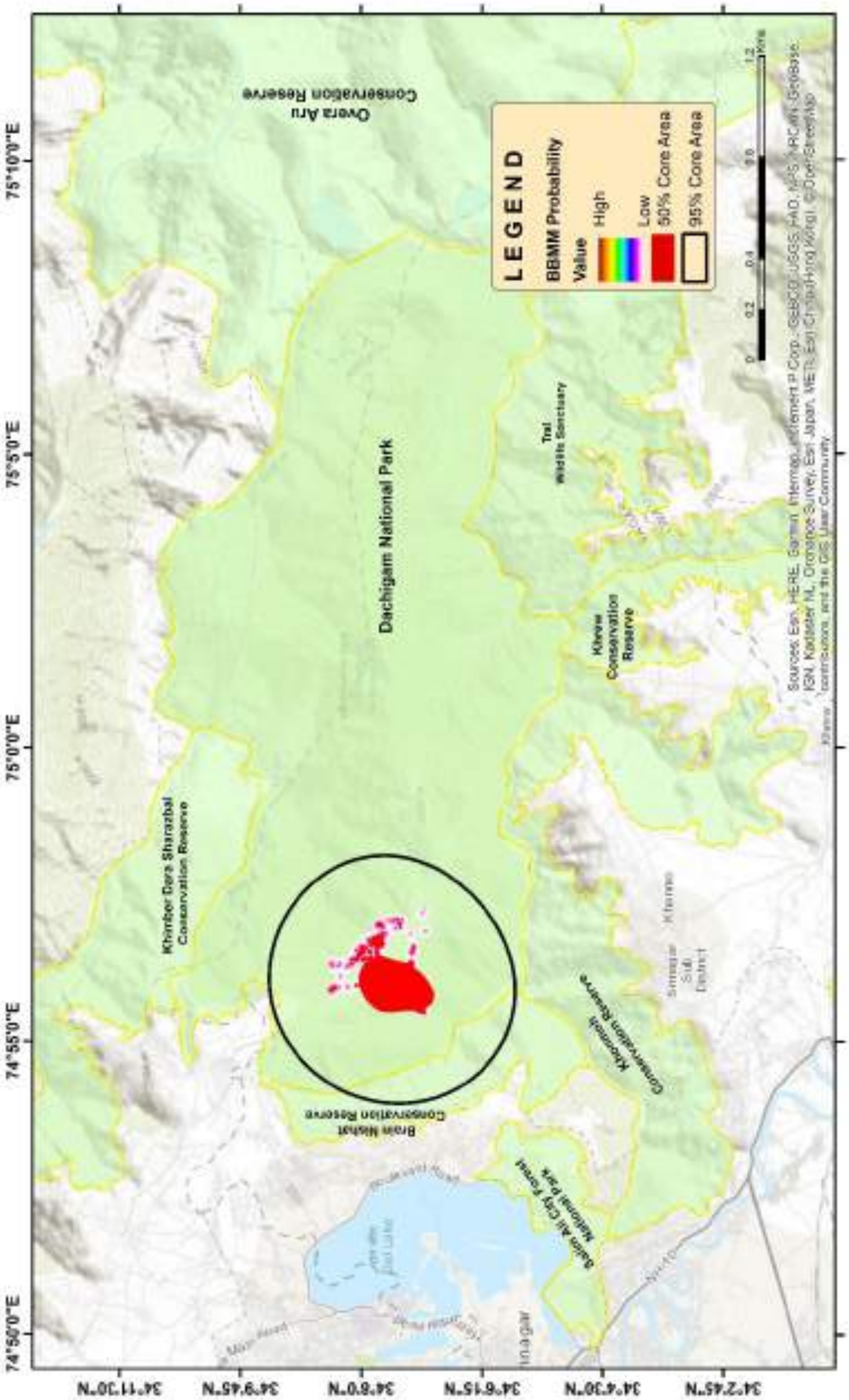


Fig 19: Brownian Bridge Movement Model (BBMM) Home Range (50 and 95 %) of Female (F3) Satellite Collared Hangul in DNP (2020)

Analysis of Angular data

The angular data analysis done in R using the packages spatstat, circular and knitr indicated movement of Hangul in a circular pattern and movements all across different areas of their home range (Fig.14).

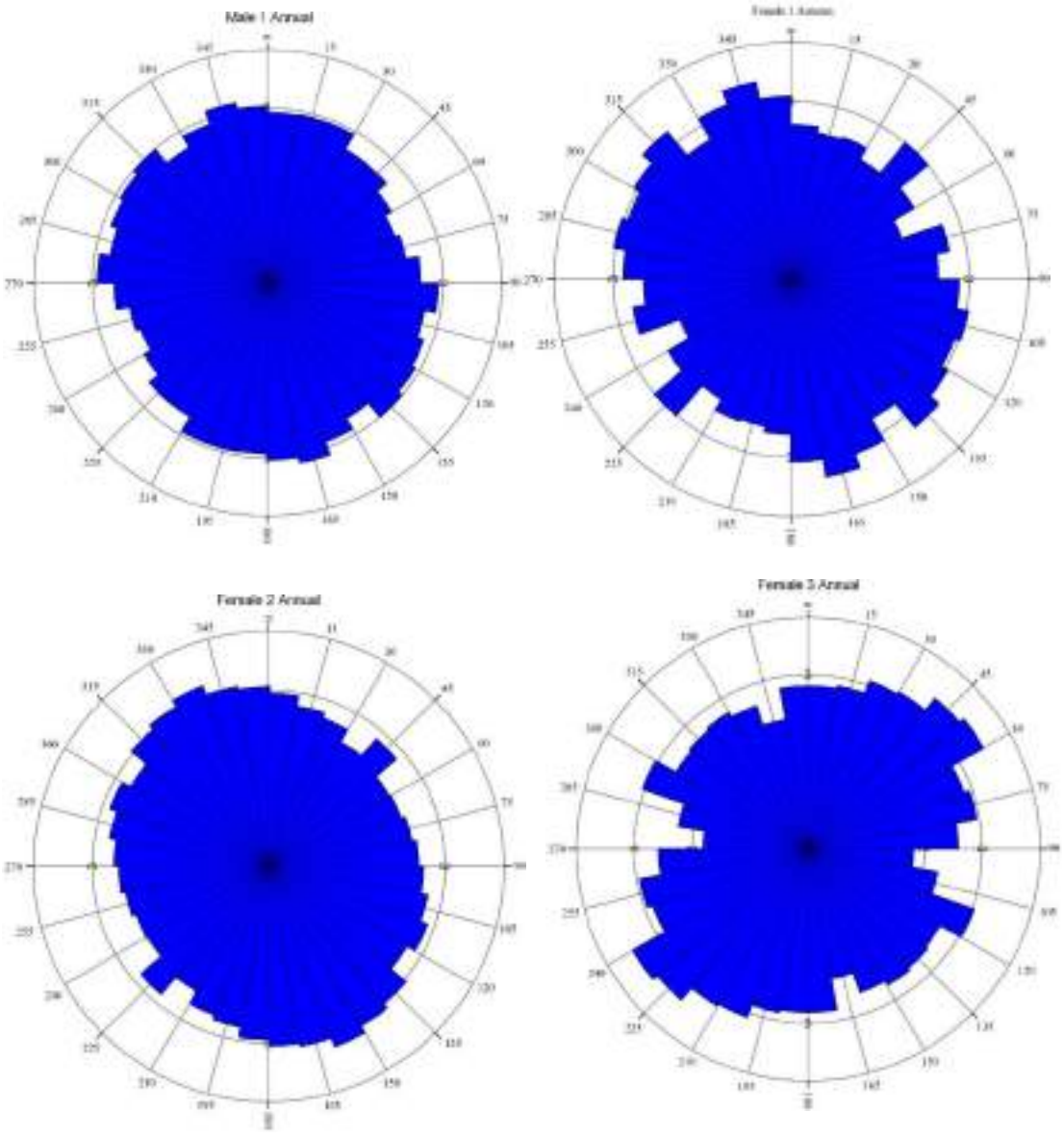


Fig. 20: Rose Diagrams of the angular data of all collared Hangul individuals

IDENTIFICATION OF HANGUL MOVEMENT CORRIDORS & CORRIDOR HABITAT ASSESSMENT

Identifying and restoring corridors is often a cornerstone in conservation of wildlife populations in highly fragmented habitats. Corridors may facilitate daily and seasonal migrations and also periodic dispersal of animals to maintain population and genetic connectivity. Corridors are easy to identify within landscapes where the difference between habitat and non-habitat is clear (Sukumar 1989; Sukumar et al., 2003; Johnsingh et al., 2006; Menon 2017). Wildlife corridor assessment has become a widely adopted management strategy for the conservation of species in fragmented habitats. Fragmentation reduces the size of habitat patches and increases the isolation of the populations within them, potentially resulting in extinction due to stochastic processes. However, in rugged terrains of Greater Himalayan mountain ranges, identifying corridors of movement of the long ranging Kashmir red deer or Hangul between the fragmented habitats has always been challenging.

Dachigam National park which inhabits the last viable global population of the critically endangered Kashmir red deer or Hangul is bounded with Sindh valley and Wangath Conservation Reserve to the north east; Tarsar, Lidderwath, Kolhai of Lidder valley and Overa –Aru Wildlife Sanctuary in the far east; Tral Wildlife Sanctuary and Shikargah CR in the south east and Harwan, Brain and Nishat in the west and south west which together constitute Greater Dachigam landscape. This landscape contiguity offers habitat linkages and critical movement corridors crucial for large-ranging animals such as Hangul which use these forest corridors for seasonal migration and movement patterns.

The satellite telemetry of Hangul has provided valuable data and information on the ranging and movement patterns of Hangul and has enabled us to identify the movement corridor areas of Hangul between Dachigam NP and Wangath-Naranag CR and validate the information published during earlier studies (Ahmad 2006 & 2007: Ahmad et.al 2009; Ahmad et. al 2013; Ahmad and Nigam 2014; Qureshi et.al 2009) on the movements of Hangul between Dachigam National Park and relic range areas of Gurez-Tulel in the north-west through Wangath-Naranag CR.

Attempts were made to assess and evaluate the vegetation and the habitat conditions of the identified corridor areas in the Sindh Forest Division for effective habitat management of the identified corridor areas for long term conservation planning of Hangul and its habitats in the critical landscape. Attempts were also made to study, establish and assess the occurrence, distribution extend of the isolated relic Hangul population in the Shikargah Conservation reserve south of Dachigam.

Methodology

Corridor habitat assessment and evaluation was done by vegetation sampling. Vegetation (trees, shrubs, and ground cover) and landscape parameters (altitude, aspect, and slope) were quantified at every 100 m interval along all along the Hangul movement corridor area identified and delineated through satellite telemetry data in the Sindh Forest Division block following Mueller-Domboise and Ellenberg (1974) and Rutledge (1982). The intensive vegetation sampling and phyto-sociological data

collection was done within 203 plots around the Yachhama area (which turned out to be the identified important stop over site and corridor to migration of collared Hangul between Dachigam NP and Wangath-Naranag CR) (Fig. 21).

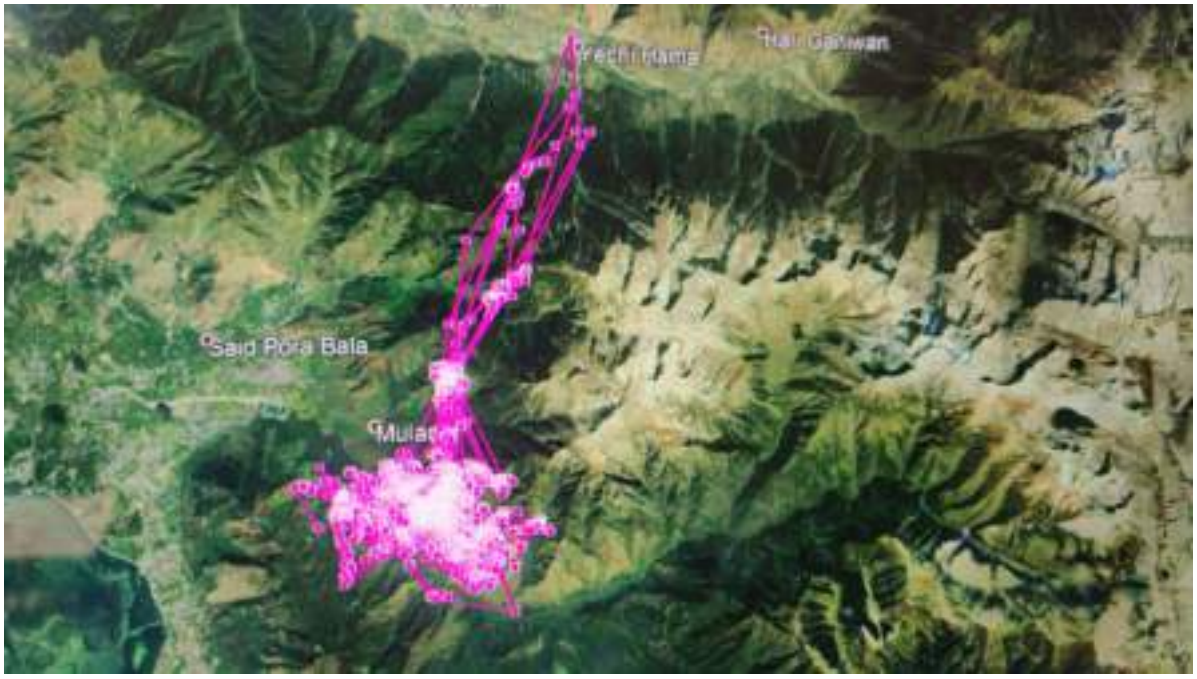


Fig.21 Important stop over and corridor of migration identified and delineated in the Sindh forest division outside Dachigam N.P through tracking of Satellite collared Female Hangul (F2).

The sampling was done at randomly regular intervals in all the possible habitats and vegetation associations and the optimum size of vegetation sampling plots was chosen from the species-area curve. At every sampling plot, data were collected on the vegetation and habitat parameters such as broad habitat/vegetation type (riverine, grassland/scrub, pine Parrotiopsis, mixed coniferous, mixed woodland, mixed Morus, mixed oak, and grassy/rocky slopes), altitude (in m) using altimeter and GPS, aspect (north, northeast, east, south, southwest, west, northwest) using compass and GPS, and slope (flat 0–160, gentle 16–250, steep 25–340, very steep 34–500) based on visual estimation. In these plots, trees (the number of species and the number of individuals for each species) were quantified in circular plots (10.3 m radius), shrubs (the number of species and the number of individuals for each species) were quantified in 5 m circular plots, and ground cover (percentage of grass, herb, litter, bare ground rock, and snow) was quantified by line-intercept method (1 m tape) in four different directions following Mueller-Domboise and Ellenberg (1974) and Rikhari et al. (1989). Habitat types were defined based on the predominant tree species or in other cases by the name that provided information about the main habitat features (such as riverine, grassland/scrub, etc.).

Analysis

Preliminary analysis was done to obtain the values of various parameters such as density, percentage of frequency, and abundance of vegetation (trees, shrubs, and ground cover) following Mueller-Domboise and Ellenberg (1974). The vegetation diversity indices, (Krebs 1989), and measurements of various diversity indices (Shannon-Weiner, Simpson, and Hill's number) were done using BioDiversity

Pro (2000) windows-based software package developed by Neil McAleece for the Natural History Museum, London. The primary data recorded on number of individuals in a species and girths were utilized to derive secondary attributes like density and frequency following standard phyto-sociological methods of Misra (1968). Relative values were calculated following Philips (1959). Important Value Index (IVI) was calculated by adding up relative frequency, relative density and relative dominance (Curtis, 1959). In the case of shrubs, herbs and saplings; IVI was calculated based only on relative values, i.e., relative frequency and relative density.

Results

The survey monitoring and camera trapping efforts resulted in successfully establishing for the first time the significant population of Hangul in Shikargah-Tral Wildlife Sanctuary through capturing of 12 Hangul individuals (two male, 08 female and 02 young ones) in one single frame in the camera trap in March 2020.

Plate 14: First ever camera trap pictures Hangul Herd & solitary male captured at Shikargah & Tral wildlife sanctuary under this and the CAMPA Hangul Conservation Breeding Project-Remarkable Achievement.

The vegetation composition in the identified Hangul corridor area comprised of thirty-four (34) woody species including twenty-four (24) tree species belonging to 13 families with highest number of species (n=5) belonging to family Rosacea and ten (10) species of shrubs. The prominent tree species recorded in the corridor area were *Abies pindrow, Pinus wallichina, Picea smithiana, Prunus cornuta, Acer pictum and Ulmus wallichiana*. The average tree density turned out to be 228±37 trees per hectare with highest IVI of 57.82 for *Abies pindrow* followed by 46.847 for *Pinus wallichina* and lowest in Pirus communis 1.73. (Table 3). The prominent shrub species were *Rubus ulmifolius*, *Viburnum grandiflorum* and *Rubus lasiocarpus* with a mean density of 390±20 shrubs per hectare (Table 4). A total of ninety-nine (99) grass species were identified and assessed in the corridor area with an average density of with 143661.9718 ± 562 plants per hectare. The relative densities and IVIs of grass species is given in Table 5.

Species diversity, richness, heterogeneity and equitability in various layers forest community have been given in Table 1. Understory exhibited highest richness and diversity of Grass and herb vegetation (H = 3.69) while as Shrubs had lowest richness and diversity (H = 1.95) (Table 6).

Table 3: The relative densities and important value index (IVI) of Tree species recorded along the identified Hangul corridor areas in Sindh Forest Division.

S.no:	Tree Species	Common Name	Family	Relative Dominance	Relative Frequency	Relative Density	IVI
1	*Abies pindrow*	Budul	Pinacea	7.142	24.183	26.502	57.827
2	*Pinus wallichina*	Kaiur	Pinacea	4.853	15.686	26.308	46.847
3	*Picea smithiana*	Kachul	Pinacea	6.440	8.497	7.210	22.147
4	*Prunus cornuta*	Bharat	Rosaceae	4.736	8.497	4.287	17.520
5	*Acer pictum*	Tarkina	Sapindaceae	6.387	5.882	3.508	15.777
6	*Cedrus deodara*	Deodar	Pinacea	13.252	0.654	0.779	14.685
7	*Ulmus wallichiana*	Braari	Ulmaceae	12.423	1.307	0.779	14.510
8	*Parrotiopsis jacquemontiana*	Hatab	Hamamelidaceae	4.810	5.882	3.313	14.005
9	*Ulmus villosa*	Bren	Ulmaceae	5.522	3.922	1.364	10.807
10	*Prunus spp*	Gordail	Rosaceae	1.246	2.614	6.626	10.486
11	*Juglans regia*	Doon	Juglandaceae	3.189	4.575	1.364	9.128
12	*Aesculus indica*	Handun	Sapindaceae	2.215	3.922	2.533	8.670
13	*Populus alba*	Fras	Salicaceae	5.522	1.307	1.754	8.583
14	*Betula utilis*	Burj	Betulaceae	1.988	1.307	4.287	7.582
15	*Celtis australis*	Brimij	Cannabaceae	1.670	2.614	3.118	7.403
16	*Prunus persica*	Chenan	Rosaceae	5.522	0.654	0.390	6.565
17	*Taxus baccata*	Postul	Taxaceae	1.988	1.961	1.169	5.118
18	*Salix alba*	Vir	Salicaceae	2.706	1.307	0.974	4.987
19	*Prunus armeniaca*	Chear	Rosaceae	1.380	1.307	1.364	4.052
20	*Alnus nitida*	Chaamp	Betulaceae	1.380	1.307	0.974	3.662
21	*Castanea sativa*	Chestnut	Fagaceae	1.988	0.654	0.195	2.836
22	*Ailanthus excelsa*	Ailanthus	Simaroubaceae	1.380	0.654	0.585	2.619
23	*Cotinus coggygria*		Anacardaceae	1.380	0.654	0.585	2.619
24	*Pyrus communis*	Tang	Rosaceae	0.883	0.654	0.195	1.732

Table 4: The relative densities and important value index (IVI) of Shrub species recorded along the identified Hangul corridor areas in Sindh Forest Division.

S.No	Shrub species	Relative density	Relative Frequency	Relative abundance	IVI
1	Rubus ulmifolius	29.817	14.925	29.817	74.558
2	Viburnum grandiflorum	25.688	20.896	25.688	72.272
3	Rubus lasiocarpus	11.468	10.448	11.468	33.384
4	Berberis lycium	8.257	11.940	8.257	28.454
5	Cotoneaster insignis	5.046	10.448	5.046	20.540
6	Chenault coralberry	5.046	8.955	5.046	19.047
7	Sorbaria tomentosa	4.587	7.463	4.587	16.637
8	Rhododendron arboretum	4.587	4.478	4.587	13.652
9	Rubus ulmifolius	3.211	5.970	3.211	12.392
10	Rubus fruticosus	2.294	4.478	2.294	9.065

Table 5: The relative densities and important value index (IVI) of Grass species recorded along the identified Hangul corridor areas in Sindh Forest Division.

S.No	Grass species	Relative Frequency	Relative Abundance	Relative Density	IVI
1	*Achillea millefolium*	0.1894	0.0980	0.0981	0.3855
2	*Adiantum capillus-veneris*	0.3788	0.1471	0.1471	0.6729
3	*Aergiron bonarsis*	0.1894	0.0490	0.0490	0.2874
4	*Ajuaja pariflora*	0.1894	0.1471	0.1471	0.4836
5	*Ajuga parviflora*	1.1364	0.4412	0.4413	2.0188
6	*Allium stoliczka*	0.1894	0.1471	0.1471	0.4836
7	*Althaea rosa*	0.1894	0.0490	0.0490	0.2874
8	*Amaranthus retroflexus*	0.1894	0.0490	0.0490	0.2874
9	*Anagallis arvensis*	0.1894	0.0490	0.0490	0.2874
10	*Androsace mucronifolia*	0.3788	0.1471	0.1471	0.6729
11	*Androsace rotundifolia*	0.5682	0.2451	0.2452	1.0584
12	*Arabidopsis thaliana*	0.3788	0.1471	0.1471	0.6729
13	*Aristida adscensionis*	7.3864	8.5294	8.5319	24.4477
14	*Aristida adsisons*	0.1894	0.3431	0.3432	0.8758
15	*Artemisia scoparia*	0.7576	0.4902	0.4903	1.7381
16	*Artemisia vulgaris*	0.9470	0.4412	0.4413	1.8295
17	*Arthraxon lansifelus*	0.1894	0.0980	0.0981	0.3855
18	*Arthraxon lenceolatus*	2.0833	1.7157	1.7162	5.5152
19	*Artimisaia vulgaris*	0.1894	0.0490	0.0490	0.2874
20	*Asparagus filicinus*	0.3788	0.4412	0.4413	1.2613
21	*Asperagus recemosus*	0.7576	0.4902	0.4903	1.7381
22	*Aster flaccidus*	0.5682	1.1765	1.1768	2.9215
23	*Bergenia ciliata*	1.5152	1.0784	1.0787	3.6723
24	*Bothriochloa ischaemum*	0.9470	0.5392	0.5394	2.0256
25	*Bromus japonicus*	2.4621	8.8725	8.8751	20.2098
26	*Buplereum candollei*	3.0303	2.8922	2.8930	8.8155
27	*Cannabis sativa*	0.7576	0.3922	0.3923	1.5420

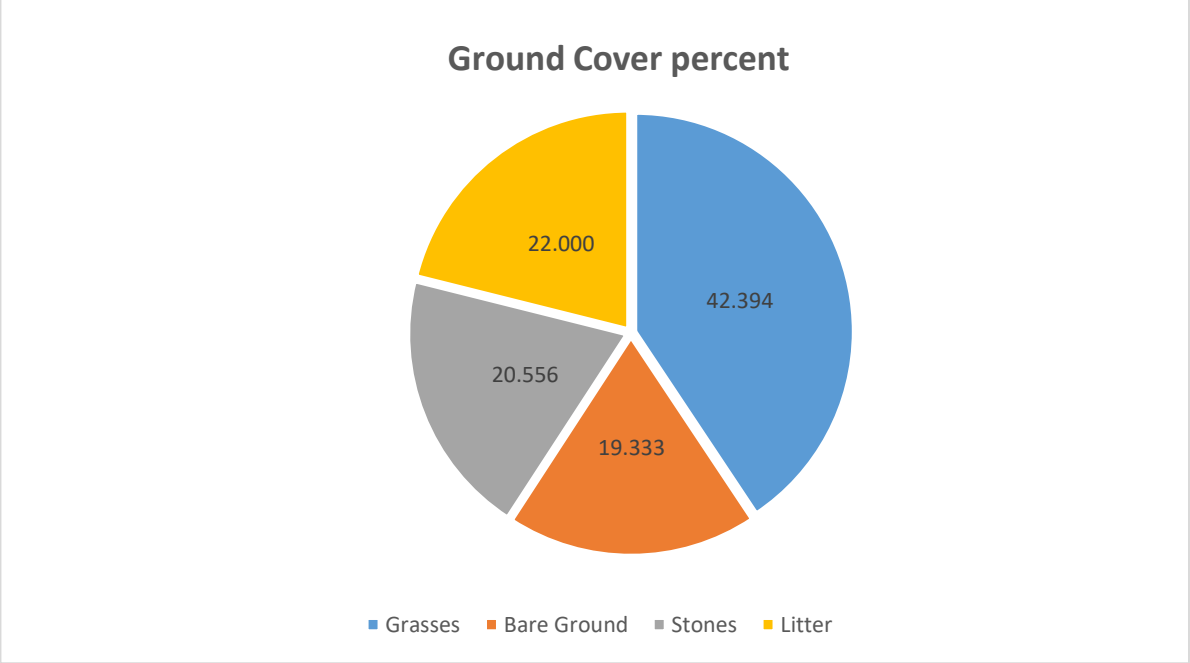
28	*Carduus edelbergii*	0.9470	0.5882	0.5884	2.1236
29	*Carpesium cernuum*	1.1364	0.9804	0.9807	3.0974
30	*Celosia argentea*	0.1894	0.4902	0.4903	1.1699
31	*Chamchi pater*	0.1894	0.0490	0.0490	0.2874
32	*Clinopodium vulgare*	4.1667	3.1373	3.1382	10.4421
33	*Colchicum luteum*	0.1894	0.0980	0.0981	0.3855
34	*Colnus albasibarica*	0.1894	0.5882	0.5884	1.3660
35	*Conium maculatum*	0.1894	0.1961	0.1961	0.5816
36	*Cynodon dactylon*	0.5682	1.6176	1.6181	3.8039
37	*Dactylis glomerata*	0.1939	0.1471	0.1471	0.4836
38	*Datura stramonium*	0.1894	0.2941	0.2942	0.7777
39	*Daucus carota*	0.3788	0.3922	0.3923	1.1632
40	*Delphinium cashmirianum*	0.1894	0.1961	0.1961	0.5816
41	*Dephni mucronata*	0.1894	0.1471	0.1471	0.4836
42	*Discorea deltoidea*	0.3788	0.1471	0.1471	0.6729
43	*Dryopteris balanfordii*	5.1136	3.7745	3.7756	12.6638
44	*Erigeron canadensis*	0.1894	0.3922	0.3923	0.9738
45	*Eryngium planum*	0.5682	0.2451	0.2452	1.0584
46	*Euphorbia chamaesyce*	0.1894	0.0490	0.0490	0.2874
47	*Fagopyrum esculentum*	0.1894	0.0490	0.0490	0.2874
48	*Frageria nubicola*	2.8409	4.8039	4.8053	12.4502
49	*Fritillaria imperialis*	0.1894	0.0490	0.0490	0.2874
50	*Galium aparine*	0.3788	0.1961	0.1961	0.7710
51	*Galium palustre*	2.4621	1.4216	1.4220	5.3057
52	*Geranium lucidum*	0.7576	0.4412	0.4413	1.6401
53	*Geranium nepalense*	0.3788	0.1961	0.1961	0.7710
54	*Geranium pratense*	1.7045	1.2255	1.2258	4.1559
55	*Geranium wallichianum*	0.3788	0.1961	0.1961	0.7710
56	*Hedera nepalensis*	0.5682	0.2941	0.2942	1.1565
57	*Indigofera heterantha*	0.3788	0.1961	0.1961	0.7710
58	*Iris hookeriana*	0.1894	0.1471	0.1471	0.4836
59	*Jatropha curcas*	2.8409	2.1569	2.1575	7.1553
60	*Lychinus cronaris*	0.1894	0.0490	0.0490	0.2874
61	*Malva neglecta*	0.3788	0.0980	0.0981	0.5749
62	*Malva sylvestris*	0.7576	0.3431	0.3432	1.4440
63	*Marrubium vulgare*	0.1894	0.9804	0.9807	2.1505
64	*Medicago polymorpha*	0.3788	0.2451	0.2452	0.8691
65	*Origanum vulgare*	1.3258	0.5882	0.5884	2.5024
66	*Orisopsisrecimose*	0.1894	0.3922	0.3923	0.9738
67	*Oxelis corniculete*	0.1894	0.0980	0.0981	0.3855
68	*Papvhepalan nadee*	0.1894	0.0490	0.0490	0.2874
69	*Parthenium hysterophorus*	0.3788	0.2451	0.2452	0.8691
70	*Phytolacca acinosa*	0.7576	0.6373	0.6374	2.0323
71	*Plantiago lanceoleata*	1.1364	0.8824	0.8826	2.9013
72	*Podophyllum hexandrum*	0.5682	0.1471	0.1471	0.8623
73	*Polygonum amplexicaule*	0.5682	0.4902	0.4903	1.5487
74	*Polygonum hydropiper*	2.6515	2.5000	2.5007	7.6522
75	*Prunella vulgare*	0.7576	0.3431	0.3432	1.4440
76	*Rabdosia rugosa*	0.9470	0.2941	0.2942	1.5353

77	*Rheum webbianum*	1.5152	1.4706	1.4710	4.4568
78	*Roripa sylvestris*	3.7879	2.0098	2.0104	7.8081
79	*Rosa banksiae*	0.1894	0.0490	0.0490	0.2874
80	*Rubia cardifolia*	0.1894	0.0980	0.0981	0.3855
81	*Rubus idaeus*	0.3788	0.7843	0.7845	1.9476
82	*Rumex patienta*	6.0606	3.3824	3.3833	12.8263
83	*Salvia moorcroftiana*	0.5682	0.1471	0.1471	0.8623
84	*Sambucus ebulus*	0.5682	0.2941	0.2942	1.1565
85	*Sambucus wightiana*	0.5682	0.2941	0.2942	1.1565
86	*Saussurea costus*	0.1894	0.0490	0.0490	0.2874
87	*Senecio vulgaris*	0.1894	0.1471	0.1471	0.4836
88	*Setaria viridis*	0.3788	2.1078	2.1085	4.5951
89	*Silphium terebinthinaceum*	0.1894	0.0980	0.0981	0.3855
90	*Spartium junceum*	0.7576	0.4902	0.4903	1.7381
91	*Stellaria media*	0.1894	0.0980	0.0981	0.3855
92	*Stipa sibirica*	0.5682	1.1275	1.1278	2.8234
93	*Taraxacum officinale*	0.7576	0.9314	0.9316	2.6206
94	*Themeda anathera*	0.3788	0.4412	0.4413	1.2613
95	*Thymus linearis*	7.7652	8.1373	8.1396	24.0420
96	*Trichopus zeylanicus*	3.2197	1.3725	1.3730	5.9652
97	*Trifolium pratense*	1.8939	6.8627	6.8648	15.6214
98	*Trifolium repens*	0.9470	4.9020	4.9034	10.7523
99	*Utrica diocia*	2.2727	2.1569	2.1575	6.5871

Fig. 6. Diversity Indices for Trees, shrubs and grasses along the Hangul corridor area in Sindh Forest Division

Index	Grass	Shrub	Trees
Taxa_S	99	10	24
Dominance_D	0.04071	0.1857	0.1575
Simpson_1-D	0.9593	0.8143	0.8425
Shannon_H	3.693	1.945	2.343
Evenness_e^H/S	0.4058	0.6996	0.4338
Brillouin	3.601	1.857	2.255
Menhinick	2.192	0.6773	1.059
Margalef	12.86	1.671	3.685
Equitability_J	0.8037	0.8449	0.7372
Fisher_alpha	21.75	2.163	5.217
Berger-Parker	0.08873	0.2982	0.2646
Chao-1	107.7	10	24.5

Ground cover (percent) showed significant difference between the seasons and habitats with grasses contributing largely in the ground cover.



Relative abundance of wild faunal diversity along the identified Hangul corridor assessed on the basis of sign encounter rates showed higher abundance for Red fox, Jackal and Asiatic black bear in the corridor area (Table 7).

Table 7. Relative abundance of different wild mammals recorded along the Hangul corridor area in the Sindh Forest Division

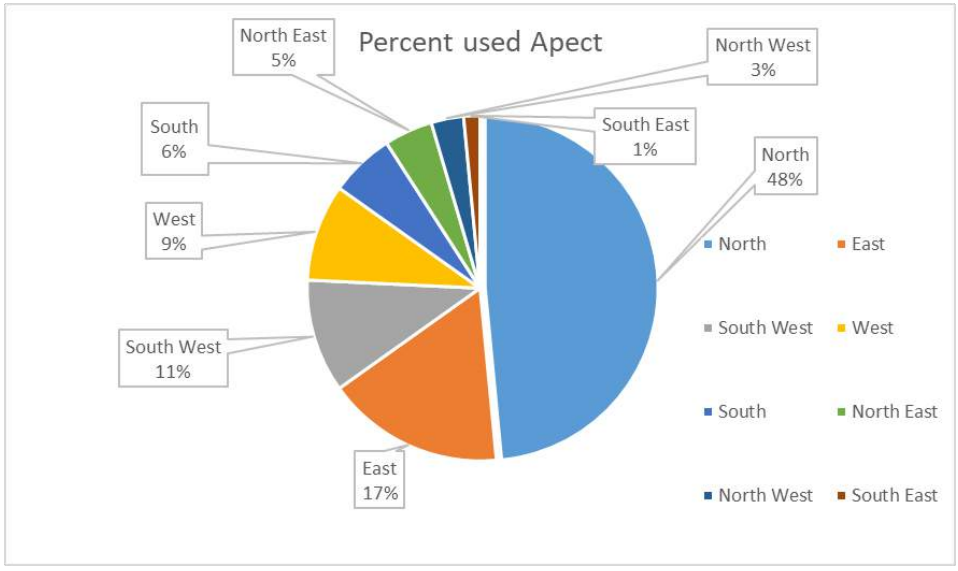
Species	Relative Abundance
Himalayan black bear	15.125
Leopard	5.25
Hangul	9.375
Jungle cat	13.8
Red fox	26.4
Musk deer	6.25
Jackal	23.75

The Relative abundance of domestic animals estimated from encounter rate of domestic animals and their indirect evidences showed highest abundance of Goat and sheep with fairly low cattle abundance (Table 8).

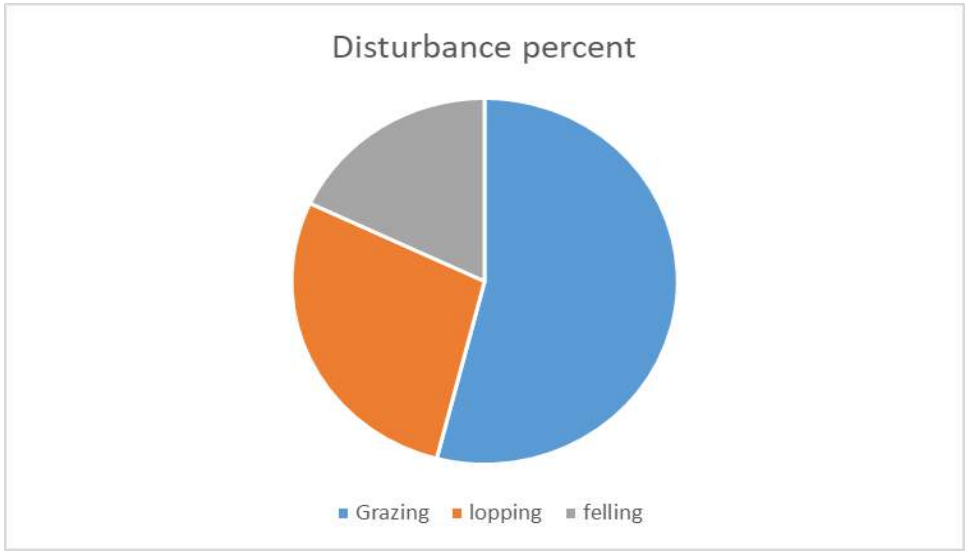
Table 8. Relative abundance of different wild mammals recorded along the Hangul corridor area in the Sindh Forest Division

Domestic Animals	Relative abundance
Goat	56.769
Sheep	37.231
Cow/buffalo	3.692
Horse	1.769
Dog	0.538

Most (48%) of the animal sightings along the identified Hangul corridor area in Sindh Forest Division were recorded in the north facing aspects



The Livestock grazing turned out to be the major disturbance and potential threat to Hangul in the corridor area.



Predation by Meso-Carnivores

Feeding ecology is a critical aspect of predator ecology and has important implications when formulating species and ecosystem management strategies. In order to ascertain the important ecological issues of predation pressure of meso carnivores particularly Red fox Vulpes vulpes and Golden Jackal Canis aureus on Hangul population, the observational study was conducted from 2019 to 2020, with an aim to enhance and update the information on the population status, seasonal habitat use and food and feeding habits of meso carnivores for better management and conservation of Hangul in Dachigam National Park. Data was recorded on the direct sightings and indirect evidences during regular intensive surveys along eight trails/transects laid down in four habitat types in an intensive study area during autumn and winter. During the study period, 90 trail or transect monitoring were carried out in eight transects of Dachigam National Park.

Fecal samples of common leopard and other meso-carnivores would also be collected for their further laboratory analysis for studying the aspect of predation pressure by Common leopard and meso-carnivores (Jackal and Fox) that affect Hangul distribution and movement patterns as part of the project objectives.

The study revealed that the diet of Golden jackal in autumn comprised mainly of plant matter (grass) (contributing 57.89%) and rodents (contributing 52.63%). However, during winter, rodents contributed the maximum (81.81%) followed by birds (63.63%) and grass (54.54%). Among ungulates, sheep occurred at high frequency (18.18%) followed by Hangul (9.09%). In case of Red Fox, during autumn, plant material particularly, grass (45.16), seeds (41.93%) and leaves (35.48%) occurred at high frequency while among animals, birds (32.25%) had the highest frequency of occurrence followed by rodents (29.03%). The percentage composition of Hangul in the diet of Red fox was 6.45%. During winter, rodents (75%) had the highest frequency of occurrence followed by birds (54.16%) and grass (45.83%) and Hangul constituted 4.16% in its diet.

The results of this study showed that the preferences of food types of both Golden jackal and Red fox did not differ substantially and are highly adaptable species. They have the ability to survive under various conditions and to live in various habitats. This indicates an unlimited and available food resource for both canids.

The study as such revealed a significant contribution of Hangul in the diet of Red fox and Golden jackal which need to be investigated further on long term basis to better understand the predation pressure on Hangul in Dachigam National Park.

CONCLUSIONS & RECOMMENDATIONS

The capture and collaring of the Kashmir red deer or Hangul for the first time under this study has been a milestone achievement in the field of satellite telemetry. The present study has been instrumental in providing some information on the lesser aspects of ecology and biology of the critically endangered Kashmir red deer or Hangul particularly on Hangul movement ecology, corridor identification and assessment, behavior and genetics which has resulted in some meaningful conclusions and effective management recommendations for the long term survival and conservation of single global population of Hangul and its habitats in the landscape.

The study revealed that major and viable population of Hangul are confined to Dachigam National Park. Despite availability of ideal summer habitats for the Hangul in upper Dachigam, these alpine meadow habitats are not being explored or used by Hangul. The satellite collared Hangul movements indicated that the animals showed upward movements to Dagwan alpine meadows of upper Dachigam but restricted their movements further in to the alpine meadows, possibly due to heavy disturbances of excessive livestock grazing there.

This satellite telemetry study has resulted in understanding the lesser known aspects of seasonal Hangul home ranges, movement patterns and migration, habitat use, foraging sites, animal behaviour and activity patterns and in identifying and validating the important stop-over sites of migration, movement corridors and barriers to migration of Hangul outside Dachigam NP towards Hangul relic areas of Wangath-Naranag CR in the north and Tral and Shikargah CR in the south. It is strongly recommended that urgent measures and management interventions need to be taken immediately towards expansion of Range of Hangul to alpine meadows of Upper Dachigam and potential corridor areas outside Dachigam NP identified through this research, so that these ideal summer habitats are recuperated and used by Hangul in summer as it used to in the past and to ensure gene flow between the Dachigam and adjoining range populations.

The identified Hangul corridors in the Dara-Sharisbal CR and Sindh Forest Division particularly areas in and around Yachihama which has been identified as an important stop-over site of migration be delineated and brought into PA network as part of the Greater Dachigam landscape so as to ensure effective protection and surveillance and immediate effective corridor management interventions for the long term survival of the species and its corridor habitats in the landscape.

The continued monitoring, satellite collaring of more number of Hangul individuals and surveys for collecting further baseline information on the habitat conditions and biotic interference in the identified corridor areas is imperative for Habitat evaluation to establish corridor connectively to mitigate habitat fragmentation issues and enabling re-establishment of these areas as ecologically viable corridors for Hangul movement and reintroduction and to maintain required genetic heterozygosity for population viability. Hangul conservation breeding-cum- reintroduction for species recovery programme is imperative to expand the range of Hangul by restocking and augmenting the small isolated Hangul

populations in its relic range areas outside Dachigam National Park starting with the Shikargah CR and Overa Wildlife Sanctuary which has ideal disturbance free habitats available.

As indicated by earlier studies by the Investigator (s) this study has further revealed and validated that besides poaching and continued degradation of Hangul summer habitats in Upper Dachigam, along with biotic interference in winter habitats, low breeding, female biased sex ratio, the problem of survival of the young and inadequate recruitment of calf to adulthood due to factors such as considerable predation by common Leopard, dogs and meso-carnivores (Fox and Jackal) are major challenges for the long term survival of the Hangul in the landscape. These ecological issues threatening the long term survival of Hangul need to be investigated and addressed further on long term basis through initiating a breeding biology study to better understand the causes of low breeding and fawn/calf survival in the Hangul population in Dachigam National Park and the adjoining landscape.

This research study and the earlier studies by the Investigator (s) has indicated that species due to its small population size, restricted range distribution, critically endangered status, ecological threats and potentially low genetic variation is at the brink of extinction and needs immediate management interventions to reverse the declining trend in the population. The regulated intensive monitoring of the Hangul populations on a long term scientific basis using latest techniques of satellite collaring, camera trapping and population genomics and reproductive ecology studies to better understand factors affecting the population growth and biology and responsible for low male/female adult sex and fawn/female are necessary to perpetuate the effective population recovery and long term conservation and survival of Kashmir red deer.

Strengthening Hangul genome sequencing to understand the DNA mitochondrial based phylogeography of the species and Skull based genetic investigations to link the mitochondrial DNA analysis findings with the nuclear genetic analysis to further establish the degree of closeness or divergence between Hangul and the Bacterian deer.

Given the small population size, potentially low genetic variation and no availability of information of Hangul genome, the initiation of the Hangul genomic study is recommended to generate the genome level information viz. variations, comparative genomics, species-specific nuclear markers for the species and understand further the species/population level genomic variations, local adaptations, demography and evolutionary trajectories.

Diseases are emerging as an important threat to the Hangul population. Although Bovine Tuberculosis (bTB), John's disease, lung worm infection, infection of *Dictyocaulus spp.* being reported in the Hangul population, parasitic infections seem to be potentially posing risk to the Hangul deer in Dachigam NP especially during summer and winter, when the animal shares resources with livestock and infections are more prevalent. Livestock grazing in upper Dachigam may prove harmful to Hangul in the long run. Efforts towards upper Dachigam grazing free, minimize interactions with livestock, and initiate disease surveillance, devising of effective health monitoring protocol for health monitoring in livestock and the Hangul population is recommended. The Hangul population requires close monitoring for health, infirmity and disease besides reactive efforts in preventing and controlling diseases.

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ANNEXURE 1: PLAN OF OPERATION: HANGUL CAPTURE AND COLLARING (MARCH 13–20, 2020)

With reference to the permission of Chief Wildlife Warden letter No **WLP/Res/2018/142-44 dated 04.06.2018** a meeting was held in the office of the Regional Wildlife Warden Kashmir on 12th March 2020 to discuss the plan for capture of Hangul at Dachigam National Park for collaring and Conservation Breeding Programme of Hangul under the MOEF & CC Govt. of India funded research project titled "Long term Conservation of Hangul: Hangul Movement Patterns study using GPS-Satellite Telemetry" and CAMPA Jammu & Kashmir Government Project titled "Hangul Conservation Breeding and Reintroduction".

Following points were discussed at length

1. Briefing about the activities undertaken in the project was given by Dr. Khursheed Ahmad Project Principal Investigator informing that the research team along with the frontline staff of the Park has been monitoring Hangul activity and also reported effective use of the Oak patch at different time periods of the day. Dr. Khursheed Ahmad also submitted a letter of request to the Regional Wildlife Warden, Kashmir for extension of above permission dated 04-06.2028 accorded by Chief Wildlife Warden for one more year along with the permission for capture of 04 Hangul individuals for the above purpose. In this regard the Regional Wildlife Warden, Kashmir Shri Rashid Y. Naqash assured full support and cooperation by the Park officials for successful Hangul capture exercise and duly recommended to the Chief Wildlife vide endorsement No. RWLW/K/Tech/2019-20/2204-06 dated 12.03.2020 for extension of permission for one more year along with the permission for capture of 04 Hangul individuals for the purpose.
2. Subsequently Dr. Parag Nigam reached Srinagar on 13.03.2020 afternoon for providing technical assistance in the said Hangul capture operation. A meeting was held with the Regional Wildlife Warden, Kashmir at SKUAST-Kashmir Shalimar in the evening on 13.03.2020 and it was decided to make a field visit to the capture sites in Dachigam National Park to take stock of the preparations in the field. During the site inspection it was decided that minor alterations would be required to facilitate closer animal approach for darting which include.
    i. Minor Repair of existing hides No. 1 and 02 at the capture site.
    ii. Supplementation of salt and luring vegetables.
    iii. Setting up of the camera traps at the site to monitoring area use and animal activity.
    iv. Necessary instructions to all concerned for restricting the movements in the area.
    v. Provisioning of around 8-10 frontline staff/personnel for assistance during Hangul capture operation.
    vi. Necessary preparations for logistic support (animal retrieval/animal loading, offloading/animal weighting/monitoring).

Further to discussions with the Regional Wildlife Warden, Kashmir and Wildlife Warden, Central Division, Dr. Khurhseed and Dr. Parag Nigam assured to provide the revised protocol that would form basis for field operation and the final details/mock drills would be done in consultation with the Wildlife Warden, Central Division, Shri Altaf Husain at Dachigam on 14th March 2020.

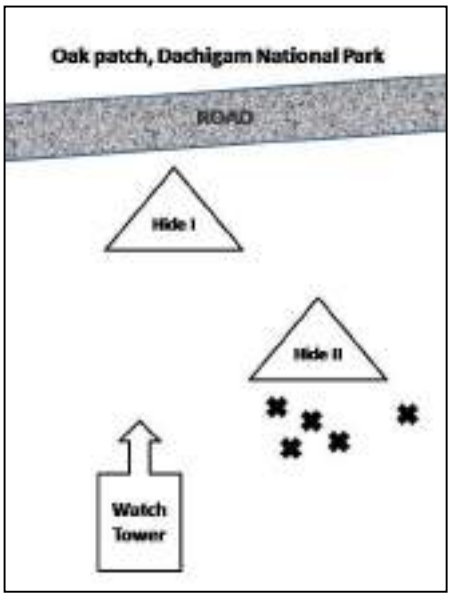
-sd	*-sd*	*-sd*	*-sd*
Sh. Altaf Hussain	**Dr Khursheed Ahmad**	**Dr Parag Nigam**	**Rashid Y. Naqash**
Wildlife Warden	Scientist & Head DWS	Scientist F, WII	Regional Wildlife Warden
Central Division	SKUAST-K, Project PI	Co-PI	Kashmir Region, Sgr.

ANNEXURE II: PLAN OF HANGUL CAPTURE FOR COLLARING AND CONSERVATION BREEDING (MARCH 2020)

{Under the MOEF & CC Govt. of India funded research project titled "Long term Conservation of Hangul: Hangul Movement Patterns study using GPS-Satellite Telemetry" & CAMPA Jammu & Kashmir Government Project titled "Hangul Conservation Breeding and Reintroduction"]

With reference to the meetings held at the office of the Regional Wildlife Warden dated 12th March 2020; at SKUAST-Kashmir dated 13th March 2020 and subsequent discussions during field visit to Dachigam National Park on 13th March 2020 and permission of the Hangul capture and collaring permission accorded by the Chief Wildlife Warden, J & K Government vide No. WLP/F-101/Res/2018-20/424-27 dated 14/03/2020 a plan for capture of Hangul for collaring and conservation breeding purpose has been prepared. The Hangul capture during 2018 and information on capture and collaring of variety of *Cervids* carried out elsewhere have formed the basis of this plan.

The plan would require addressing following major components.



1. **Location:** Habituation and capture of Hangul has to be attempted at the Oak patch of Dachigam National Park as the area has been effectively used by Hangul in the near past (Based on information from Project Researcher and departmental field staff).
2. **Animal habituation for approach for individual darting:** Habituation for capture of Hangul would be attempted at the Oak patch of Dachigam National Park. The area uses and time budgeting data over the last one year as carried out by the project team would form basis for deciding further course of action. The luring exercise would be continued for the entire duration of the exercise.
3. **Animal Selection:** Adult animals of either sex in good condition would be selected for the capture. Care would be taken to exclude out pregnant/lactating/weak animals. Apparently, health young adults/adult in good body condition of either sex would be selected.
4. **Ground preparations :** Detailed information of the area (Oak patch) w.r.t. the quality of the under-storey, vegetation thickness/density, and signs of animal trails, water channels and animal exit routes would be gathered. There is a possibility of animal going in any direction following darting and tracking the animal (for locating) would become crucial for the success of the operation. The tracking team (A**nimal tracking team I)** would comprise of 08-10 individuals who would be responsible for locating the animal. The animal search would start following completion of induction time or as per the instructions. To restrict the animal to move on the other side of Dachigam Nullah, 1-2 vehicles and 6-8 forest staff (**Animal tracking team II)** would be positioned along the road behind the Oak patch. Care would be taken to not disturb

the animal at any time. The animal tracking team II would communicate the animal movement to all concerned.

5. **Animal Darting:** Animal darting would be facilitated by air pressurized Dan-Inject long range projector. A combination of sedative and dissociative (Xylazine-Ketamine or Medetomidine-Ketamine) in appropriate doses would be used. Provision for emergency drugs would be made to manage any eventuality that may arise and would include respiratory and cardiac stimulants, NSAIDs, antihistaminics, hemostyptics etc.
6. **Animal approach Post Darting:** Intensive efforts would be made to locate the animal following darting and the search would be started following completion of drug induction/ further to instructions of the Veterinary team. The animal once located would be checked for sedation levels and if required necessary supplementation would be done. The animal would be blindfolded and further procedures initiated. In case animal if found in unsuitable area, the members of the Animal tracking team I would shift the animal onto a Stretcher and move to open area for further procedures.
7. **Field Procedures:**
    a. **Animal stabilization and positioning:** animal would be positioned on sternal recumbency and the physiological parameters would be assessed. Once the animal stablilized further procedures would be carried out. Physiological parameters of the immobilized animal would be monitored during the capture operation and data recorded as per the format.
    b. **Collaring:** Animal would be collared with the GPS-Satellite collar to address the objectives of the project. The collar would be tested prior to deployment and necessary logistics for collaring would be ensured.
    c. **Body measurements and weighting:** Specific body lengths as per the format would be recorded. Attempts would be made to weight the animal as it would provide much needed baseline information about the species and for developing future protocols.
    d. **Biological Sampling:** Biological sampling for health, disease and genetic studies has to be carried out and samples may be analyzed at SKUAST-Kashmir and WII laboratories.
    e. **Drug reversal:** Reversal drugs (Atipamezole/Yohimbine in appropriate doses) would be administered to the animal and efforts would be made to subject animal to minimal disturbance to avoid aggressive recovery.

Specific responsibilities:

a. Darting and support team (3 identified individuals).
b. **Animal Tracking/Search team I**
(8-10 frontline staff along with the project researchers having knowledge of area).
c. **Animal Tracking/Search team II**/ Animal Movement restriction team (6-8 frontline staff with 1-2 vehicles).
d. Animal monitoring and data recording (3 identified individuals).
e. Post release monitoring (Project Research Team).

Animal Handling and transportation for Conservation Breeding Program:

Once the animal is stabilized and deemed fit for transportation, it would be administered tranquilizers. Tranquilizers would be used to avoid/minimize stress during transport and subsequent release. The stretcher would be used for lifting of animal and loading on to transport vehicle. Adequately modified transport vehicle preferably (TATA 407) needs to be in place beforehand. The vehicle needs to be appropriately modified to ensure animal safety during transport, provide adequate ventilation, proper flooring and drop door for proper release at the release site. The vehicle would be subjected to dry run and *recce* of the shortest route before the actual run. Speed of vehicle should be adjusted to avoid sudden jerk/discomfort to the animal. Constant monitoring of the animal during transit would be ensured and appropriately handled. Additional fuel and stepney should be available. Escort for the transport vehicle should be made available to clear traffic and pave way for smooth uninterrupted journey. The transport of animal should be made soon after capture without any holding time.
Miscellaneous: a) Ropes, axe, *darati*, hexa blade, spray pump etc. b) emergency drug and medicaments.

Specific responsibilities:

- Loading team (4-6 frontline staff).
- Animal monitoring and data recording team (Veterinarian and project researcher).
- Transport team (2 forest staff providing assistance during animal transport).
- Off-loading team (4 frontline staff). Ensure off-loading ramp.
- Post release monitoring (Local field officer and project researcher).

Preparation at release site:

The release site would necessarily require offloading ramp keeping vehicular dimensions into consideration. Besides, the enclosure would have to be provided with visual barriers. The entire fences would be checked for integrity and that no sharp wires are protruding inside the enclosure. Other essentials include ensuring predator proofing of fence, provisioning of forage through minimal human interference, dedicated manpower including full time veterinarian and biologist and emergency plan to meet any exigencies.
Every field operation comes with a component of risk that may at times result in fatal situation/ situation of losing the animal. This is an inherent risk, however, every effort would be made to ensure that the procedures are carried out in the professional scientific and humane manner to the best of knowledge and capacity of the team. Any emergencies/problems encountered during field operations would be handled in a humane, professional, scientific and ethical manner.

-sd
Dr Khursheed Ahmad
Scientist & Head DWS
Project PI

-sd
Dr Parag Nigam
Scientist F, WII
& Co-PI

ANNEXURE III: PLAN OF CAPTURE AND COLLARING OF HANGUL (MAY 2018)

[Component of the MOEF & CC Govt. of India funded research project entitled "Long term Conservation of Hangul: Hangul Movement Patterns study using GPS-Satellite Telemetry"]

Further to the meeting held at office of the Regional Wildlife Warden…. on 3rd of May 2018 and subsequent to the discussion with all concerned, a plan for capture and collaring of Hangul has been prepared. The previous hangul capture during 2013 and information on capture and collaring of variety of Cervids carried out elsewhere have formed the basis of this protocol. The plan for capture and collaring would require addressing following major components.

1. **Animal Habituation for approach for individual darting.**

Habituation and capture of Hangul would be attempted at the Oak patch of Dachigam National Park as the efforts of luring the animal has been successful (the area use and time budgeting data over the last one year as carried out by the project team clearly shows effective use with 3-4 specific time frame of increased animal use). The luring exercise would be continued for the entire duration of the exercise.

2. **Animal Selection**

Adult animals of either sex in good condition would be selected for the capture initially. Care would be taken to exclude out pregnant/lactating/week or poor body conditioned animals.

3. **Animal Tracking**

The entire area (Oak patch) would be tracked to assess the under-storey quality and vegetation thickness/density, signs of animal trails, water channels and animal exit routes. There is a possibility of animal going in any direction following darting and tracking THE animal (for locating) it would become crucial for the success of the operation. The tracking team (A**nimal tracking team I)** would comprise of 10-15 individuals who would be responsible for locating the animal. The animal search would start following completion of induction time or as per the instructions. To restrict the animal to move on the other side of Dachigam Nullah, 3-4 vehicles and 6-8 forest staff (**Animal tracking team II)** would be positioned along the road behind the Oak patch. Care would be taken to not disturb the animal at any time. The animal tracking team II would communicate the animal movement to all concerned.

4. **Animal Darting**

Animal darting would be facilitated by air pressurized Dan-Inject long range projector. A combination of sedative and dissociative (Xylazine-Ketamine or Medetomidine-Ketamine) in appropriate doses would be used. Provision for emergency drugs would be made to manage any eventuality that may arise and would include respiratory and cardiac stimulants, NSAIDs, anti-histaminics, hemostyptics etc.

5. **Animal approach Post Darting:**

Intensive efforts would be made to locate the animal following darting and the search would be started following completion of drug induction/ further to instructions of the Veterinary team. The animal once located would be checked for sedation levels and if required necessary supplementation would be done. The animal would be blindfolded and further procedures initiated. In case animal if found in unsuitable area, the members of the Animal trachimg team I would shift the animal onto a Stretcher and move to open area for further procedures.

6. **Field Procedures:**
    a. **Animal stabilization and positioning:** animal would be positioned on sternal recumbency and the physiological parameters would be assessed. Once the animal

stablilized further procedures would be carried out. Physiological parameters of the immobilized animal would be monitored during the capture operation and data recorded as per the format.

b. **Collaring:** Animal would be collared with the GPS-Satellite collar to address the objectives of the project. The collar would be tested prior to deployment and necessary logistics for collaring would be ensured.
c. **Body measurements and weighting:** Specific body lengths as per the format would be recorded. Attempts would be made to weight the animal as it would provide much needed baseline information about the species and for developing future protocols.
d. **Biological Sampling:** Biological sampling for health, disease and genetic studies has to be carried out and samples may be analyzed at SKUAST-Kashmir and WII laboratories.
e. **Drug reversal:** Reversal drugs (Atipamezole/Yohimbine in appropriate doses) would be administered to the animal and efforts would be made to subject animal to minimal disturbance to avoid aggressive recovery.

Specific responsibilities:

a. Darting and support team (3 identified individuals).
b. **Animal Tracking/Search team I:** (10-15 frontline staff along with the project researchers having knowledge of area).
c. **Animal Tracking/Search team II**/ Animal Movement restriction team (6-8 frontline staff with 3-4 vehicles).
d. Animal monitoring and data recording (3 identified individuals).
e. Post release monitoring (Project Research Team).

Every field operation comes with a component of risk that may at times result in fatal situation/ situation of losing the animal. Limited information and field experience is presently available about the species with only one successful record of collaring Hangul in 2013.

Every effort would be made to ensure that the procedures are carried out in the professional scientific and humane manner to the best of knowledge and capacity of the team. Any emergencies/problems encountered during field operations would be appropriately addressed for which necessary preparedness would be ensured.

-sd
Dr Khursheed Ahmad
Scientist & Head DWS
Project PI

-sd
Dr Parag Nigam
Scientist F, WII
& Co-PI

The coordinated efforts put in by the Officials and frontline staff of the Department of Wildlife Protection, Govt. of Jammu and Kashmir, WII, SKUAST-K and local staff were extremely important for the entire operation and without a synchronized team work such an operation would not have been possible. It is not possible to acknowledge all the workers individually but their contributions are gratefully acknowledged.

ANNEXURE IV: FIELD INSPECTION REPORT: HANGUL CONSERVATION BREEDING CENTRE, SHIKARGAH, 15TH MARCH 2020

FIELD INSPECTION REPORT:HANGUL CONSERVATION BREEDING CENTRE, SHIKARGAH

15th March 2020

Submitted by

Dr Parag Nigam, Scientist F, Wildlife Institute of India, Dehradun
Dr Khursheed Ahmad, Scientist & Head, Division of Wildlife Sciences, SKUAST-Kashmir
Dr. Umar Nazir Zahid, Veterinary Assistant Surgeon, Dept. of Wildlife Protection

FIELD INSPECTION REPORT: HANGUL CONSERVATION BREEDING CENTRE, SHIKARGAH, 15th March 2020

Further to grant of permission for Hangul capture for collaring/ conservation breeding by the Chief Wildlife Warden, J&K Govt vide letter no. WLP/F-101/Res/2019-20/424-27 dated 14th March 2020 (Annexure I) and order issued by the Regional Wildlife Warden, Kashmir region vide letter no. RWLW/K/Estt./1920/2016-22 dated 14th March 2020 (Annexure II), a field visit to the Hangul Conservation Breeding Centre (CBC), Shikargah was undertaken on 15th March 2020 by a team comprising of following:

1. Dr. Parag Nigam Scientist F, WII
2. Dr. Khursheed Ahmad, Scientist & Head, Division of Wildlife Sciences, SKUAST-Kashmir
3. Dr. Umar Nazir Zahid, Veterinary Assistant Surgeon, Department of Wildlife Protection
4. Mr. Khursheed Iqbal, Range Forest Officer, Tral

The team reached the CBC in the forenoon and carried out assessment of the existing facility and infrastructure at the CBC, Shikargah. The objective of the visit was to assess the preparedness of CBC for receiving the Hangul from Dachigam NP. The animals would form the founder stock for conservation breeding at the CBC. The detailed account of the inspection carried out is provided for further consideration by the Dept. of Wildlife Protection.

Area of enclosures:

The CBC is spread over 5.5 ht (Enclosure I) that has a quarantine enclosure (Enclosure II) and a isolation facility (Enclosure III).

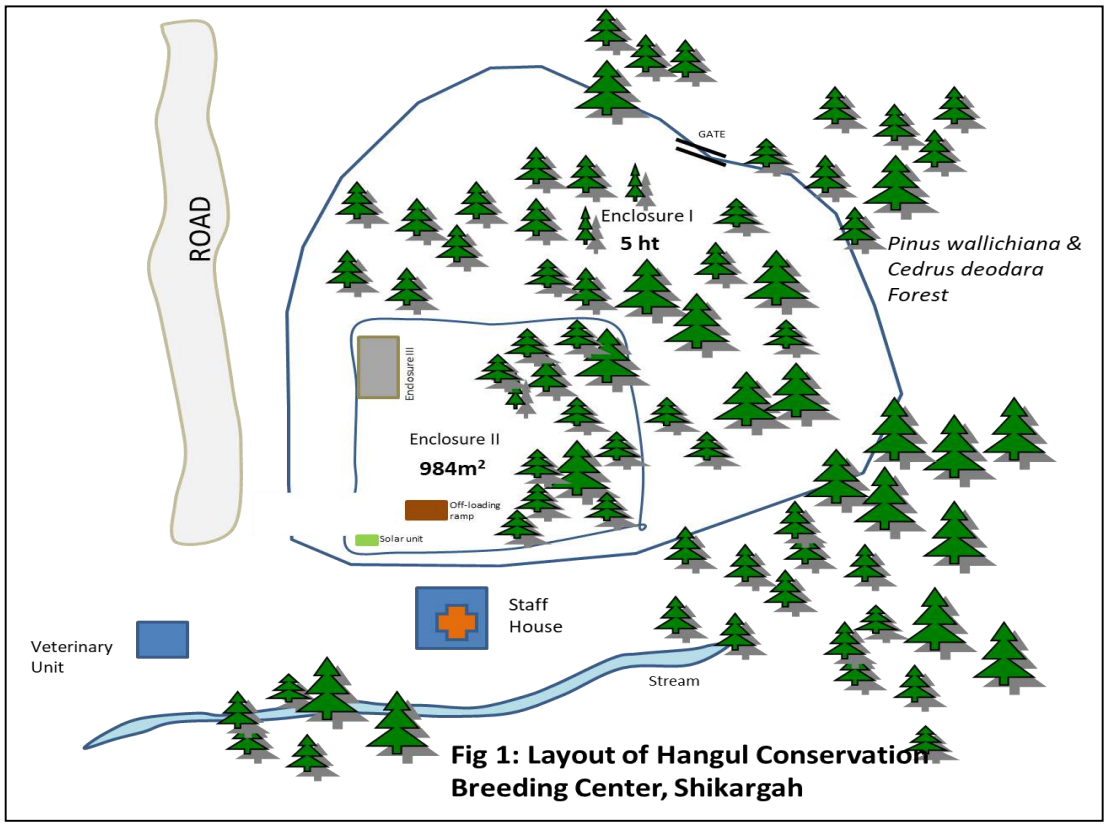


Fig 1: Layout of Hangul Conservation Breeding Center, Shikargah

The Enclosure II has been identified for housing the hangul (founder stock) form conservation breeding. The enclosure is rectangular with an area of 984 m2. The vegetation inside the enclosure includes mainly *Pinus wallichiana* and *Parratiopsis jacquimonsiane* that covers half of the enclosure. The other half of the enclosure is barren that also has a small isolation unit (Enclosure III) on one of the sides. The effective area available for use by housed animals in the enclosure II is around 500m2.

It would be appropriate to consider expansion of the area to meet the minimal requirement for housing Hangul as recommended by the Central Zoo authority. The CZA recommends minimum area of around 1500 m2 for a breeding pair of Hangul against an available area. The enclosure II can be expanded by opening the fencing from one side; increasing the area and simultaneously maintaining the integrity of the habitat. This would provide adequate area for Hangul to utilize, provide hiding spaces for initial acclimatization and expose animal to minimal stress from human presence (likely to happen in the present situation with rest house/ staff quarter being adjacent to the enclosure).

The enclosure III is an isolation unit within the enclosure I and has been made with the objective of keeping animal requiring intensive care. It would be appropriate if the structure could be shifted elsewhere preferably outside the enclosure II.

Fences and Structures

The entire facility is fenced with chain link and modified suitably to make it predator proof. Efforts have been made to energize the fence also. During inspection, it was given to understand that due to recent downpour and civil work in progress, the fence is not functional however; the same would be made functional following completion of works.

Civil work of placing iron sheets on the fence to further make it predator proof is being undertaken. The idea is to provide slippery surfaces so that the predator does not get hold to climb. Though the effort is good, the iron sheets are quite heavy to be mounted and can result in the fence falling off in case of heavy wind or weight. The strength of the fence needs to be assessed by structural engineer and if possible, replaced with alternatives (Lightweight sheets). Leopard activity around the enclosure was also reported by the staff making it essential to carry out above-mentioned activities.

The angle iron and nut bolt arrangement of chain link fence pose a major threat to the animal especially if it tries to jump/ dash in an effort to escape or negotiate the fence. Dashing onto fences can result in injuries resulting from edges of iron bars as well as protruding nuts/bolts inside the enclosure. It is important to understand that the facility is going to receive free ranging animals that would be shy, nervous, excited and at times aggressive with tendency to flee.

It would be appropriate to cover up and trim all the blunt and sharp edges. As a temporary solution, padding with grass and gunny bags and covering the entire fence with high density Agri-mesh can be helpful. This would also act as physical/ visual barrier that the animal would learn to respect with time. Alternatively, lightweight tin sheets should be fastened on chain link fencing of enclosure II making sure that the surface is smooth and no nut/ bolts are protruding.

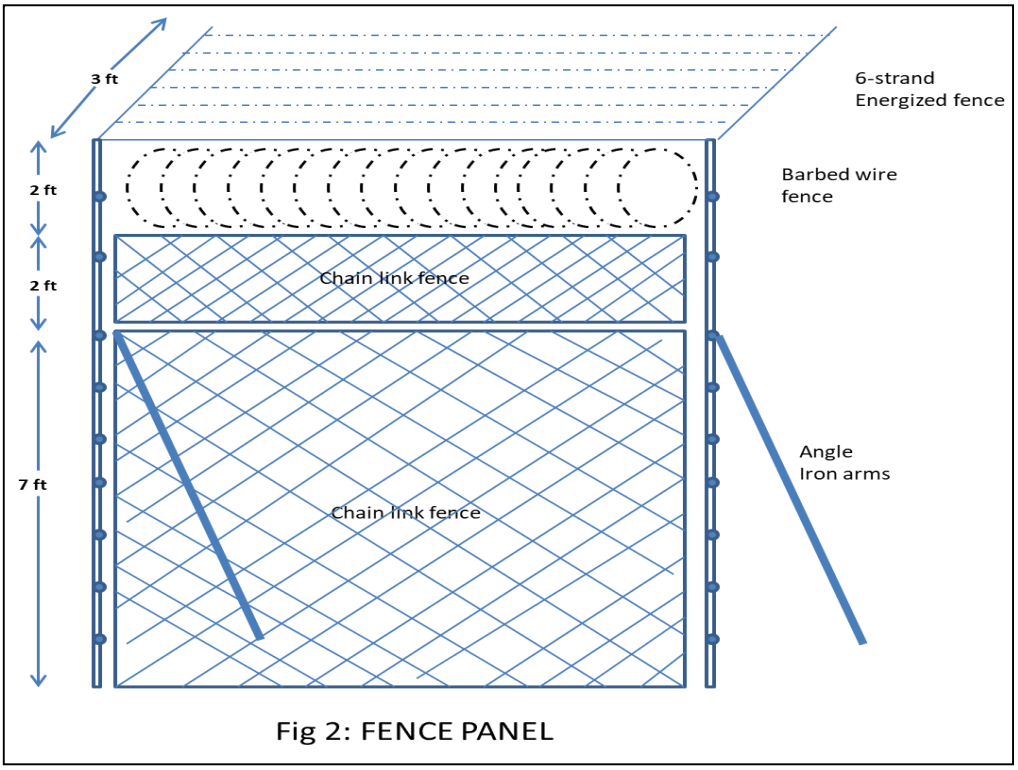


Fig 2: FENCE PANEL

The supporting angle iron bars used for reinforcement of chain link fencing are placed inside the enclosure II. This may pose a problem by hindering animal movement and also act as obstacle as animal tries to run around the boundary or in an effort to escape.

Fig 3: Fence at the Enclosure II

These need to be appropriately addressed to ensure the safety and free movement of the animal. The enclosure also needs to have snake proofing. This can be facilitated by putting small sized mesh up to a height of 1.5 mtrs. The solar panel unit installed at the entry point of the enclosure can be shifted outside the enclosure as it is non-functional and serves no purpose.

Entry points

The entry gates of both the enclosures (I & II) need to be installed and checked for smooth functioning. These have been kept on hold as the civil work is still going on. The double gate system should have sliding doors for smooth functioning. An off-loading ramp has been prepared inside the enclosure II. It would be appropriate that the path and the ramp be prepared in a manner that it suits the dimensions of the vehicle that would get the animal to the facility. Cemented foot bath can be established at the entry gates to avoid any chance of contamination gaining into the enclosure.

Meeting nutritional demands

It is important that the animals brought into the facility are provided forage that is similar to that available in natural habitat. This would avoid any digestive problem that may arise during the acclimatization phase. Though the higher reaches have suitable grasses; provisioning the same would have to be ensured in captivity. The existing enclosure has limited vegetation presently. Provisioning of water may be ensured through carving out small stream / waterhole inside the enclosure.

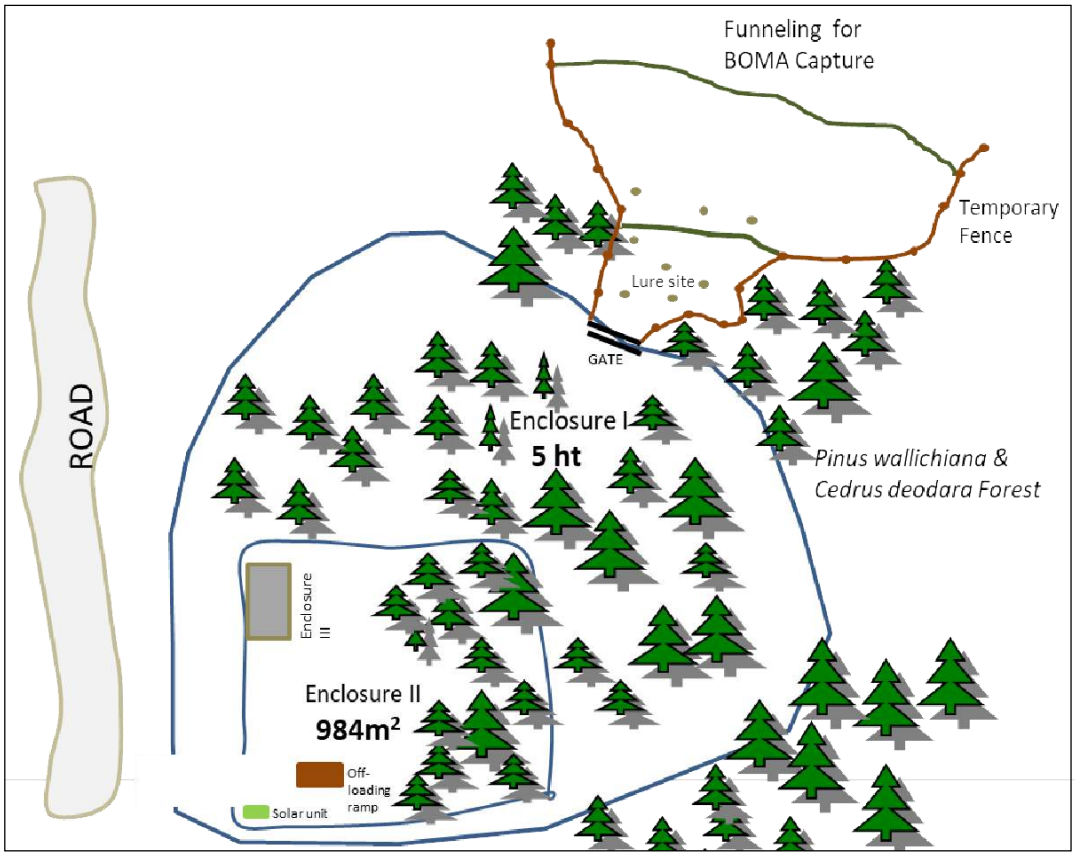


Fig 4: Layout for funnelling for BOMA Capture

Monitoring of animal post release.

It is important that the animals brought to the facility are closely monitored. This can be facilitated by constructing watch tower/ hide within the enclosure. Additionally, few trails can be developed inside the enclosure for use by animal as well as human in case of emergency. Monitoring can also be facilitated by placing cameras inside the enclosure.

Additional Point

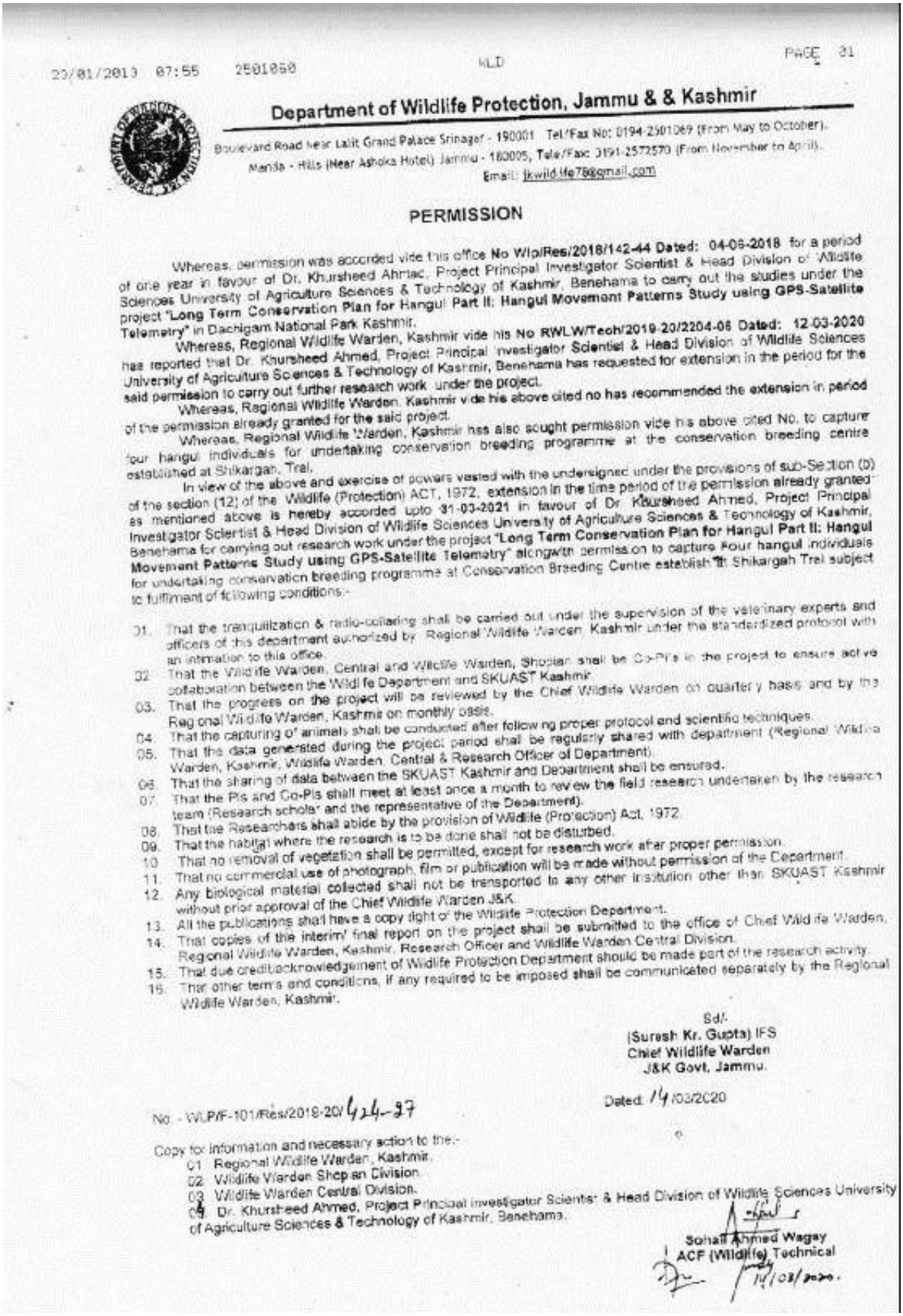
During the discussion, it was informed by the field staff that free ranging Hangul had been visiting the surrounding areas of CBC. Both direct and indirect evidences were available of use of Hangul around the enclosure. It would be worthy to try using BOMA capture technique for getting the animals inside the enclosure. The technique involves luring the animal near to the enclosure on regular basis, funnelling using temporary physical barriers and subsequently driving the animals into the enclosure. The technique has been effectively used in India for capturing Blue bulls, Chital and Swamp deer besides variety of African ungulates in the African subcontinent. Use of BOMA technique can be kept as Plan B for building population in CBC Shikargah.

Conclusion

Based on the field visit, considerable work needs to be completed at the Conservation Breeding Centre, Shikargah prior to animals being brought to the facility. Decisions for necessary modifications and alterations that are required at the centre needs to be taken so that the centre is well prepared prior to receiving the animals. It would be appropriate to have detailed discussions with all concerned. The modifications/ alterations need to be worked out taking into consideration animal's behaviour and possible unpredictable behaviour as it gets into captivity, specific needs of animal and its husbandry requirements. The civil work need to be supervised appropriately at every stage with due concern on veterinary husbandry, care and upkeep. A meeting with all concerned need to be done at the earliest for taking necessary decisions for continuing the work.

Dr. Parag Nigam	**Dr. Khursheed Ahmad**	**Dr. Umar Nazir Zahid**
Scientist F, WII	Head, Div. of Wildlife, SKUAST-K	VAS, Dept. of Wildlife Protection

ANNEXURE V:



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Department of Wildlife Protection, Jammu & & Kashmir

Boulevard Road near Lalit Grand Palace Srinagar - 190001 Tel/Fax No: 0194-2501069 (From May to October).
Manda - Hills (Near Ashoka Hotel) Jammu - 180005, Tele/Fax: 0191-2572570 (From November to April).
Email: jkwildlife78@gmail.com

PERMISSION

Whereas, permission was accorded vide this office **No Wlp/Res/2018/142-44 Dated: 04-06-2018** for a period of one year in favour of Dr. Khursheed Ahmad, Project Principal Investigator Scientist & Head Division of Wildlife Sciences University of Agriculture Sciences & Technology of Kashmir, Benehama to carry out the studies under the project **"Long Term Conservation Plan for Hangul Part II: Hangul Movement Patterns Study using GPS-Satellite Telemetry"** in Dachigam National Park Kashmir.

Whereas, Regional Wildlife Warden, Kashmir vide his **No RWLW/Tech/2019-20/2204-08 Dated: 12-03-2020** has reported that Dr. Khursheed Ahmed, Project Principal Investigator Scientist & Head Division of Wildlife Sciences University of Agriculture Sciences & Technology of Kashmir, Benehama has requested for extension in the period for the said permission to carry out further research work under the project.

Whereas, Regional Wildlife Warden, Kashmir vide his above cited no has recommended the extension in period of the permission already granted for the said project.

Whereas, Regional Wildlife Warden, Kashmir has also sought permission vide his above cited No. to capture four hangul individuals for undertaking conservation breeding programme at the conservation breeding centre established at Shikargah, Tral.

In view of the above and exercise of powers vested with the undersigned under the provisions of sub-Section (D) of the section (12) of the Wildlife (Protection) ACT, 1972, extension in the time period of the permission already granted as mentioned above is hereby accorded upto **31-03-2021** in favour of Dr Khursheed Ahmed, Project Principal Investigator Scientist & Head Division of Wildlife Sciences University of Agriculture Sciences & Technology of Kashmir, Benehama for carrying out research work under the project **"Long Term Conservation Plan for Hangul Part II: Hangul Movement Patterns Study using GPS-Satellite Telemetry"** alongwith permission to capture four hangul individuals for undertaking conservation breeding programme at Conservation Breeding Centre establish at Shikargah Tral subject to fulfilment of following conditions:-

01. That the tranquilization & radio-collaring shall be carried out under the supervision of the veterinary experts and officers of this department authorized by Regional Wildlife Warden Kashmir under the standardized protocol with an intimation to this office.
02. That the Wildlife Warden, Central and Wildlife Warden, Shopian shall be Co-PI's in the project to ensure active collaboration between the Wildlife Department and SKUAST Kashmir.
03. That the progress on the project will be reviewed by the Chief Wildlife Warden on quarterly basis and by the Regional Wildlife Warden, Kashmir on monthly basis.
04. That the capturing of animals shall be conducted after following proper protocol and scientific techniques.
05. That the data generated during the project period shall be regularly shared with department (Regional Wildlife Warden, Kashmir, Wildlife Warden, Central & Research Officer of Department).
06. That the sharing of data between the SKUAST Kashmir and Department shall be ensured.
07. That the PIs and Co-PIs shall meet at least once a month to review the field research undertaken by the research team (Research scholar and the representative of the Department).
08. That the Researchers shall abide by the provision of Wildlife (Protection) Act, 1972.
09. That the habitat where the research is to be done shall not be disturbed.
10. That no removal of vegetation shall be permitted, except for research work after proper permission.
11. That no commercial use of photograph, film or publication will be made without permission of the Department.
12. Any biological material collected shall not be transported to any other institution other than SKUAST Kashmir without prior approval of the Chief Wildlife Warden J&K.
13. All the publications shall have a copy right of the Wildlife Protection Department.
14. That copies of the interim/ final report on the project shall be submitted to the office of Chief Wildlife Warden, Regional Wildlife Warden, Kashmir, Research Officer and Wildlife Warden Central Division.
15. That due credit/acknowledgement of Wildlife Protection Department should be made part of the research activity.
16. That other terms and conditions, if any required to be imposed shall be communicated separately by the Regional Wildlife Warden, Kashmir.

Sd/-
(Suresh Kr. Gupta) IFS
Chief Wildlife Warden
J&K Govt, Jammu.

No. - WLP/F-101/Res/2018-20/ 424-27 Dated: 14/03/2020

Copy for information and necessary action to the:-
01. Regional Wildlife Warden, Kashmir.
02. Wildlife Warden Shopian Division.
03. Wildlife Warden Central Division.
04. Dr. Khursheed Ahmed, Project Principal Investigator Scientist & Head Division of Wildlife Sciences University of Agriculture Sciences & Technology of Kashmir, Benehama.

Sohail Ahmed Wagay
ACF (Wildlife) Technical
14/03/2020.

ANNEXURE VI:

Government of Jammu and Kashmir

Department of Wildlife Protection

OFFICE OF THE REGIONAL WILDLIFE WARDEN KASHMIR REGION

BOULEVARD ROAD SRINAGAR

PH. / Fax No. 0194-2502596

Email: rwlwkashmir@gmail.com

Subject: **Permission for capture of Hangul for satellite collaring and conservation breeding programme under MOEF&CC funded research study on "Hangul Movement Patterns Study using GPS – Satellite Telemetry" and CAMPA Project on "Hangul Conservation Breeding and Reintroduction".**

ORDER

In pursuance of permission granted by the Chief Wildlife Warden, J&K Govt. vide his endorsement No. WLP/F-101/Res/2019-20/424-27, Dated 14-03-2020, sanction has been accorded to the grant extension to the permission upto 31-03-2021 in favour of Dr Khursheed Ahmad, Project Principal Investigator, Scientist & Head, Division of Wildlife Sciences, SKUAST, Kashmir for carrying out the research work under the MoEF&CC project titled **"Hangul Movement Patterns Study using GPS – Satellite Telemetry" and CAMPA Project tiltled "Hangul Conservation Breeding and Reintroduction".**

In this regard, Dr. Umer Nazir, Veterinary Assistant Surgeon, Range Officer, Central Control Room alongwith his all staff of all ranks are deputed to collaborate in the project in order to build up the capacity and get trained in animal captive/ handling/ tranquilization and release techniques. The team of officials shall associate themselves fully in the project till 20-03-2020.

The boarding/ lodging and other ancillary items shall be borne by Project Principal Investigator of the project under the envisaged provisions of the project.

Wildlife Warden, Central Division is directed to completely ban any type of vehicular traffic from NIC onwards. This has to be ensured at all costs.

Sd/-
Regional Wildlife Warden
Kashmir Region

No. RWLW/K/Estt/2019-20/2016-22 Dated:- 14/03/2020

Copy to:-

1. The Chief Wildlife Warden, J&K Government, Jammu for information please. No. WLP/F-101/Res/2019-20/424-27, Dated 14-03-2020.
2. Wildlife Warden, Central/ Shopian/ Wetlands for information and necessary action. This is in continuation to this office endorsement No. RWLW/K/Tech/2019-20/2258-60, Dated:- 14-03-2020.
3. Wildlife Warden, Wetlands Division for information and necessary action.
4. Dr., Khursheed Ahmad, Project Principal Investigator, Scientist & Head, Division of Wildlife Sciences, SKUAST, Kashmir, for information and necessary action.
5. Dr. Umer Nazir, Veterinary Assistant Surgeon, Department of Wildlife Protection, Srinagar for information and compliance.
6. Order File (2019-20).

Regional Wildlife Warden
Kashmir Region

14/3 14/03

Further Contact

Dr. Khursheed Ahmad
Associate Professor-cum- Senior Scientist & Head
Division of Wildlife Sciences, Faculty of Forestry
Sher-e-Kashmir University of Agricultural Sciences &
Technology of Kashmir (SKUAST-Kashmir)
Benhama Campus,Benhama 191201,
Ganderbal Jammu & Kashmir
Tel: 00 91 194 2262312(O),
Fax: +91 (0) 194 2262207
Email: khursheed47@gmail.com

भारतीय वन्यजीव संस्थान
Wildlife Institute of India