CHAPTER 06

OBJECTIVE 03

To study seasonal variation on pheasants' diversity, abundance along habitats.

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BACKGROUND

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6.1. Background

Pheasants represent the most distinctive bird family, with large-bodied, brightly coloured, ground-dwelling birds, exhibiting greater sexual dimorphism in both size and plumage, and belonging to the taxonomic order Galliformes and family Phasianidae. They act as an important role in forest ecosystem services, as considered as bio-indicators for owing to their sensitivity to habitat degradation, indicate habitat quality of forest, vulnerability to anthropogenic pressure and climate change, and central position in the food web (Kaul, 1989; Fuller & Garson, 2000; Chhetri et al., 2018). However, climate change in the Himalayas is more pronounced than the global average (Bhutiyani et al., 2007). Whereas, the diversity and endemism in the Himalayas are under threat due to change in climatic variables and land use pattern (Jetz et al., 2007; Sekercloglu et al., 2008). The ecological implications of the changes remain opaque and un-quantified in much higher faunal taxa, including birds. Quantitatively, climate change effects are more pronounced in the birds and butterflies' populations (Peh, 2007; Parmesan et al., 1999; Root, 1988; Ashmole, 1963; Velasquen- Tibata et al., 2012; Chen et al., 2009), resulting in habitat shifts towards higher altitudinal gradients. The knowledge on these changes is important for the conservationists because that helps them to identify species which are more sensitive towards climate change by directly measuring the changes in the ecological pattern of the species. The pattern of the ecology of species and the forces behind the species range shifts over time in the different topological landscape along

the altitudinal gradient have always added further curiosity to intensive field researchers all over the world. Additionally, detecting and understanding the changes in population size and distribution patterns of the species in density, and space and time are also crucial for conservation directives to plan appropriate habitat management and conservation strategies (Bibbly et al., 2000; Martin et al., 2007). Estimation of avian abundance and density is considered as an important tool for investigating dynamism in population size and habitat association in the landscape (Norvell et al., 2003). In this regards, a variety of survey approaches has been developed to model detectability, i.e. to correct the number of animals detected in space and time (reviewed in Buckland et al., 2008). Distance sampling is a biological method used to estimate density and abundance of the species in the target area accounting detection probability. There are publications available for supporting optimizing Distance survey methods, from point to line transect (Rosenstock et al., 2002, Buckland, 2006, Buckland et al., 2008), while others have shown point counts may give more biased estimates than the line transects (Gale et al., 2009; Cassey et al., 2007). Therefore, a line transect has advantages as it increases the detection probability (Wilson et al., 2000) and also the ratio of survey to transit time is increased in line transect design (Buckland, 2006), which shows a line transect to be the most efficient and least biased method for estimating density and abundance of a species in space and time (Chhetri et al., 2017).

CHAPTER 06

OBJECTIVE 03

MATERIALS & METHODS

6.2. Materials and Methods

6.2.1. Population assessment of Himalayan Pheasant in the Khangchendzonga Biosphere Reserve

6.2.1.1. Perception-based information

The secondary information was gathered for the entire region, especially focusing on the area of KBR and surroundings, through a literature survey, and also by interacting with the inhabitants of local area particularly former hunters, Himal-Rakshaks (Protectors), forester, identified the forests and collected the historical data to find out presence or absence of the pheasants in the particular area (Jolli et al., 2011).

6.2.1.2. Field surveys

The field surveys were conducted in the two major altitudinal transects in the Khangchendzonga Biosphere Reserve viz. Yuksom-Black Kabru (Dome), and Tholung-Kisong transects (KBR, extending along 27°15’-27°57' N. lat. 88° 02’-88°40’ E long; Badola and Subba, 2012), in Sikkim Eastern Himalaya, using standardized methodology of line transect during May, 2014 and April, 2017. The Yuksom-Black Kabru transect a part of the southwest KBR in West Sikkim whereas, the Thulong-Kisong transect a part of the southeast KBR in North Sikkim were surveyed for the Himalayan Pheasants especially covering the core zone of KBR, which recently been inscribed as the World Heritage Site on 17.07.2016 by the UNESCO, based on natural and cultural aspects under mixed category. The study areas covered the altitudinal gradient around c. 1760 m-5000 m asl in the KBR.

6.2.1.3. Stratified random sampling

Samples of the Himalayan pheasants and their associated habitat compositions were measured using stratified random sampling: a) Encounter Rate b) Tape recording c) Hide build and d) Photography. GIS (Geographic Information Systems) technologies were used for spatial analysis and also to generate distribution maps and to estimate abundance, density, and encounter rate for these Pheasants.

A. Dawn and Dusk Encounter Rate or Detection rate of pheasants: were calculated by summing up the total number of individuals counted per unit effort in the trail walk. This was obtained using the formula, Encounter rate = n/l, where, n=number of pheasants sighted and l= Distance walked. Each encounter was selected and the GPS readings of elevation, latitude, and longitude were taken for each census point (Jolli et al., 2011).

B. Hide build: Hides were built of available materials in the forest (e.g. Deadwood, moss). In hides, the entry was usually made before dawn and occupied for up to three hours after sunrise to make observations and photography, cautiously.

C. Photography and field notes: Field notes and photography were used as an important tool for identifying pheasants and their habitats.

6.2.4. Sampling design

For the extensive study, the two major transects were selected in the core zone of the KBR, covering the northern and western part of the region. Depending upon the accessibility in the study area, different sub-transects were laid down at major broad habitats based on altitudinal gradient and forest composition. Within sub-transacts, a total of 680 point grids having 200 m x 200 m were laid down to detect

the presence of the Himalayan Pheasants at the perpendicular line based on altitude. The minimum 200 m distance between two successive points was maintained in each transect (Jia et al., 2005).

6.2.1.5.. Distance analysis

A line transect method was used which relatively gives an unbiased density of the population study is proven to be more effective only if the assumptions associated with it are addressed effectively and aptly. But in Eastern Himalaya, due to its undulating, steepness, inaccessible mountainous region landscape, the terrain curvilinear transect/trail sampling have been used (Sathyakumar, 1994; Vinod & Sathyakumar, 1999; Ramesh, 2003). Therefore, distance sampling was used on the Himalayan Pheasants' populations obtained from trail sampling method (collected from the year 2014-2017, the three successive years). The distance program was used (Thomas et al., 2005; Anderson et al., 2015) to estimate the Himalayan pheasants' density, encounter rate, detection probability, mean cluster size, and effective strip width (ESW). Distance data were analyzed using the software program Distance 7.0 version, which has basically four key functions such as Uniform, Half-normal, Hazard rate, and Negative exponential all with cosine series adjustment. Akaike's Information Criteria (AIC) and the Chi-square statistical tests were directly used to assess the 'goodness of fit' of each function (followed by the similar approach by Burnham et al., 1981; Buckland et al., 1993; Kidwai et al., 2011). Based on the pooled data across the years were used to increase the number of detections, are recommended to estimate density with a reasonable degree of accuracy using program Distance (followed by the similar approach of Scott et al., 2006).

The Akaike's Information Criterion (AICc) was applied to select the most parsimonious model from all possible combinations for the small size number, i.e. of Uniform, Half normal, and Hazard rate models with Cosine, Simple polynomial and Hermite polynomial adjustment. The Half Normal function with Cosine adjustment was fitted best in the model to achieve consistent convergence (followed by a similar approach of Anderson et al., 2015). Encounter rate was quantified of Himalayan Pheasant of Khangchendzonga Biosphere Reserve using lines transect and trail sampling. The encounter rate is defined as the number of animals seen per unit effort (Rodgers, 1991). Similarly, in this context, Encounter rate was quantified using the formula, Encounter rate = n/L, where n=Number of Sightings and L=the length of transect/trail walked (whereas, a distance was treated as the sampling effort).

CHAPTER 06

OBJECTIVE 03

RESULTS

6.3. Results

6.3.1. Population assessment of Himalayan Pheasant in the Khangchendzonga Biosphere Reserve

6.3.1.1. Presence of Himalayan Pheasant

The total four (04) species of Himalayan Pheasants were confirmed through direct sighting, photo, dropping, and indigenous knowledge of the people who were directly and indirectly associated with the Khangchendzonga Biosphere Reserve.

Table 5.1: Details of sightings of the Himalayan Pheasants in the Khangchendzonga Biosphere Reserve

Species	**Sightings (Individuals)**	**Photograph**	**Dropping**
Blood Pheasant	80 (536)	confirmed	confirmed
Himalayan Monal	35 (74)	confirmed	confirmed
Kalij Pheasant	25 (103)	confirmed	confirmed
Satyr Tragopan	21 (54)	confirmed	confirmed

Table 5.2: Details of encounter male, female, and chick of the Himalayan Pheasants in the Khangchendzonga Biosphere Reserve

Species	Male	Female	Chick	Total
Blood Pheasant	314	186	36	536
Himalayan Monal	43	26	5	74
Kalij Pheasant	54	41	8	103
Satyr Tragopan	12	19	23	54

Presence of Blood Pheasant (*Ithaginis cruentus*), Himalayan Monal (*Lophophorus impejanus*), Kalij Pheasant (*Lophura lecomelanos*), and Satyr Tragopan (*Tragopan satyra*) were confirmed in the Khangchendzonga Biosphere Reserve. The details of their confirmation and abundance of the Himalayan Pheasants in the study area are given (Table 5.1 & 5.2).

6.3.1.1. 1. Detection probability, density and effective strip width of Blood Pheasants in Khangchendzonga Biosphere Reserve, 2014 – 2017

The Blood Pheasant was the most sighted one among the Himalayan Pheasants in the Khangchendzonga Biosphere Reserve.

Table 5.3: Abundance estimation of the Himalayan Pheasant based on Distance sampling in the Khangchendzonga Biosphere Reserve during the study period (2014-2017)

Parameter	Blood Pheasant	Himalayan Monal	Kalij Pheasant	Satyr Tragopan
Detection Probability (CV %)	0.42±0.0036 (CV%7.05)	0.35±0.05 (CV%16.81)	0.75±0.12 (CV%16%)	0.75±0.16 (CV% 21.9)
Encounter Rate (km/walk)	0.78±0.14	0.10±0.20	0.14±0.033	0.079±0.02
Density (≠/km^2) (SE)	11.07±2.23/km^2	1.5±0.33	1.6±0.45	0.79±0.35
ESW (m) (SE)	29.23±3.04	24.94±4.19	46.184±7.8	41.43±9.07
M. Cluster Size (SE)	6.78±1.092	2.09±0.22	4.04±0.48	2.54±0.37
Cluster size Range	1-80	1-5	1-8	1-6

It was sighted with 536 individuals on 80 occasions with aggregations up to range from 1- 80 individuals. Based on Distance 7.0, the detection probability of the Blood

Pheasant in the targeted site was estimated at 0.42±0.0036 (CV% 7.05). Trail sampling resulted in 80 sightings (536 individuals) of Blood Pheasant. The trail sampling data was applied to estimate the abundance of the Blood Pheasant in the intensive study area. Detection probability of Blood Pheasant was modelled using different models and adjustment terms and according to the AIC value, the Half-Normal model without any adjustment term provided the best fit at the point, i.e. detection function of individuals should be 1.0.

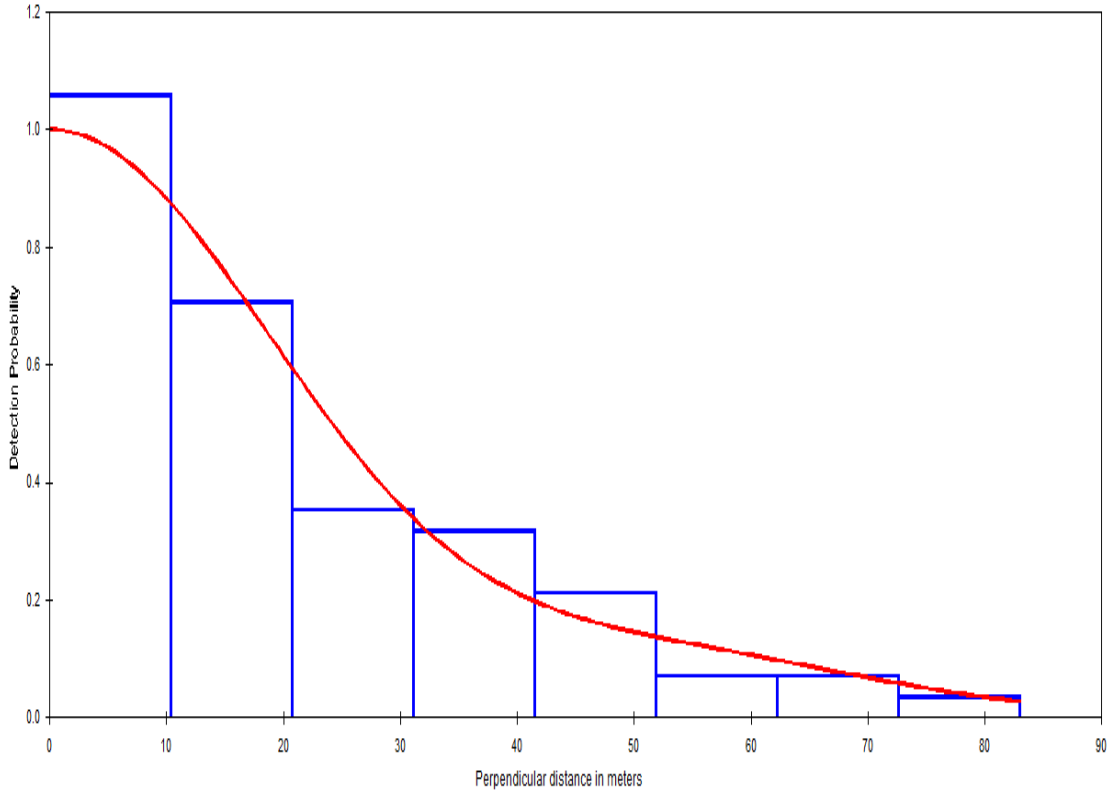

Figure 5.1: The best fit detection function model generated by DISTANCES 0.7 analyses considering all Blood Pheasant in the Khangchendzonga Biosphere Reserve during the study period (2014-2017).

The probability of detecting the Blood Pheasant decreased as the distance from the point increased for observations (Figure 5.1). The overall density (11.07/sq. km) and

the encounter rate (0.78±0.14/ km) of the Blood Pheasant were quantified in the Khangchendzonga Biosphere Reserve (Table 5.3).

6.2.3. Detection probability, density and effective strip width of the Blood Pheasant in different major seasons of the Khangchendzonga Biosphere Reserve, 2014 – 2017

The seasonal density (≠/sq. km) of the Blood Pheasant was quantified in the Khangchendzonga Biosphere Reserve (estimated from post stratification option of distance sampling analysis using the same Half-Normal model). The highest seasonal density was quantified during summer (4.7±1.5/ sq. km) followed by winter (2.6±1.4/sq. km) and autumn (2.6±1.6/ sq.km) (Table 4.2.4). In the study site, 49 observations were made during the summer season followed by 18 in winter (18) and 13 in the autumn season (Table 5.4).

Table 5.4: Detection probability, density and cluster size in different seasons of the Blood pheasant in Khangchendzonga BR during the study period (2014-2017)

Season	Observation	Detection probability (SE)	Density (SE) #/km^2	Mean Cluster size (SE)	ESW (SE)
Summer	49	0.33±0.038	4.7±1.5	3.84±0.37	21.58±2.51
Autumn	13	0.70±0.14	2.6±1.6	10.4±2.55	56.63±11.8
Winter	18	0.61±0.11	2.6±1.4	12.77±4.02	43.24±8.07

The density (#/sq. km) of the major forest types were also quantified in the Khangchendzonga Biosphere Reserve (estimated from post stratification option of distance sampling analysis using the same Half-Normal model). The highest density of the Blood Pheasant was quantified in temperate (5.2±2.9/sq.km) followed by

subalpine (4.2±2.0/sq. km), and alpine (1.5± 0.73/sq. km). In the study area, 33 observations were made in sub alpine followed by 26 in temperate, and 20 in alpine zone (Table 5.5).

Table 5.5: Detection probability, density and effective strip width of the Blood Pheasant in different major forest types of the Khangchendzonga Biosphere Reserve, 2014 – 2017

Major Forest	Observation	Detection probability (SE)	Density (SE) #/km^2	Mean Cluster size (SE)	ESW (SE)
Alpine	20	0.62±0.11	1.5± 0.73	5.4±1.11	51.39±9.09
Sub-alpine	33	0.35±0.06	4.2±2.0	4.42±0.53	17.76±3.09
Temperate	26	0.58±0.08	5.2±2.9	10.84±2.86	38.38±5.37

6.3.1.1.2. Detection probability, density and effective strip width of the Himalayan Monal in Khangchendzonga Biosphere Reserve, 2014 – 2017

The Himalayan Monal was sighted with 74 individuals on 35 occasions with aggregations up to range from 1- 5 individuals. Based on Distance 7.0, the detection probability of the Himalayan Monal in the targeted site was estimated at 0.35±0.05 (CV% 16.81). Overall density (1.5±0.33/ sq.km) and encounter rate (0.10± 0.20/ km) of the Himalayan Monal in the target area was estimated (Table 5.3).

The trail sampling data was applied to estimate the abundance of the Himalayan Monal in the intensive study area. Detection probability of Himalayan Monal was modelled using different models and adjustment terms and according to the AIC value, the Half-Normal model without any adjustment term provided the best fit at the point, i.e. detection function of individuals should be 1.0. The probability of

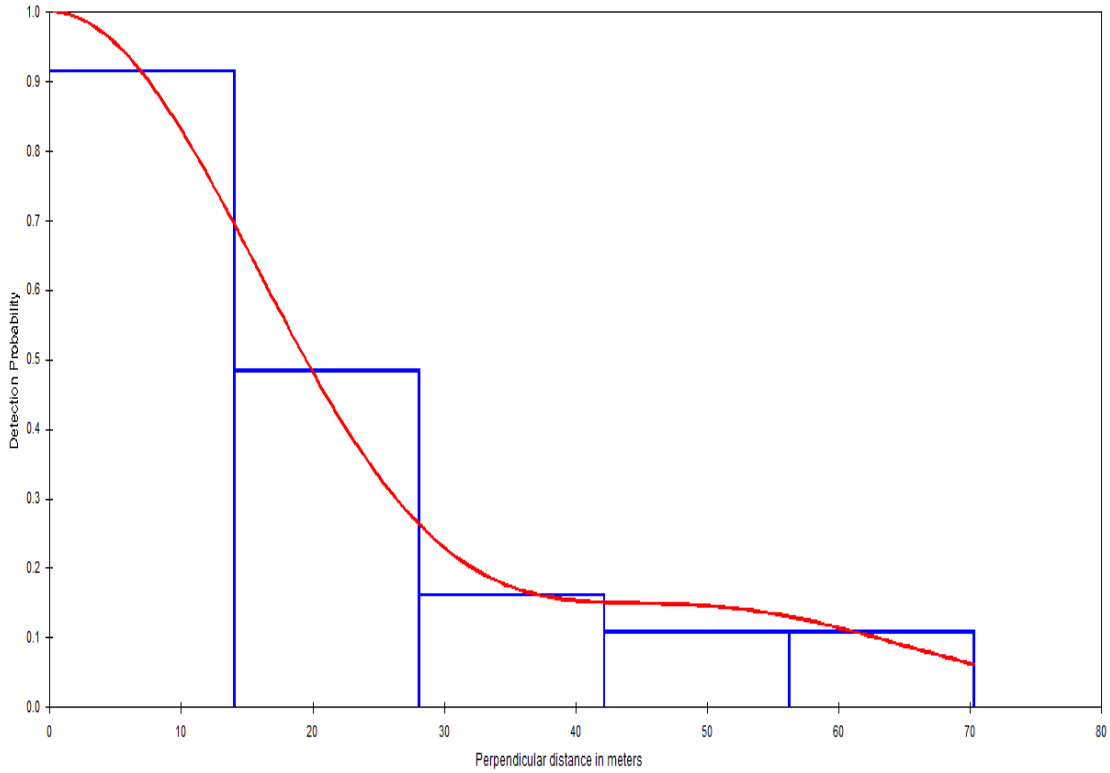

Figure 5.2: The best fit detection function model generated by DISTANCES 0.7 analyses considering all Himalayan Monal in the Khangchendzonga Biosphere Reserve during the study period (2014-2017).

Table 5.6: Detection probalility, density and cluster size in different seasons of the Himalayan Monal in the Khangchendzonga BR during the study period (2014-2017)

Season	Observation	Detection probability (SE)	Density (SE) #/km^2	Mean Cluster size (SE)	ESW (SE)
Summer	19	0.81±0.14	0.55±0.17	2.26±0.34	57.30±10
Autumn	07	0.69±0.19	0.42±0.2	2.28±0.38	28±7.83
Winter	09	0.76±0.22	0.28±0.13	1.66±0.23	38.55±11.37

detecting the Himalayan Monal decreased as the distance from the point increased for observations (Figure 5.2). The seasonal density (≠/sq. km) of the Himalayan Monal was quantified in the Khangchendzonga Biosphere Reserve (estimated from post stratification option of distance sampling analysis using the same Half-Normal model). The highest seasonal density was quantified during summer (0.55±0.17/sq. km) and followed by autumn (0.42±0.2/ sq. km) and winter (0.28±0.13/ sq.km). In the study site, 19 observations were made during the summer seasons followed by 09 in winter and 07 in autumn (Table 5.6).

Table 5.7: Detection probability, density and effective strip width of the Himalayan Monal in different major forest types of the Khangchendzonga Biosphere Reserve, 2014 – 2017

Major forest	Observation	Detection probability (SE)	Density (SE) #/km^2	Mean Cluster size (SE)	ESW (SE)
Alpine	19	0.46±0.06	0.93±0.43	2.21±0.20	33.0±4.3
Sub-alpine	9	0.46±0.19	0.31±0.19	2.11±0.36	28.10±12
Temperate	5	0.99±0.39	0.19±0.15	1.6±0.15	30.49±12

The density (#/sq. km) of the major forest types was quantified in the Khangchendzonga Biosphere Reserve (estimated from post stratification option of distance sampling analysis using the same Half-Normal model). The highest density of the Himalayan Monal was quantified in Alpine (0.93±0.43/sq. km) followed by subalpine (0.31±0.19/sq. km) and alpine (0.19±0.15/sq. km). Observations were made in alpine (19) followed by sub-alpine zone (9) and temperate (5) [Table 5.7].

6.3.1.1.3. Detection probability, density and effective strip width of the Kalij Pheasant in Khangchendzonga Biosphere Reserve, 2014 – 2017

The Kalij Pheasant was sighted with 103 individuals on 25 occasions with aggregations up to range from 1- 8 individuals. Based on Distance 7.0, the detection probability of the Kalij Pheasant in the targeted site was estimated at 0.75±0.12 (CV% 16). Overall density (1.6±0.45/ sq. km) and encounter rate (0.14±0.033/km) of the Kalij Pheasant in the target area was estimated (Table 5.3).

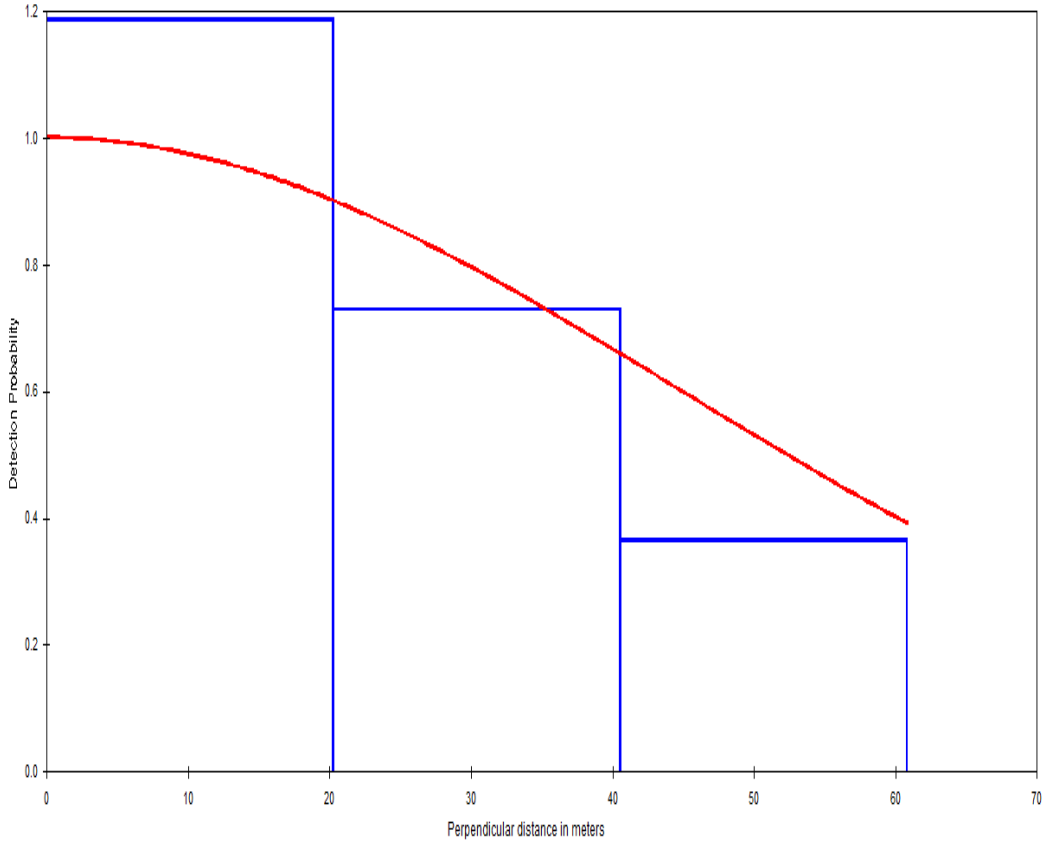

Figure 5.3: The best fit detection function model generated by DISTANCE analysis considering all the Kalij Pheasant in the Khangchendzonga Biosphere Reserve during the study period (20014-2017).

Detection probability of the Kalij Pheasant was modelled using different models and adjustment terms and according to the AIC value, the Half-Normal model without any

adjustment term provided the best fit at the point, i.e. detection function of individuals should be 1.0. The probability of detecting the Kalij Pheasant decreased as the distance from the point increased for observations (Figure 5.3).

6.3.1.1.4. Detection probability, density and effective strip width of the Satyr Tragopan in Khangchendzonga Biosphere Reserve, 2014 - 2017

The Satyr Tragopan was sighted for 54 of individuals on 21 occasions with aggregations up to range from 1- 6 individuals. Based on Distance 7.0, the detection probability of the Satyr Tragopan in the targeted site was estimated at 0.75 (CV% 21.9). Overall density (79±0.35/ sq. km) and encounter rate (0.079±0.02/km) of the Satyr Tragopan in the target area was estimated (Table 5.3).

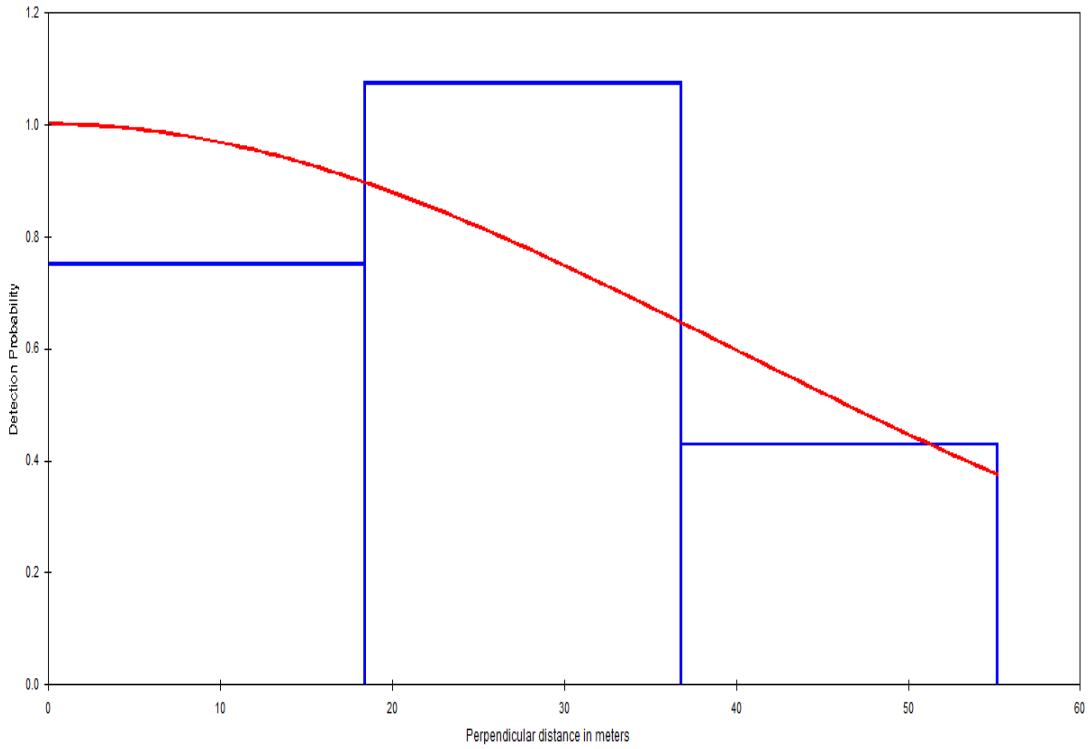

Figure 5.4: The best fit detection function model generated by DISTANCE analysis considering all Satyr Tragopan in the Khangchendzonga Biosphere Reserve during the study period (20014-2017).

Detection probability of Satyr Tragopan was also modelled using different models and adjustment terms and according to the AIC value, the Half-Normal model without any adjustment terms provided the best fit at the point, i.e. detection function of individuals should be 1.0. The probability of detecting the Satyr Tragopan first decreased initially and after a certain distance again the detection probability increased and thereafter decreased with increasing distance from the observer (Figure 5.4).

6.3.1.2. Field observation on Himalayan Pheasants' ecology in KBR

6.3.1.2.1. Blood Pheasant

A total 536 individuals of Blood Pheasant was recorded on 80 occasions which aggregating up to range of 1-80 individuals during May 2014 - March 2017 in the Khanchendzonga Biosphere Reserve across the two major transects, i.e. Yuksom – Black Kabru and Tholung- Kisong. The Blood Pheasant populations were encountered along of 3200 -4900 m asl across the cold temperate forest to the alpine meadows in the Khangchendzonga Biosphere Reserve. Enumerated habitat composition of the Blood Pheasant along the altitudinal gradients was dominated by the following woody taxa: *Rhododendron arboreum* (Ericaceae), *Rhododendron barbatum* (Ericaceae), *Sorbus* sp. (Rosaceae), *Abies densa* (Pinaceae), *Viburnum* spp. (Adoxaceae) and *Betula* spp. (Betulaceae) in the cold temperate forest (cold temperate coniferous-broad-leaved forest, 2800-3600 m asl); *Rhododendron wightii* (Ericaceae), *Rhododendron campanulatum* (Ericaceae), *Rhododendron lanatum* (Ericaceae), *Micromeles thomsonii* (Rosaceae), *Viburnum* spp. (Adoxaceae) and *Prunus cerosoides* (Rosaceae) in the subalpine (3600-4100 m asl); and *Juniperus*

spp. (Cupressaceae), *Rhododendron setosum* (Ericaceae) and *Rhododendron anthopogon* (Ericaceae) in the alpine zones (above 4100 m asl) in the Khangchendzonga Biosphere Reserve. Within the three study years, the overall ecology of Blood Pheasants in Khangchendzonga Biosphere Reserve (Sikkim Eastern Himalaya) was investigated by direct encounters, tracing their droppings and foot marks on soil and snow, by especially focusing on the winter, summer, and autumn seasons. Blood Pheasants are swift and strong runners; they usually run uphill and sometimes fly downhill when they have to tackle threats such as sudden encounter of predators and other animals. In comparison to the other Pheasants in the Khangchendzonga Biosphere Reserve, they are very active, hasty, almost restless in a daytime, and are acquainted with people if they are not getting disturbed in the field. The following footless ecology of Blood Pheasant was observed within the three successive years study period:

Social behaviour

Blood Pheasant lives socially organised (dwells in a flock) except during breeding season during an almost entire year, as noted in Sikkim Himalaya. During winter, the Blood Pheasant was found in a big flock sometimes up to 70-80 individuals. The first-time observation was made in Sikkim Himalaya, that the flocks of Blood Pheasants are monitored by the respective older supreme male leader like Guardian, who leads the flock to right direction, and monitor any intruder or danger ahead. In the presence of any notable danger the male guardian of the flock would produce a short sound, then all females and all males along with chicks in the unit follow him and the other associated guardian silently waits for a while to screen and check the area for any predator chasing them or not. During the flock foraging in

shrubberies, one or two associated guardians climb on the branches of shrubberies and start screening the foraging ground as well as guard the unit. If there is a presence of more sign of danger a few other males will also join to screen and check the presence of predators in the surroundings. The present observation suggests based on the number of spurs of the male, he may be the guardian male and his maturity may be recognized by counting the number of spurs; it seems that the guardians are much older than others and have lots of expertise to guide the flock to the right direction in the field. In the flock, they show altruism behaviour, each individual tries to save their kin by producing sound if they encounter with any threat and alert their flocks by taking the risk. In the breeding season in summer, the Blood Pheasants start segregating in the couples. During the post-breeding season, having chicks they form nuclear families and again come to join the unit. The Blood Pheasants always try to forage in a flock, if an individual separates from the flock immediately it produces a short sound to the flock, following that the flock also respond back to the sound. This behaviour suggests that the Blood Pheasants feel safer in a flock rather than being isolated and it also increases the probability of their survival rate. The winter flock of Blood Pheasants is larger than those of summer season perhaps the nights are too cold and it is not the perfect time to pair up for breeding couples. During winter, by huddling in the flock they might be maintaining their body temperature which helps them to cope and develop better survival capacity in the harsh climatic conditions.

Foraging behaviour

The foraging time of the flocks of Blood Pheasant starts from dawn to dusk. They relish foraging on lichen laden rocks with small patches of the green grass of alpine region during summer and autumn. As lichens are considered as a bio-indicator of pollution free zone (Conti and Cecchetti, 2001), they forage lichen laden area, it also indicates that Blood Pheasants prefer pollution -free areas. They feed on lichens, small white pebbles, insects, and young shoots of plants and during winter the Blood Pheasants also exhibit an arboreal mode of feeding. As observed, in the winter, the Blood Pheasants mainly forage on branches of shrubberies and a small tree for mosses, lichens, berries, insects and dry leaf litters and sometimes they also take a small hop to catch a flying insect. During summer, the Blood Pheasants also act as an indicator for the *Ophiocordycep sinsensis* (an expensive medicine as Himalayan gold of the Himalayas used for eternal youth and energy booster for the immune system) because the Pheasants forage on the species laden habitat ground in the alpine meadow and relish feeding the same.

Breeding Season

The breeding season of Blood Pheasant starts from the month of April to June. During nidification, the couples of Blood Pheasant descend slightly towards lower altitudinal level in the subalpine region. This may be that they maintain hatching temperature and make nests within the base of shrubberies of Rhododendrons such as *Rhododendron lanatum, Rhododendron campanuatum* and *Rhododendron wightii,* so on. Throughout the incubation period, the male partner guards the female along with the nest while sitting on the branches of trees. After hatching, the female mostly rears the chicks and the male guides the territory. The Blood Pheasants keep their chicks in

the same area within shrubberies of Rhododendron forest of *Rhododendron campanulatum, Rhododendron aeruginosum, Rhododendron wightii, Rhododendron lanatum, Rhododendron hogdsonii,* and *Sorbus* sp., for two months to provide them protection from the predators such as eagle, snow leopard, and fox. Then the nuclear family of the Blood Pheasant moves towards higher altitude to join the main flock. May be the breeding time slightly varies for different couples of Blood Pheasants because some hatch earlier than others may be depending upon the maturity of the couples. It was observed that at the same time the size of chicks differs in different nuclear families. It was observed that during autumn season lots of nuclear families of the Blood Pheasant having 5-8 chicks.

Seasonal Migration

Blood Pheasant exhibits a short distance migration during summer and winter, in the summer they are found in the altitude regions of sub-alpine and alpine meadow (c. 3800-4900 m asl) and in winter they descend in the cold temperate broad- leaved forests (in and around 3200 m asl). In summer, Blood Pheasants inhabit in the shrubberies and the scrubs (*Rhododendron lanatum, Rhododendron wightii, Rhododendron campanulatum, Rhododendron anthopogon, Rhododendron setosum, Juniperus recurva* and others), in small caves and in the crevices of rock as shelters. In winter, the Blood Pheasants prefer shrubberies of the cold broad leaved forests (*Rhododendron grande, Rhododendron barbatum*, *Eurya japonica* and so on) and their branches for shelter. During winter the high altitude alpine and the subalpine zones are covered with snow making the temperature unbearable, and all foods are snow covered then this situation makes Blood Pheasant to slowly shift towards the lower altitudinal range in the cold temperature broad- leaved forests to cope up with

the harsh conditions of winter. Although, the winter is harsh for the Blood Pheasants due to the severe climatic conditions and scarcity of foods along with the threats of getting snared at a lower altitude range. With the onset of summer season, the temperature slowly rises in the high altitude region and the snow- covered area starts melting on the slope, and varieties of vegetation start sprouting, which call forth the upward movement of the Blood Pheasant in the region. The study did not record a sign of any presence of the Blood Pheasant below 3200 m asl.

6.3.1.2.2. Himalayan Monal

The Himalayan Monal was sighted for 74 individuals on 35 occasions with aggregating 1-5 individuals during May, 2014- April, 2017 in the Khangchendzonga Biosphere Reserve across the two major transects i.e. Yuksom –Black Kabru and Tholung-Kisong transects. The Himalayan Monal populations were encountered between ranges of 3000 m asl -5000 m asl across the cold temperate forest to alpine meadow in the Khangchendzonga Biosphere Reserve. Similarly, the habitat of the Himalayan Monal along the altitudinal gradients was dominated by various woody taxa, viz. *Rhododendron arboreum* (Ericaceae), *Rhododendron barbatum* (Ericaceae), *Sorbus* sp. (Rosaceae), *Abies densa* (Pinaceae), *Viburnum* spp. (Adoxaceae), and *Betula* spp. (Betulaceae) in the cold temperate forest (cold temperate coniferous-broad-leaved forest, 2800-3600 m asl); *Rhododendron wightii* (Ericaceae), *Rhododendron campanulatum* (Ericaceae), *Rhododendron lanatum* (Ericaceae), *Micromeles thomsonii* (Rosaceae), *Viburnum* spp. (Adoxaceae), and *Prunus cerosoides* (Rosaceae) in the subalpine (3600-4100 m asl); and *Juniperus* spp. (Cupressaceae), *Rhododendron setosum* (Ericaceae) and *Rhododendron anthopogon* (Ericaceae) in the alpine zones (above 4100 m asl) of the study area. The overall

ecology of Himalayan Monal in the Khangchendzonga Biosphere Reserve (Sikkim Eastern Himalaya), observed within the three successive years, by direct encounters, tracing their droppings and foot marks on soil and snow, by especially focusing on the winter, summer, and autumn seasons. Himalayan Monal is a strong runner; they usually run uphill and sometimes fly downhill when they have to tackle with threats as a sudden encounter of predators and other animals. When the male Himalayan Monal flies then it's all nine colours of beautiful patterns of plumage can be seen.

Social behaviour

The whole year, usually the male Himalayan Monal lives in the male group and the female Himalayan Monal in the female group; some time they live in solitary and a small group of individuals (2-4), except breeding season.

Foraging behaviour

The foraging time of the Himalayan Monal starts from dawn to dusk. They relish foraging on lichen laden rocks with small patches of the green grass of wet area of the alpine region during summer and autumn. During a sunny day, they love to sun basking on the top of the hills especially male Himalayan Monal. They feed on lichens, small pebbles, insects and young shoots and roots of the plants. During foraging, they love to dig wet soil in search of worms and insects under the soil. During summer, the Himalayan Monal also acts as an indicator for the *Ophiocordycep sinsensis* (an expensive medicine in the Himalayas used for eternal youth and energy booster for the immune system) because they love to forage on the species laden habitat ground in the alpine meadow.

Breeding Behaviour

The breeding season of Himalayan Monal starts from the month of April to June and during nidification, the couples of Himalayan Monal descend slightly towards the lower altitudes in the alpine region, similar to Blood Pheasant, may be to maintain hatching temperature and to make nests in the crevice of rocks. Similarly, like Blood Pheasant, the chicks of the Himalayan Monal can be seen in the lower altitude of alpine (3900-4100 m asl) for two months after that they shift to the higher altitudes in the alpine zone when they can able to tackle with threats.

Seasonal Migration

Himalayan Monal exhibits a temporal migration during summer and winter, in the summer they are found in the altitudinal ranges between 3900 -5000 m asl (or even more than our transects) and in winter the male can be seen up to 3000 m asl down in cold temperate broad-leaved forest but the female remains in the lower altitude in alpine region. The Himalayan Monal shares almost similar habitat and ecological niche of the Blood Pheasant during their seasonal migration. They slowly move towards the higher altitudes with the offset of winter.

6.3.1.2.3. Kalij Pheasant

The Kalij Pheasant was sighted with 103 individuals on 25 occasions, and aggregating up to range from 1-8 individuals during May, 2014-April, 2017 in the Khangchendzonga Biosphere Reserve across the two major transects i.e Yuksom-Black Kabru and Tholung- Kisong. The Kalij Pheasant populations were encountered in a habitat range, which starts in the study transects from 1700 m asl – 2800 m asl the temperate broad leaved forest in the Khangchendzonga Biosphere Reserve. The enumerated habitat composition of the Kalij Pheasant was *Rhododendron arboreum,*

Magnolia cambellii, Quercus pachyphylla as dominated forest at 2600 m asl, *Quercus lamellosa, Quercus lineata, Castronopsis* spp., *Acer cambellii* as dominated forest at 2000 m asl and *Alnus nepalensis, Macaranga denticulatum,* so on at 1800 m asl.

Foraging behaviour

The Kalij Pheasants forage mainly in dense undergrowth bamboos and big bushes of the deep cold temperate broad-leaved forest in the KBR. They feed on insects, wild seeds, and young shoot of plants. They forage in a group (2-8 individuals) and take shelter on the branches of trees for the nights.

Breeding Behaviour

The breeding season of Kalij Pheasant starts from the month of March-May and during nidification, the couple uses bore of a sloppy area for nesting. During the incubation period, the male partner guards the nest by sitting on the branch of the tree. After breeding season the chicks are mainly reared by the female partners and the male guards the territory.

6.3.1.2.4. Satyr Tragopan

The Satyr Tragopan was sighted with 54 individuals on 21 occasions with aggregating up to range from 1-6 individuals during May, 2014-April, 2017 in the Khangdchendzonga Biosphere Reserve across the two major transects i.e Yuksom-Black Kabru and Tholung- Kisong transects. The Satyr Tragopan populations were encountered in a narrow stretch of habitat range (2800 m- 3400 m asl) of the ecotone of cold temperate broad leaved forest and subalpine regions of the Khangchendzonga Biosphere Reserve. The enumerated habitat composition of the Satyr Tragopan was *Abies densa, Rhododendron falconeri, Betula alnoides,* and *Rhododendron barbatum* at 3400 m asl, *Rhododendron falconeri, Rhododendron arboreum,* and *Abies densa*

at 3100 m asl, and *Abies densa, Rhododendron falconeri,* and *Rhododendron arboreum* at 3000 m asl, *Rhododendron arboreum* and *Magnolia campbellii* at 2900 m asl, *Rhododendron arboreum*, *Magnolia campbellii,* and *Quercus pachyphylla* at 2800 m asl in study areas.

Foraging behaviour

The Satyr Tragopan mainly forage in dense undergrowth bamboos patches areas of the cold temperate broad- leaved forest and subalpine region in the KBR. They mostly like to forage in a deep forest and feed on insects, ferns, wild seeds. They forage in a small group (up to 6 individual) or solitary. They mostly shelter on the branches of trees during the nights.

Breeding Behaviour

The breeding season of Satyr Tragopan starts from the month of March-May and during nidification, the couple uses dead logs and/or branches of a tree for nesting. After breeding season the chicks are mainly reared by the female partner.

CHAPTER 06

OBJECTIVE 03

DISCUSSION

6.4. Discussion

Out of the four Himalayan Pheasants, the populations of Blood Pheasant were comparatively large in size than the other Pheasants in the Khangchendzonga Biosphere Reserve, followed by Himalayan Monal, Kalij Pheasant, and Satyr Tragopan. Overall, during the study period, the encounter rate (0.78±0.14) and the density (11.07± 2.23 / sq. km) of the Blood Pheasant were recorded. Whereas, some adjacent parts of Annapurna Conservation (ACA) in Nepal revealed more or less similar results, which observed the encounter as 0.81±1.39 (Poudayl, 2008). The seasonal trend of the Blood Pheasant for major seasons showed that the highest density was in summer (4.7±1.5) and followed by winter (2.6±1.4) and autumn (2.6± 1.6). Habitat-wise, Blood Pheasant showed its highest density in the temperate region (5.42±0.73/sq.km) of the Khangchendzonga Biosphere Reserve followed by sub-alpine (4.2±2.0/sq.km) and alpine region (1.5±0.73/sq.km). This pattern shows their preference for the particular habitat types. In Khangchendzonga Biosphere Reserve, the study estimated the overall encounter rate (0.10±0.20) and the density (1.5±0.33/sq.km) of the Himalayan Monal. Whereas, the previous study recorded in Western Himalaya by Ramesh et al. (1999) from Kedarnath Wildlife Sanctuary estimated the relative abundance of 1.5±0.35 to 3.5 ± 0.38 birds/ km walk and encounter rate as 1.5±0.35 and 3.9±0.32 birds/ km walk. Similarly, in Annapurna Conservation Area, Nepal, Poudyal (2008) quantified the encounter rate of the Himalayan Monal as 6.74 birds /km which was much high as compared to our present study. The overall density (79±0.35/ sq. km) and encounter rate (0.079±0.02) of the

Satyr Tragopan in the target area was estimated in the Khangchendzonga Biosphere Reserve, whereas, from Nepal, encounter rate of Satyr Tragopan with a pooled mean 0.42±0.91 birds/km was quantified excluding the trails where the birds were not observed at all (Poudyal, 2008). The density estimation of Satyr Tragopan was done by Khaling et al. (1998), in Singhalila National Park, Darjeeling, which showed 6.19 birds /sq.km, 4.52 birds/sq.km, and 5.46 birds/ sq.km during three successive years.

The overall density (1.6±0.45/ sq. km) and encounter rate (0.14±0.033) of the Kalij Pheasant in the Khangchendzonga Biosphere Reserve was recorded, however, similar studies in Annapurna Conservation (ACA), showed a pooled mean encounter rate 0.36±0.76 birds/km walk (Poudyal, 2008). The official IUCN Red List of Threatened Species Assessment designated the status of the Himalayan Pheasants and provided their altitudinal range, which quite differed with the primary observation of present altitudinal range in the Khangchendzonga Biosphere Reserve. The result also indicated that these Himalayan Pheasants are shifting their habitat range towards the high-altitude mountain landscape. According to IUCN Red List of Threatened Species Assessment, the altitudinal habitat range of Blood Pheasant is given as 2500-4500 m asl (Birdlife International, 2016), whereas in the Khangchendzonga Biosphere Reserve the present study reported 3200-4900 m asl range for the Blood Pheasant. This is may be a sign that the Blood Pheasant is shifting their habitat range towards high altitude mountainous landscape and making their amplitude of habitat range narrower compared to the last century. Similarly, reported from northeast India, Blood Pheasant in summer goes up to 4600 m asl and in winter descend to lower altitude at 2600 m asl (Ali & Reply, 1987). Cheng et al (1978) have reported that the altitudinal

range of Blood Pheasant was 2000 m -3500 m asl in China and similarly, studies from Nepal, reported 3200 m-4400 m asl range for the same (Poudyal 2008). Based on IUCN Red List of Threatened Species Assessment, the altitudinal range of Himalayan Monal given as 2100-4500 m asl and whereas our reported range for the Himalayan Monal in Sikkim Himalaya is 3000 -5000 m asl and the similar habitat range reported by Choudhury (2005) from Arunachal Pradesh and Sikkim with their elevation ranges of 2500 m-5000 m asl. Himalayan Monal occupies habitat range from temperate forest to alpine meadow along 2400-4500 m asl but they largely concentrate in a narrow belt of 2700 -3700 m asl (Grimmet et al., 1998), whereas, Ramesh (2003) has reported that they largely concentrated in the middle elevation mostly in 2600-3000 m asl and they exhibit clear attitudinal migration up to the lower belt 2000 m, also in winter. Himalayan Monal was found in the altitudinal range from 3000 m-3500 m asl in the subalpine forest and tree line in Nanda Devi Biosphere forest (Bhattacharya et al., 2007). Based on the studies from Jiva Valley of Great Himalayan National Park, HP, the Himalayan Monal were found in the altitudinal range from 2800-3400 m asl (Yahya, 1992). It seemed that the Habitat range of the Himalayan Monal is also shifting in the Sikkim Himalaya towards the high altitude mountain landscape. Treeline is found at slightly higher altitude range (up to 4100 m asl) in the Eastern Himalayas than the Western Himalayas, it may be the reason, the upper range limit of the Himalayan Monal is slightly higher altitudinal in the Eastern Himalayas compared to the Western Himalayas. The Western Himalayas as being the closest to Tran Himalaya zone and the most of the higher altitude zones are covered with snow which is the main reason for restricted altitudinal distribution of the Himalayan Monal (Ramesh, 2003). For Satyr Tragopan the altitudinal range given by IUCN Red List of

Threatened Species Assessment, is 2200-4250 m asl compare to its present range of 2800 m -3400 m asl in Khangchendzonga Biosphere Reserve. Similarly, Satyr Tragopan reported from eastern and western Bhutan along 2743–3353 m asl altitudinal range (Ludlow & Kinnear, 1937). Satyr Tragopan range has been reported from the Nepal Himalayas by several authors, along 1600-3200 m asl (Lelliott & Yonzon, 1980; Forster, 1982; Roberts, 1983; Picozzi, 1985; Roberts, 1987; Amatya, 1997; Maskay, 1997; Poudyal, 2008). Although, the maximum species density of Satyr Tragopan was associated within the altitudinal range of 2625 – 2900 m asl in Singhalila National Park (Khaling et al., 1999). However, in Kumaun Himalaya, Satyr Tragopan is distributed along the 2400-4250 m asl (Young & Kaul, 1987). It seemed that the Satyr Tragopan's habitat range is under threat because it is confined in a narrow stretch of habitat range from 2800 m -3400 m asl of cold temperate and subalpine regions in Khangchendzonga Biosphere Reserve, within an ecotone of the cold temperate and subalpine region, where community's succession always occur (Chhetri et al., 2017). Similarly, in Khangchendzonga Biosphere Reserve, the Kalij Pheasant is recorded along 1700 m -2800 m asl, however, Kalij was also found in the lower elevation but the present study is focused only on the core zone of Khangchendzonga National Park, which started from c. 1700 m asl. The similar altitudinal range of Kalij Pheasant was reported (550m -2700 m asl) in Dodoha district of Western Himalaya (Pandey & Tandon, 2007). Whereas in Kinnaur district, the range of the species is reported from 1800-2650 m asl in the oak forest (Pandey & Tandon, 2007). This species is reported to have a wide range of altitudinal distribution from 200- 2800 m asl, covering low tropical forests to temperate forests (Sinha & Chandola, 2007). Overall, these Himalayan Pheasants are slowly altering their habitat

range towards high altitude mountainous landscape and making their amplitude of habitat range narrower compared to the last century. However, due to climate change, Eastern Himalaya is reported for its widespread warming of generally 0.01 to 0.04˚C per year (Sharma et al., 2009) and uncertain rainfall (Goswami et al., 2006). Consequently, the climate change in the Himalayas is drastically intensified which affects its biodiversity and ecological pattern of the species including range shifts in several species. Several authors have reported that the tree lines are shifting from lower elevation to higher elevation (Löffler et al., 2004, Bakkenes et al., 2002), and diversity of flora is increasing in high altitude zones due to climate change. Studies found *Abies spectabilis* has been shifting towards higher altitude at the rate of 2.61m/per year since 1850 (Gaire et al., 2014), and tree phenology is shifting in the Himalayas (Badola, 2010; Gaira et al, 2014). It is documented that the climate change in the Himalayas may be the main reason for Himalayan Pheasants shifting their range; adopting suitable strategies in an attempt to cope with the possible effects of future environmental changes (Gentili et al., 2015).

Plate 07: Challenges for studying in mountain ecosystem like KBR; Poisonous plants like *Aconitum ferox* Wall. Ex Ser. (A), walking on delicate bridge due to landside wiped the trekking trail (B), field study in harsh weather in alpine (C), and halt in freezing night in winter (D).

Plate 08: Rough trail due to mudslide (A), hanging bridge (B), snare for Blood Pheasant (C), and snare for Himalayan Monal (D)