1. INTRODUCTION

1.1 Background

1.1.1 Grassland Ecosystem and Small Mammals

Grasslands are highly dynamic ecosystems that provide goods and services to support flora, fauna and human populations worldwide, including a large number of endangered species (White *et al.*, 2000). Ecosystem in which Grasses (monocotyledonous) include Poaceae or Gramminaceae family as well as the sedges (Cyperaceae) and the rushes (Juncaceae) dominate the vegetation are termed as Grassland. Grasses are the most widespread plant type found except Antarctica possessing natural advantages like thriving after being eaten and burned, perform both types of reproduction and can grow in wide variation of altitude and environment(Pearce, 2009). Grassland types includes Tropical and subtropical, temperate, flooded Mountain, polar and Xeric grassland (Tandan, 2009). Seasonal flooding is natural phenomenon which helps to maintain grassland habitat, but if too heavy or occur frequently it reduces grassland quality and water logging other area, resulting in grassland becoming overgrowth or excessively sandy reducing the extent of grassland and affecting the fauna residing in it. Therefore, sufficient grassland needs to be maintained outside the Riverine floodplains to provide habitat for grassland fauna during heavy floods. Grassland are universally one of the most threatened ecosystem, with grazing, grass-cutting, agriculture and burning activities, reducing the available habitat for grass-dependent species (Maheswaran, 2002).

Natural grasslands of Nepal are restricted to apart of the alpine zone above 3800m whereas the rest of grasslands are semi-natural (Jha, 1992). The lowland grassland below 1000m is floristically characterized by *Imperata cylindrica*, *Dichnthium annulatum*, *Cynodon doctylon*, *Paspalum distichum* (Anon, 1984).

Grass is important natural resources which plays an integral part of subsistence living in Nepal. Today many grassland areas in lowland are under cultivation and therefore the remaining in protected areas are becoming important source of grasses (Bolton, 1976).

Although many extensive studies on the large mammals have been done in the Tarai grassland of Nepal (Peet *et al.*, 1997). Small mammals especially on Hispid hare such studies are scarce. Small mammals play crucial role in natural ecosystem, serving as prey,

seed dispersers, and predators keeping pest species down. (Tandan, 2009).A healthy, diverse community of small mammals can serve as an indicator of ecological condition and wildlife habitat value of a whole area, because small mammals are particularly sensitive to habitat alteration(Olson and Brewer, 2003; Green *et al*., 2005; Hole *et al*., 2005; RMA, 2009).

The distribution and abundance of small mammals depends upon topography, altitude, vegetation, ground cover and elevation. Most species of small mammals are nocturnal and crepuscular in habit. They can forage more easily without being readily located by any aerial predators (Adhikari, 2001).

Grassland also support a range of other endangered animal species, including tiger (*Pantheratigris*), rhino (*Rhinoceros unicornis*), and Bengal florican (*Eupodotis bengalensis*) (IUCN, 2010). In Nepal grasslands are important not only for biodiversity conservation but also to local people for farming and resources such as fuel and grass for thatch roofing (Bhatt, 1999). Increasing agricultural pressure and the use of grassland burning to promote grass growth has resulted in the reduction of available habitat for grass-dependent wildlife (Aryal and Yadav, 2010).

Grassland of Shuklaphanta National Park supports a small population of Hispid hare (Aryal and Yadav, 2010). Annual grass harvest and burning practices are part of current grassland management by local people and protected area authorities in Nepal (Aryal *et al.*, 2012).

However, the effect of current grassland management practice on local small mammal communities is not known and has not been taken into consideration in management planning. Few studies of small mammals and grassland in SNP, have been carried to investigate aspect of the ecology, biology and threats to grassland and its dependent species (Bhatt and Shrestha, 1997; Bell, 1987; Peet *et al*., 1997; Yadav, 2005).

Fire and associated increase in temperature within habitat influence pattern of animal distribution and potentially has biological consequences and negative impacts on breeding success and food availability. However, very little is known about the influence of fire on the vegetation component of diet selection by hares (Aryal and Yadav, 2010).

1.1.2 Hispid hare

1.1.2.1 Morphology

Hispid hare (*Caprolagus hispidus)* is cited as an Endangered species by IUCN (1978) in IUCN Red list (2002) and is listed on Appendix I of CITES & NPWC Act-1973 (Tandan, 2009). Hispid hare belongs to the Order Lagomorpha and family leporidae. The mean body weight is 2248gm for male and 2518gm for female (Bell, 1987). The coarse, bristly coat is dark brown on the dorsal surface, due to a mixture of black and brown hairs, ventrally brown on the chest and whitish on the abdomen. The tail is short (approx. 30mm) brown throughout. The ears are also short, approx. 56mm (Bell, 1986).

1.1.2.2 Distribution

Historically, Hispid hare was recorded in tracts along the southern Himalayan foothills from Uttar Pradesh through Nepal and West Bengal to Assam, extending southwards as far as Dhaka in Bangladesh, although fossil evidence suggests a more extensive Pleistocene distribution which included central Java (Blandford, 1888; Dawson, 1971).

Known distribution of Hispid hare till late 90's was recorded from the North Kheri (Uttar Pradesh/Nepal border), Chuka Dhaya (Pilibhit Forest Division, Uttar Pradesh), Goalpara District of southwest Assam and the Rajagarh areas of the Mangaldai sub-division of Darrang District of northwest Assam, Manas Reserve Forest, Manas Sanctuary, Khalingdaur Reserve Forest, Mana Tiger Reserve, Ripu Reserve Forest (Kochugaon Division), Subankhata Reserve Forest, Orang Wildlife Sanctuary Assam, Jaldapara Wildlife Sanctuary and Buxa Tiger Reserve in West Bengal, Valmiki Wildlife Sanctuary (West Champaran District), Bihar, Kanha National Park (Madhya Pradesh), Dudwa National Park in the Kheri District of Uttar Pradesh, Chitwan National Park, Bardia National Park and Shuklaphanta Wildlife Reserve in the Tarai area of southern and southwestern Nepal.(Chapman and Flux, 1990).

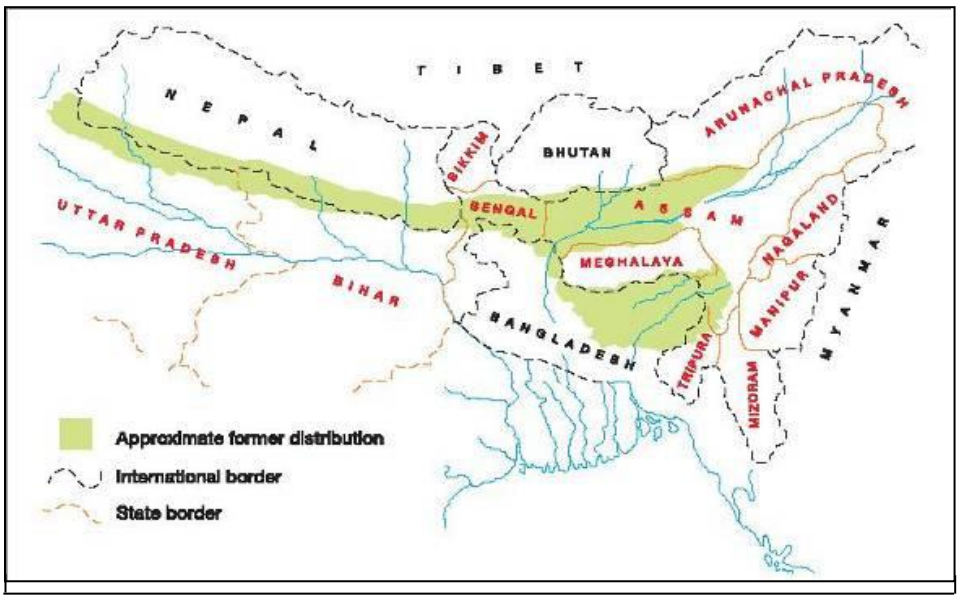

Figure 1- Map showing the approximate former distribution of Hispid hare. (Chapman and Flux, 1990)

1.1.2.3 Habiatat

The habitat of Hispid hare is the early successional riverine communities, typically comprising dense tall grasslands, commonly referred to as elephant grass or thatch land. These grasslands are a feature of the succession between primary colonizing grasses, (particularly tall grasses, on new alluvium deposited by changing water courses), through deciduous riverine forest to the *Sal* (*Shorea robusta*) forest climax. Tall grassland may also form an under storey during later stages of the succession, particularly near rivers, or in forest clearings and abandoned cultivation and village sites (Chapman and Flux, 1990).

Its diet consist of mainly of bark,shoot and root and inner core of grasses, like *Narenga porphyrocoma, Imperata cylindrica* and leaves of *Cymbopogan* species.(Yadav,2005)

1.1.2.4 Behaviour and Reproduction

Hispid hare is both structurally and behaviorally more of a rabbit than a hare. The home range of Hispid hare is restricted to a mean areas of 8200 m^2 for males and 2800m^2 for females within the dense cover provided by unburned tall grassland. Overlapping home ranges suggest that these animals live as pairs, although the total home range of individual males is larger than that of individual females (Nath, 2009).The dry season grassland burning coincides exactly with the hares breeding season which is January and February (Bell, 1987).

1.2 Objectives of the study

1.2.1 General Objective

The general Objective of this study was to explore the distribution pattern and habitat utilization of Hispid hare in SNP.

1.2.2 Specific objectives

- To study the hare population and density in different areas of SNP.
- To study the habitat utilization of Hispid hare.
- To identify the existing threats to Hispid hare.
- To give the recommendation for future conservation and management of Hispid hare in SNP.

1.3 Significance of the study

Every creature of this universe is equally important. Evolution causes new species originated and old becomes extinct. This process of extinction and origin takes very long time which cannot be compared with human scale time. Increasing human pressure on grassland, a very limited area is left as a refuse for small mammal. To add on this, the ecological consequences of these species in the grass land are poorly explored as compare to large mammals, pushing them to the brink of extinction. This even raises a serious question for its long term survival outside the protected natural habitat. Several impacts of human activities, which have serious effect on the cover tolerance small mammals like Hispid hare. In the case of Nepal we have been few report about Hispid hare But Shuklaphanta National Park is internationally significant for its presence since 80s for Hispid hare. Attitude of local people towards the Hispid hare and proposed Hispid hare conservation area is also less active. Illegal entry of domestic cattle into the Reserve for grazing, invasion of grassland by broadleaved species, haphazard firing, impact of Kharkhadai, and also flood due to the Mahakali River frequently, have declined its presence in the only remaining protected area of Nepal. Because we do not have scientific population data in other protected areas of Nepal on the Hispid hare species.

For the proper management of protected area system, scientific information on the species on their behavior and ecology is needed. Hispid hare is most important species of SNP

and need latest information for its proper management and conservation. However, it is still lacking. Long term systematic study in Shuklaphanta National Park is lacking to find out the impact of human activities. It is much influenced by the human activities, either by landless peasants' encroachment or by illegal regular human activities. It seems the activities are serious and their effect on the small mammals like Hispid hare has been beyond tolerance. Therefore the study was of vital necessity to protect the species and with the specific activities to attain the ultimate goal of conservation.

1.4 Hypothesis

1. Differences in the habitat are associated with the distribution pattern of Hispid hare.

2. LITERATURE REVIEW

2.1 National Context

Little known studies on Hispid hare have been conducted so far. Bell (1987) studied the Biology and conservation problems of the Hispid hare in the Shuklaphanta National park , she concluded that Grassland area universally one of the most threatened ecosystem, with grazing, grass-cutting, agriculture and burning reducing the available habitat for grass-dependence species and estimated the population density about 6.10/ha. She concluded the dry season grassland burning coincides exactly with the hares breeding season.

Yadav (2005) studied about the status distribution and habitat utilization of Hispid hare in Shuklaphanta National park (SNP) and found that hare preference was *Narenga sp.* in tall grassland and no pellet closer to 290 m with an average of 600m from nearest water sources. Whereas, the most of pellets were found to be in the distance less than 50m and population density found to be (1.01/ha) and showed zero preference for short grassland, riverine forest and broadleaved forest. The existing threats to hispid hare were fire, grazing flood, predation and thatch collection.

Tandan (2009) studied distribution and habitat Utilization of Hispid hare in both on summer and winter seasons in Bardiya National Park of west Nepal. A total of seven phantas were selected for study. The population density of the hare was found to be 0.45/ha in winter and 0.976/ha in summer. The study revealed that the species mostly preferred open area, rather than tall busy grassland habitat. It mostly preferred Riverine and open grassland in winter and open and open tall grassland in summer season.. Uncontrolled park burning, poor park management, predation and flooding were found as major threats to this species.

Aryal *et al.*, (2012) studied about the Diet and Habitat use of Hispid hare (*Caprolagus hispidus)* in Shuklaphanta National Park. They reported 0.06 individuals/ha, with a maximum total population of 219±40. Hispid hare primarily used Tall grassland habitat. Grassland burning, flooding was found as Major threats.

2.2 Global Context

Maheswaran (2002) studied the status and ecology of endangered Hispid hare in Jaldapara Wildlife Sanctuary West Bengal, India; suggested that Tall grassland together with short vegetation and coverage influence the movement of Hispid hare.Population density was found to be 0.087/ha during study period.

Nath (2009) Conduced study in Manas National Park during 2009-2010. Field survey was carried out in 2.65 hectare area. Study revealed random distribution of Hispid hare within tall grasslands. 265 transects and 330 quadrates were laid for pellet and vegetation. pellets occurred in grasslands dominated by *Imperata cylindrica* followed by *Saccharum narenga*. Few pellets occurred in grasslands with *Arundo donax* and *Phragmitis karka* suggesting wet alluvial grasslands are preferred less during winter. Uncontrolled burning of grassland, overgrazing, weed invasion, unsustainable thatch harvesting, traditional hunting are Major threats of Hispid hare.

Nath and Machary (2015) studied the Ecological assessment of Hispid hare in Manas National park India. They are found population density of Hispid hare to be of 3.81 individuals/ha in Manas National park, India. They reported that Hispid hare preferred dry savannah grasslands to wet alluvial grasslands during winter and avoided recently burned patches due to lack of cover and food. The distribution pattern observed was clumped with more evidence of Hispid hare presence in areas where ground cover was dense, dry and away from water sources.

3. MATERIALS AND METHODS

3.1 Study area

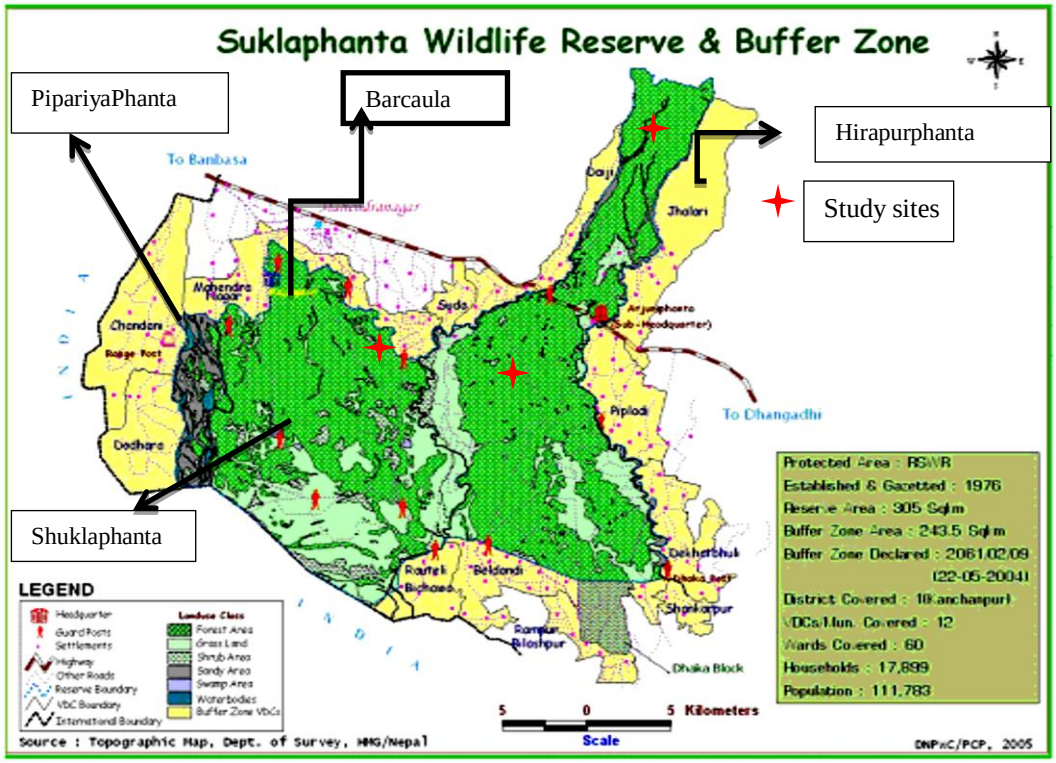

Figure 2- Map showing study area in SNP. (DNPWC, 2005)

3.1.1 Location

The Shuklaphanta National Park is situated in the extreme southwestern Tarai in the Kanchanpur district of Far-Western Nepal (Latitude 28°45'16" & longitude 80°06'04" E (Adhikari, 2003).The altitudes range from 80m to 600m above sea level.(DNPWC, 2005).

The reserve is bounded in the east and north by protected forest of Kanchanpur district, Lagga Bagga, a national forest in India, in south and Mahakali River in the west.The area extends from the flat lands in the south to the Churia hill range in the north and contains many different ecosystem and habitat types, that includes the Siwalik hills, grasslands, and flood plains created by various River systems (Mahakali, Bahuni, Radha,Syali and Chaudhar). The Siwalik ridge links the hills with the Terai forests by maintaining a natural corridor and allows for vertical migration of wild animals.

3.1.2 Climate

The climate of the region is subtropical monsoonal with mean annual rainfall of 1,579 mm (62.2 in) that occurs from June to September and is highest in August. The winter months of December and January are fairly cold with daytime temperatures of 7–12 °C (45–54 °F) and occasional frost. From February onwards temperatures rise up to 25 °C (77 °F) in March and reach 42 °C (108 °F) by end of April. When the first pre-monsoon srains reach the area in May, humidity increases (DNPWC, 2013).

3.1.3 Biological feature

3.1.3.1 Flora

This reserve is the rich Tarai protected area in terms of floral diversity. It protects more than 665 species of plants belonging to 438 genera within 118 families. Which is the highest, reported for any given protected areas in Tarai (Aryal and Yadav, 2010).Sal (*Shorea robusta*) is the predominant species in the reserve. The habitat can be categorized into three types of the forest, grassland and aquatic habitat. The Riverine forest is composed of sisso (*Dalbergiasisoo*) and khayars (*Acacia catechu*).Marsh vegetation dominates the wetland areas. The main grass species of the phantas include *Imperata cylindrical* and *Heteropogan contortus* which are used for thatching.

3.1.3.1.1 Grassland

The composition of vegetation varied in grassland with dominant type occurring *Imperata, narenga, Saccharum, Desmodium,t hemeda* with *Phragmites* species in waterlogged area. Recently vacated land has very little ground cover with *Cynodon doctylon*. (Yadav, 2005)

3.1.3.1.2 Aquatic habitat

The Mahakali River flow in the West of the reserve. There are several lakes like Rani Taal, Sikari Taal, and Kalikitch they are prominent ones and has religious and historical values. The aquatic vegetation includes floating species *like Pistacia stratiotes, Nelumbo nucifera, Nympho idesindica, Nymphoides hydrophyllum, Charm green* and green algae and blue algae, *Percicaria capitat, Persicaria glabra, Polygonum plebeium, Polygon*

umpulcherum and near the water side species like *Dryopteris cochleata, Phragmites karka, Equisetum diffusum* are and available (DNPWC, 2005)

3.1.3.2 Fauna

The SNP is equally rich in faunal diversity. it support more than 53 species of mammals among which swamp deer (*Cervus duvaucelii*) is the most popular species due its herd size and number Nepal and abroad (Chalise, 2008). The herd of Swamp deer currently stands at 2170 individuals. This is the largest herd of this species in the world (DNPWC, 2013). The Reserve is also a home to Golden monitor lizard (*Varanus flavescens),* Bluebull (*Boselaphustrago camellus),* Barking deer (*Muntiacusmuntjak),Hog deer (Axis porcinus),* Wild boar *(Sus scrofa),* Leopard *(Panthera pardus*), Jackals *(Canis aureus),* Langur *(Semnopithecus entellus),*and Rhesus monkey*(Maccaca mulatta*) and different species of small mammals.

The reserve provides habitat for about 424 species of birds, including the highest population of Bengal florican, Grass owl, warblers and flycatcher. (DNPWC, 2013). The reserve also house a diverse population reptiles like marsh mugger crocodile, cobra and python (DNPWC, 2014).

3.2 Materials

- GPS (Global Positioning System)
- Binocular
- Camera
- Questionnaire

3.3 Methods

3.4.1 Reconnaissance survey

The reconnaissance surveys of the proposed study area were carried out in second week of September, 2015. During that time distribution and habitat utilization pattern were identified. The data gathered were primary such as pellet observation, discussion with park people, field staff of park, elephant centre staffs, game scouts, concerned and knowledgeable people, vegetation survey of Hispid hare habitat, questionnaires with local people whereas secondary was from literature.

The major study seasons were winter (November- December, 2015) and summer (April-May, 2016) also winter referred as before burned of grassland and summer as after burning.

3.4.2 Grassland survey

Initially all grassland patches of Shuklaphanta National Park were surveyed. During this initial phase sites for detail study were found out by the observation of live animals or the fresh pellets groups.

3.4.3 Transect line

Strip transects were randomly laid in the Hispid hare's possible distribution area. Each transect was 20 m long, and 2 m width on either side of the transect line was taken into consideration for counting pellet groups. Each transect was covered by 2 people carefully looking pellet groups of the animal.

3.5 Data collection

The study was based on the primary and secondary data collection. The primary data were collected through transect line, Pellet Observation and questionnaire survey

3.5.1 Primary data

The primary data collection followed following procedure:

3.5.1.1 Hispid hare Observation and Sampling their sign

Hispid hare can also be observed as they cut thatch, apart from the pellets. (Maheswaran, 2002). Therefore signs were searched to that were helpful to find its food preference. Thatch cutting and fecal depositions are the only physical evidence of Hispid hare activities. Also hare habitat was discussed with park warden, game scout and field staff of park.

3.5.1.2 Pellet estimation

Direct count of hare is not a suitable method to determine its distribution on a fine grained scale (Burnham *et al.*, 1980 and Buckland *et al*., 1983). Pellet gives higher diversity value then direct observation (Redpath, Clark, and Simon, 2001). Many factor restricted the

selection of transect and indirect count method. Consequently, not all the grasslands could be surveyed during the study. This is because some of the grassland patches were too large to reach up to the center, isolated, quite far from the road network of the Park and walking on foot through these tall grasslands involved significant risk from animal attack because of presence of potentially dangerous mammals like tiger, Rhino, elephant and wild boar. Taking into consideration the size of the Hispid hare and its habitat of tall grassland makes it impossible to even see them. Therefore, pellet count method was followed to determine the population density.

Four study sites (Pipariya study site -1, Barcaula study area-2, Shuklaphanta study area-3, Hirapurphanta study area-4) were selected for Hispid hare study. Four major different types of habitats (Tall grassland, short grassland, forest and open grassland) were selected for the presence or absence of Hispid hare pellets for this study.

Strip transects were randomly laid in the Hispid hare's proposed distribution area. Each transect is 20 m long, and 2 m width on either side of the transect line is taken into consideration for counting pellet groups. Each transect were covered by 2 people carefully looking pellet groups of the animal. 185 plots were used after annual fire burning and 210 plots were sampled after the fire for calculation of population density. It was calculated on the basis of second time count method after 10 days interval. For population density estimation, I used only the fresh pellet data. To calculate pellet density and population density, I followed defecation rate- 9 as explained by Aryal *et al*. (2012) and Nath and Machary (2015). All pellets, 257 pellet groups (before fire 94 and after fire 163) including fresh and old that were found in the first time survey was counted and cleared from the plot for the second time count. During data collection, the parameters noted were pellet group and nature of pellet (old/fresh). Indirect evidences (pellets, dungs and scats of animals) were identified with the help of the senior knowledgeable forest staff. Observations were recorded in a standard datasheet and all the relevant information (general habitat, microhabitat, grass species composition, presence of water body, ground cover etc.) were noted including GPS location and the level of threats (fire, overgrazing, invasion of weed species, thatch extraction etc.) in the sampled area. This practice was repeated once every ten days at all potential areas where the evidence of the animal (pellet) was found.

3.5.1.3 Pellet Identification

Picture 1- Pellet of Hispid hare Picture 2- Pellet of Indian hare

The fecal pellets of both Hispid hare and Indian hare can found in same habitat as they are sympatric in many places. However they can be readily distinguished on the basis of their color, relative size and shape. The pellet of Hispid hare is large, flattened, rounded in shape and golden color whereas Indian hare pellets have small, often darker, elliptical or pointed end (Yadav, 2005).

3.5.1.4 Animal distribution

The animal distribution was observed on the basis of direct Observation, presence or absence of pellet group, tract and from interview with reserve staffs and forest users people specially security personal. Geographic location of the site of the pellet and the species observation were noted using GPS.

3.6.1.5 Threats and Conservation Measures:

Questionnaire survey was conducted among the park people, wildlife experts and local people explore the status information, survival threats and conservation measures of Hispid hare in SNP. Two sets of semi structured questionnaires were prepared for the presence or absence, status and habitat of their uses.

3.5.2 Secondary data collection

Secondary data were collected from published and unpublished journals, thesis, books regarding habitat preference, food ecology, etc by Hispid hare in SNP, Nepal.

3.5.3 Data Analysis

3.5.3.1 Pellet and population density

Pellet density and population density was estimated by following formula.

$$\text{Pellet Density}\left(\frac{\text{N}}{\text{ha}}\right) = \frac{\text{Total Pellet Groups}}{\text{Transect Area} \times \text{Transect Number}} \times 1000$$

$$\text{Population Density(per ha)} = \frac{\text{Observed Pellet Density in Specific Time Period}}{\text{Estimated Defecation Rate for Same Time Period for Single Animal}} \times 1000$$

4.5.3.2 Habitat Preference

Habitat preference was calculated by following Formula. (Aryal *et al*., 2012)

$$\text{Habitat preference(HP)} = \frac{\text{Pellet present in each habitat type}}{\text{Total pellet present in all habitat type}} \times 100$$

3.5.3.3 Vegetation Analysis

For vegetation analysis of the Hispid hare habitat, layout of transects and plots were same except for the plot shape and size. 10mx10m for tree layer, 4mx4m for all woody undergrowth to 3m in height.1mx1m were used for grass species The data were used for calculating the frequency, relative frequency, and relative density by using following formula. (Yadav, 2005)

$$\text{Frequency of 'A' Species} = \frac{\text{Number of Quadrates in which Species A occur}}{\text{Total Number of Quadrates}} \times 100$$

$$\text{Relative Frequency (RF)} = \frac{\text{Frequency of Species A}}{\text{Sum of Frequency of all Species}} \times 100$$

$$\text{Density of Species 'A' } = \frac{\text{Frequeny of Species A in All Quadrates}}{\text{Total Number of Quadrates } \square \text{Size of Quadrates}}$$

$$\text{Relative Density of Species 'A' (RD)} = \frac{\text{Number of Individuals of Species A}}{\text{Total Number of Individuals of All Species}} \times 100$$

4. RESULTS

4.1 Population density

The average Population density of Hispid Hare in different study areas of Shuklaphanta National park before the fire (in winter) and after fire (in summer) was 0.1820/ha and 0.2208/ha respectively. The highest population density was found at Hirapurphanta (0.2252/ha) in winter and at Shuklaphanta (0.3186/ha) in summer (Table 1).

Table 1- Population density of Hispid hare in different study sites within Shuklaphanta National Park during 2015-2016.

S.N.	Study Sites	Population Density (/ha)		Surveyed Area (m^2)		Average Density/ha	
		Winter	Summer	Winter	Summer	Winter	Summer
1	Pipariya	0.1461	0.2032	1520	1640	0.182	0.2208
2	Barcaula	0.1586	0.1602	1400	2080		
3	Shuklaphanta	0.1983	0.3186	2240	2440		
4	Hirapurphnata	0.2252	0.2923	1480	1520		

4.2 Habitat Utilization

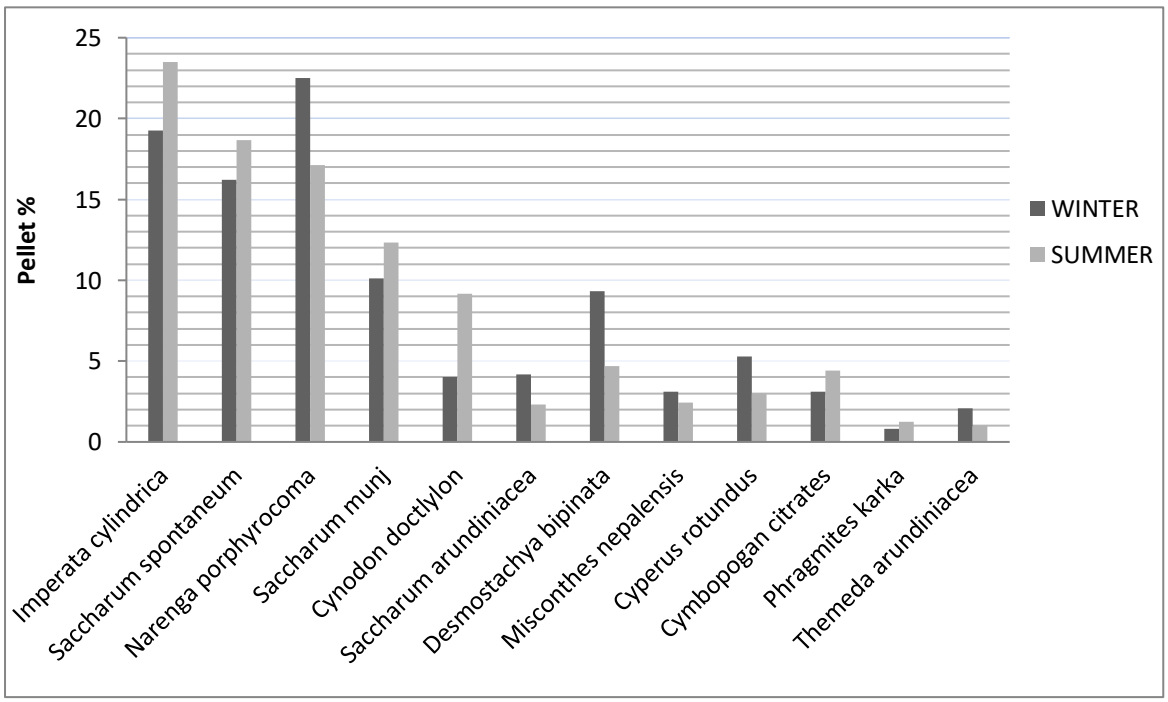

Figure 3- Grass preferred by Hispid hare

Altogether, there were 12 grass species found in Hispid hare habitat in Pipariya , Barcaula, Shuklaphanta and Hirapurphanta area, *Narenga porphyrocoma (*RF-23.45%) was most dominant species of Hispid hare habitat followed by *Imperata cylindrica* (RF-22.75%) in winter and *Imperata cylindrica* (RF-23.89%) followed by *Saccharum spontaneum* (RF-23.21%) in summer in Pipariya site whereas in the Barcaula site most dominant species was *Naranga prophyrocoma* in both winter and summer season (RF-31.17% in winter and RF-25.50% in summer) followed by *Imperata cylindrica* (RF-14.03% in winter and RF-17%in summer) and *Saccharum spontaneum* (RF-11.22% in winter and RF- 14.27% in summer) in both seasons.

In Shuklaphanta site, most dominant species was *Imperata cylindrica* in both seasons (RF-22.72% in winter and RF-24.09% in summer) followed by *Saccharum spontaneum* (RF-22.27% in winter RF- 22.65% in summer) and *Saccharum munj* (RF-13.86% in winter and RF-13.86% in summer). Similarly, in Hirapurphanta most dominant species was *Imperata* (RF-41.01% in winter and RF-34% in summer) followed by *Saccharum spontaneum* (RF-24.19% in winter and RF-15.41% in summer) and *Cynodon dactylon* (RF-13.98% in winter and RF-27.21% in summer).pellets were seen high no in *Narenga* grass (22.56%) in winter season and in summer season more pellets % was found in *Imperata cylindrica* (21.48%) during the field visit most of soft part of stem of *Narenga* grass, leaves of *Cynodon dactyl*on, *Imperata cylindrica* and inner core of the *Saccharum spontaneum* was eaten as food by Hispid hare.

4.3 Distribution of Hispid hare in reference of Water Bodies

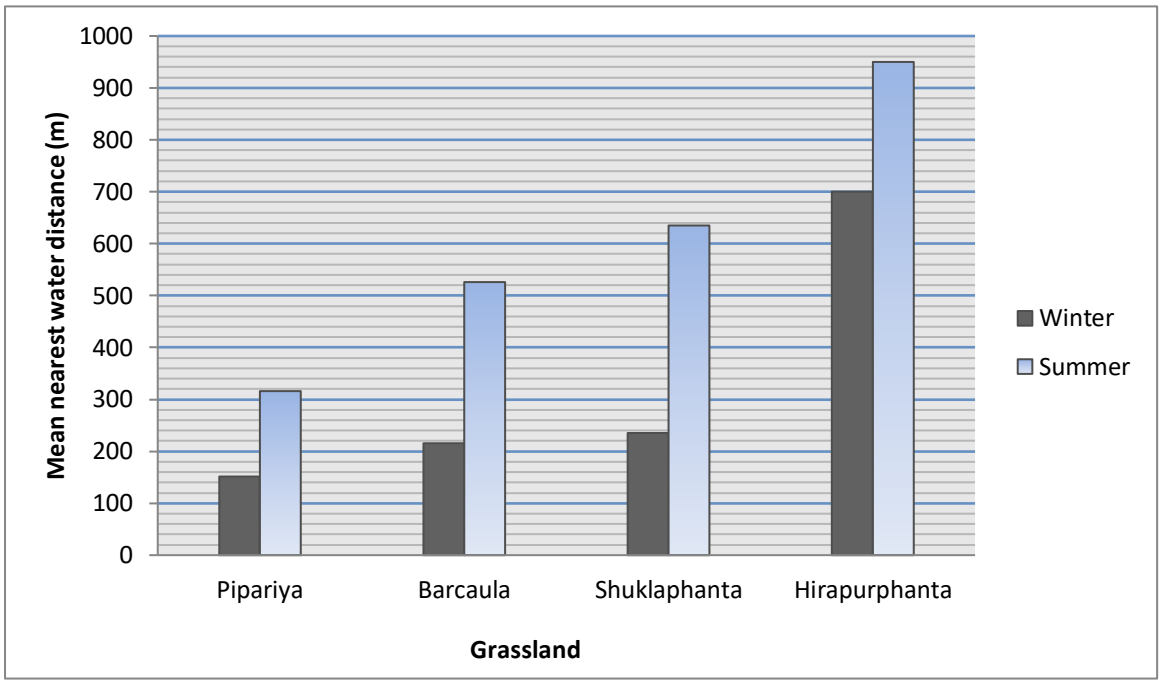

Figure 4- Mean nearest water distance in different study sites, in SNP.

Hispid hare distribution was found on distance from water bodies that ranged from 151m to 700m mean distance in winter and 315m to 900m mean distance in summer. Hirapurphanta had the highest distance from water source (mean distance 700m to 900m in winter and summer).

In the field observation no any evidence including pellets were seen near the water sources. After fire, more pellets were found far from the water sources(200m to 900m) compared to before fire (100 m to 600 m).Hispid hare signs were more frequently found in areas distant from water if new grown grass existed compared to when only unburned grass was present. This suggest that Hispid hare benefit from the water content of new growth grasses enabling them to expand their range away from water sources after fire.

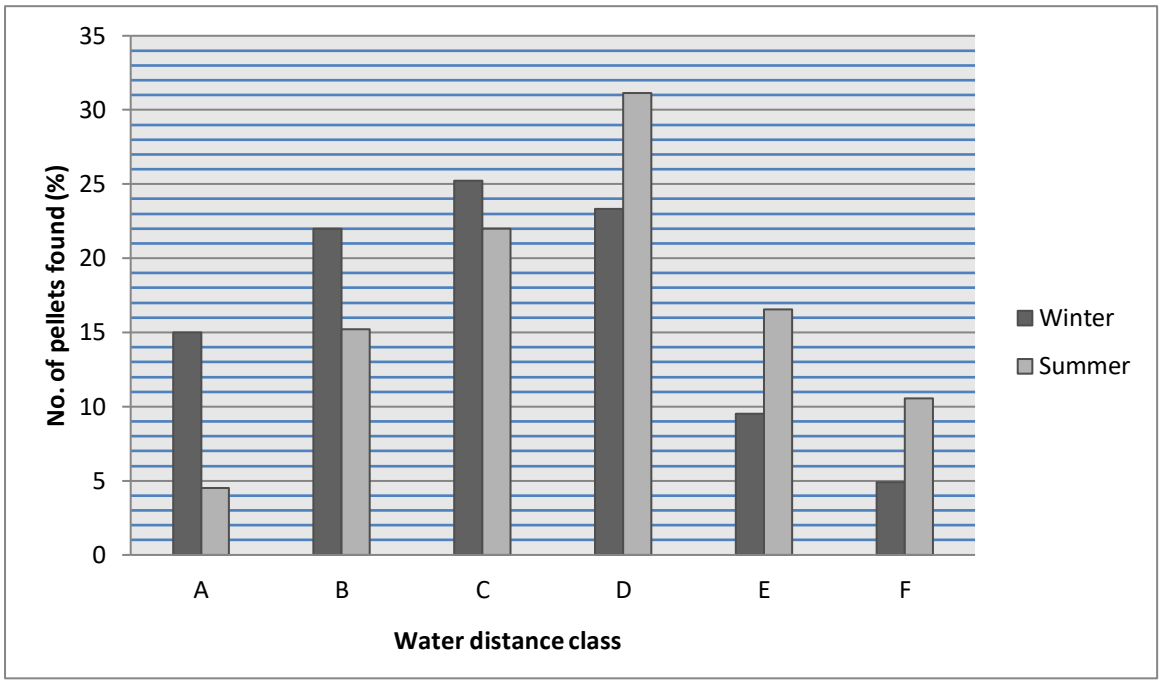

Figure 5- Water distance preference by Hispid hare in SNP.

Regarding the nearest water distance, from where the pellets were found were classified into 6 categories, **Viz: A (0-100), B (101-200), C (201-300), D (301-400), E (401-500), F (>500)**. Whereas the hare mostly preferred the water distance of class **C** (25.23%) in winter and Class **D** (35.67%) in summer (fig. 5).

4.4 Ground cover

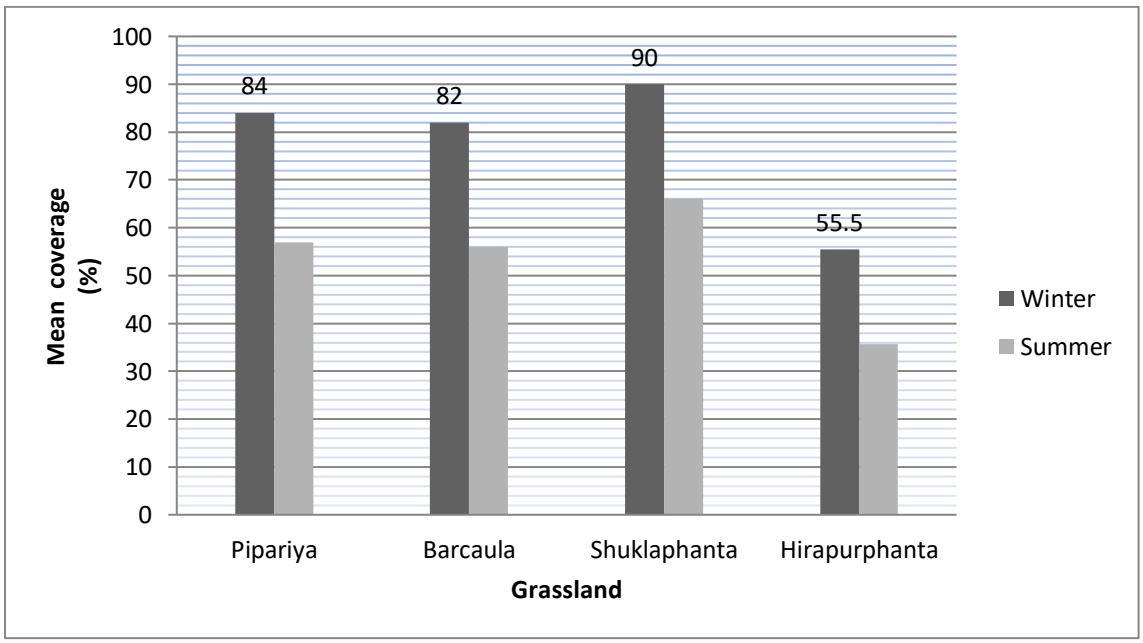

Figure 6 - Mean coverage percentage of plant species in study areas.

Pellet groups deposition rate is generally increased when the density of ground cover increases from the moderate to dense**.** In addition to the feeding grounds, hares need cover against predators and places for breeding to successfully thrive. (Yadav, 2005) Shuklaphanta had the highest coverage percentage (90%) in winter and (66%) in summer, whereas Hirapurphanta had the least coverage (55.50%) in winter and (35.65%) in summer season.

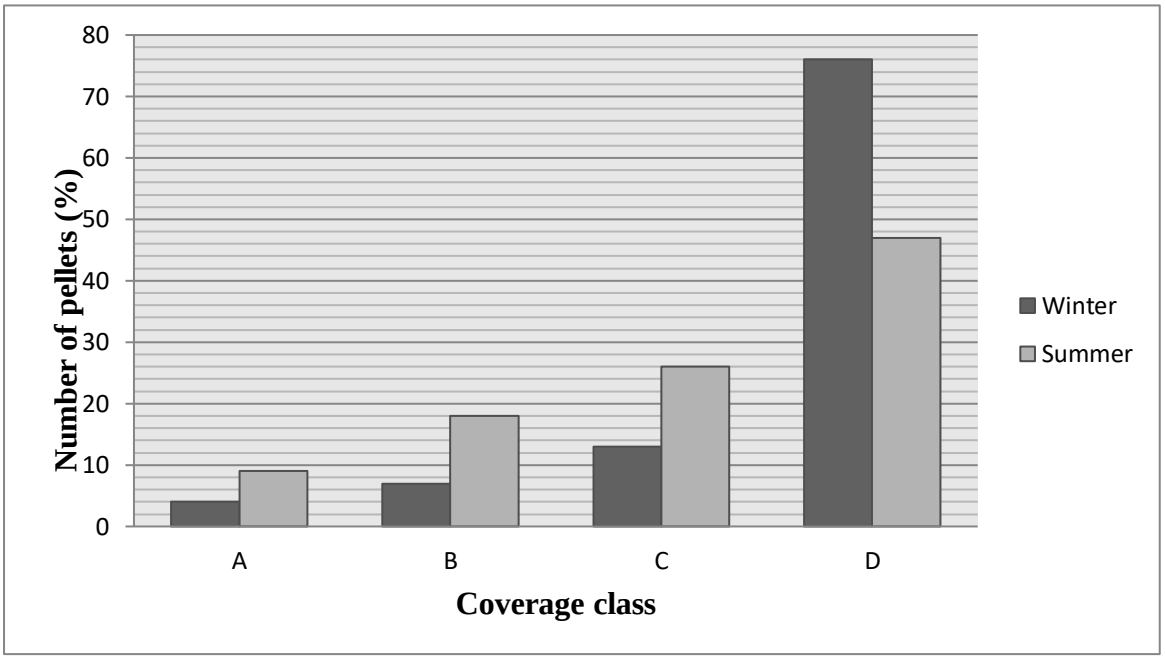

Figure 7- Mean coverage percent of plant species in study sites, in SWR.

Regarding to the ground coverage The coverage percentage of the habitat preferred by hispid hare were classified in to 4 classes, **Viz: A (0-25%); B (26-50%); C (51-75%); D (>75).**The species was found to prefer the high coverage area, because most of pellet (76% in winter& 47% in summer) of the pellets were found in the area with coverage more than<75% (Fig. 7).

4.5 Habitat type and Utilization

The Habitat found to be utilized by Hispid hare was classified into 4 category.

1) Tall Grassland (Containing grasses of 2-6 m height)
2) Short Grassland (Grass height from 25cm to 2m)
3) Open Grassland (Grasses of < 25cm height)
4) Forest (Dominated by trees of any species)

Four different types of habitats were selected from study area for the observation of the Hispid hare pellets. Total number of plots in each habitat types in both winter and summer seasons with and without pellets and habitat preference values.

Table 2: Number of plots in each habitat type, plots with pellet in winter and summer season and habit preference (HP) value.

S.N	Habit types	Total No. of plot		Plots with pellets		HP (%)	
		winter	summer	winter	summer	winter	summer
1.	Tall Grassland	108	95	83	89	70.51%	42.74
2.	Short Grassland	36	73	9	61	22.93%	38.12
3.	Open Grassland	28	31	2	13	6.55	19.13
4.	Forest	13	11	0	0	0	0
Total		185	210	94	163		

Among 4 different habitat types, Tall Grassland (both in winter and summer) was most preferred (HP value 70.51% in winter and 42.74% in summer) followed by Short Grassland (HP value 22.93% in winter and 38.12% in summer) and open Grassland (HP value 6.55% in winter and 19.13% in summer). But I failed to collect pellets from Forest during the study period in both winter and summer season.

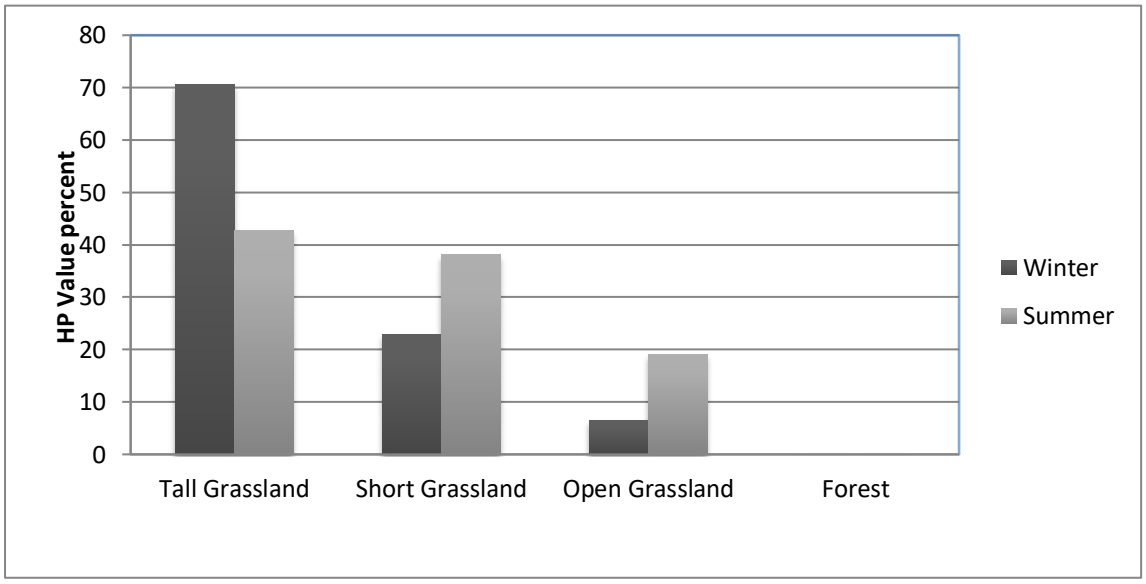

Figure 8- Graph showing the Habitat utilization by Hispid hare in winter and summer season

4.6 Existing threats

4.6.1 Grassland burning

A total of 100 respondents were questioned to gather the information on existing threats for the survival of Hispid hare in SNP. Majority of these (43%) blamed for the fire as the major threatening cause for survival of the species. Generally Reserve has been practicing controlled burning during the Dec-Jan for the grassland management. This is coinciding with the main breeding season of the Hispid hare. This may be the major declining factor to the Hispid hare population in SNP.

Picture 3- Grass land fire in Hispid hare habitat

4.6.2 Overgrazing

Grazing pressure is another major threat of the Hispid hare in Shuklaphanta Wildlife Reserve. Whereas 20% of the respondent pointed for the grazing pressure from the surrounding villages mainly let their unproductive cattle (cow, Bull, Buffalo) inside the park for grazing which degrades the habitat and cover for wild animals particularly the cover dependent species like Hispid hare.

Picture 4- Grazing pressure

4.6.3 Flood

Most of the preferred areas of the species were in grassland due to heavy rainfall in the monsoon, providing less suitable and completely destroyed the grasses of the some parts of Shuklaphanta as a result of which the condition becomes unsuitable for nesting and movement of hare species. In the Shuklaphanta, the Mahakali River enters into some parts of Reserve (Specially Pipariyaphanta) which created major effect on the habitat of Hispid hare.

Picture 5- Flooding inside grassland of SNP.

4.6.5 Thatch collection

Every year during the winter, the reserve provides permission to local people to collect the grass in an unsustainable way from reserve area that creates pressure on grassland of the park. High pressure of people creates tramping effect and disturbance for the Hispid hare. This may change composition of species.

4.6.6 Invasion of plant species

Invasion of the grass land by weed is becoming major issue for Shuklaphanta Wildlife Reserve. It is one of the prominent threats large patches of grassland are invaded by tree like shrub and *Bombax ceiba,* which are playing vital role in habitat loss. If management practices are not carried out in time all grassland maybe replaced by those broad leaved species.

5. DISCUSSION

Hispid hare is one of the less studied endangered small mammal species of the world. Historically the species was distributed throughout the southern lowland of Nepal to Uttar Pradesh, West Bengal to Assam of India. We do not have good evidence of its distribution in different protected areas of Nepal except Shuklaphanta National park and Bardiya National Park.

Due to less in number and isolated population it is less explored. Nepal considered it protected by law but its survival and conservation threats are never evaluated. The park people interaction during Kharkhadai and confusion with common hare species has caused the declination of its number and survival. Direct count of hare is not a suitable method to determine its distribution on a fine grained scale (Burnham *et al.*, 1980 and Buckland *et al*., 1983). Hispid hare is nocturnal animal (Aryal and Yadav, 2010). So the population estimation and direct census is very difficult. Therefore, in the present study, pellet count transect, questionnaires method were applied to explore Hispid hare distribution and habitat use and also assessed key threat factors for this species in SNP.

In the present study four study site`s within a survey area of 1.58 ha were selected and Strip transects were laid randomly to determine presence/ absence of Hispid hare by recording pellets and other indirect evidences. Each Transect was 20m long and 2m in width on either side of then transects line that was taken into consideration for counting pellet groups. 185 plots were used in winter and 210 plots were used in summer for calculation of population density. It was calculated on the basis of second time count method after 10 days interval the pellets were counted in the first time survey and cleared out the plot for the second time survey. Only fresh pellet we used to calculate the population density. A total 257 pellet groups including fresh and old were found in both season (94 pellet groups in winter and 163 pellet groups in summer).

The present population density of Hispid hare before and after fire was 0.1820/ha and 0.2208/ha respectively whereas as Bell (1987) reported a population density of 6.10/ha in this region. This indicates the population density is decreasing as compared to Bell. The reason behind decline hare population is unscientific burning of grass, invasion of grassland by Broadleaved trees, grazing, and flooding and thatch collection. Previous

study of Yadav (2005), and Aryal *et al.* (2012) found these existing threats as major causes of population decline in SWR.

Similarly Yadav (2005) reported a population density 1.01/ha. This study also showed that the main food species consumed by Hispid hare is *Narenga pophyrocoma* and ground cover is dense in dry places rather than wetland. Most of the pellets were found in the average distance 600m from water and no pellets were closer then 290m to water. Hispid hare preferred only Tall grassland. The current study showed Hispid hare preferred Tall grassland, short grassland and open grassland and water distance ranged from 151m to 700m mean distance in winter and 315m to 900m mean distance in grass existed when only unburned grass was present. This suggest that Hispid hare benefited from the water content of new growth grasses enabling them to expand their range away from sources after fire which is similar to the findings of Aryal *et al.* (2012).

Similarly, Tandan (2009) reported a population density of 0.45 individual/ha in Bardiya National Park before burning and 0.967/ha after fire burning. Besides this Hispid hare mostly preferred open area rather than Tall grassland habitat. It mostly preferred Riverine and open area in winter and Tall grass in summer season. Poor park management,

predation and flooding were found major threats. In this study, Hispid hare mostly preferred Tall Grassland (HP value 70.51% in winter and 42.74% in summer), Short Grassland (22.93% in winter and 38.12% in summer), and open Grassland (HP value 6.55% in winter and 19.13% in summer) in both summer and winter seasons. Aryal *et al.* (2012) reported 0.06 individuals/ha, with a maximum total SWR population of 219±40.

Maheswaran (2002) in Jaldapara Wildlife Sanctury reported population density 0.087/ha. Recentally Nath and Machary (2015) reported population density of 3.81/ha in Manas National park India. Comparing these studies, it appears that SNP has the less current Hispid hare population density. I failed to collect fresh pellets in transect one week after burning, which is perhaps due to lack of cover and food. Maheswaran (2000) also found that Hispid hare use recently burnt grassland patches less then tall grassland areas. But evidence of Hispid hare feeding was recorded during the field survey.

From my study Hispid hare preferred by Tall grass lands during winter and summer, similar to the observations of (Aryal *et al.*, 2012). Occurrence of pellet groups was more

in areas where ground was dense, away from water resources, as observed by (Yadav 2005, Aryal *et al*., 2012; and Nath and Machray, 2015).

The reason behind declining the population is unscientific grass burning and cutting. The grassland of SNP has been burned in each year of the December-January. The literature shows that the breeding season seems exactly coinciding with the grass burning season. Therefore unscientific burning practice has been playing an important role for the decline of Hispid hare population. According to survey and information collected from local people, Reserve staff and Army personal, major reason of decline of Hispid hare populations was Fire 43%, 20% Grazing and rest other factors. The park authority has only concerned with mega fauna and swamp deer. There is lack of proper management system including small mammal like Hispid hare. Besides this existing threats like fire, over grazing, thatch collection, flood may be the reason in declining population of Hispid hare. Apart from pellets of Hispid hare pellets of many other large animals were recorded. Habitat of my study sites were also found to be used by these animals.

From this study, the selected site Shuklaphanta seems higher coverage percent and Hirapurphanta has been less coverage during the winter season. Not all grasslands could be surveyed, by potentially dangerous animals including Asian Elephant, Greater One-horned Rhinoceros (*Rhinoceros unicornis)*, Tiger (*Panthera tigris*). Nevertheless, the information generated during this preliminary ecological study provides baseline information, which will help in planning future studies and in guiding efforts by the park authority to set up of effective conservation measures for this rare, endangered species.

6. CONCLUSION

The present study was conducted in Shuklaphanta National park of Kanchanpur district, located in the Far-western Terai, on the southwestern edge of Nepal. The study was done in both winter season and summer season. A total of 185 plot in winter and 210 in summer were used in four Study sites to count the (fresh and old) pellet groups and vegetation analysis.. The average population density of hare was found to be 0.1820/ha in winter and 0.2208/ha in summer. The vegetation analysis where the pellet groups presence revealed that the species highly dominant Grass *Imperata cylindrical* (19.17% pellets in winter and 23.48% pellets in summer) species *Narenga porphyrocoma* (17.13% & 22.56% pellets in winter and summer) as a main food species and *Saccharum spontaneum* (16.23% pellets in winter and 18.31% pellets in summer).

Among four different habitat types Hispid hare showed highest preference to the Tall grassland before fire and after fire (HP value 70.51% in winter and 42.74%). Pellets were also found in Short grassland (HP value 22.93% in winter and 38.12%) with open land (HP value 6.55 in winter and 19.13%) pellets were apparently absent from forest during winter and summer sea son. After fire more pellets were found far from the water sources (Average distance 700m to 900m) compared to before the fire (Average distance 151m to 700m). found in the Regarding to the ground cover the species mostly found in high coverage area 67% pellets in winter and 47% of pellets were area, with > 75% coverage. Mainly the annual burning fire (43%), overgrazing (20%), flooding and invasion by woody plant were found as the major threats to the species.

7. RECCOMMNDATIONS

Following Recommendation were drawn from the study.

- Education material development: Hispid hare is little known and only a few people (mostly the conservationists) actually know about it. To raise the awareness about Hispid hare among the mass an information brochure on Hispid hare should be developed. The brochure should contain all the general information about Hispid hare- like what (which) is Hispid hare, its classification, distribution (with maps), habitat biology, conservation status, threats, difference between hare and rabbit, difference between Hispid hare and Common hare etc. It should include the ways how one can help to conserve the highly endangered Hispid hare and its habit.
- Annual grass burning should be done consideration for following points. i) Burning must be made under close observation of the park staff. ii) Proper patch burning in the same phantas rather than widespread burning so that the species like Hispid hare can get shelter.iii) Burning must be done avoiding the breeding season of Hispid hare.
- Some programmers of cutting and digging whole root of woody plant species has been done by park. but it seems insufficient, therefore programmers must be launched.
- A check dam should be constructed at the point where the Mahakali River enters into SNP. This is a most dangerous situation for Suklaphanta and for the phanta's animals, like Hispid hare and others.
- To reduce the grazing pressure, stall-feeding for buffaloes and other cattle should be encouraged in the adjacent villages.
- Improved management of grasslands in the buffer zone will help decrease the pressure on the reserve grassland and forest.
- Very little research has been conducted about Hispid hare, so the intensive study on biology and behavior and its habitat requirement is necessary to conserve this species in the long- term survival in Nepal

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APPENDICES

Vegetation analysis of Two seasons of the Hispid hare habitat

Frequency, Relative frequency, Density and Relative Density of Grass species.

I. Table 3: Shuklaphanta site`s Grass species Analysis of Winter season

S.N.	Grass species	Frequency	RF	Density	RD
1.	*Saccharum spontaneum*	98	22.27	26.8	22.94
2.	*Imperata cylindrica*	100	22.72	29.56	25.99
3.	*Desmostachya bipinata*	40	9.09	9.78	8.60
4.	*Narenga porphyrocoma*	49	11.13	19.13	16.82
5.	*Saccharum munja*	61	13.86	9.1	6.69
6.	*Misconthes nepalensis*	36	8.18	6.95	6.11
7.	*Cynodon doctylon*	24	5.45	5.45	4.79
8.	*Cyperus rotundus*	32	7.27	9.13	8.02

II. Table 4 : Shuklaphanta site`s Grass species Analysis of summer season

S.N.	Grass species	Frequency	RF	Density	RD
1.	*Saccharum spontaneum*	94	22.65	18.71	19.63
2.	*Imperata cylindrica*	100	24.09	23.71	24.11
3.	*Desmostachya bipinata*	32	7.71	12.71	12.96
4.	*Narenga porphyrocoma*	52	12.53	15.78	16.05
5.	*Saccharum munja*	54	13.01	9.13	8.42
6.	*Misconthes nepalensis*	31	7.46	5.00	5.08
7.	*Cynodon dactylon*	37	8.91	8.21	4.79
8.	*Cyperus rotundus*	15	3.51	4.40	8.02

III. Table 5: Barcaulasite`s Grass species Analysis of Winter season

S.N.	Grass species	Frequency	RF	Density	RD
1.	*Saccharum spontaneum*	36	11.22	11.54	12.63
2.	*Imperata cylindrica*	45	14.03	13.75	15.05
3.	*Saccharum arundinacea*	28.33	8.83	8.16	8.93
4.	*Narenga porphyrocoma*	100	31.17	19	20.79
5.	*Saccharum munja*	32	9.97	9.02	9.88
6.	*Desmostachya bipinata*	23.40	7.29	7.83	8.57
7.	*Themeda arundinacea*	18.66	5.61	6.59	7.21
8.	*Cymbopogan citrates*	21.85	6.81	6.59	8.78.
9.	*Cynodon doctylon*	15.5	4.83	7.62	8.34

IV. Table 6 : Barcaula site`s Grass species Analysis of Summer season

S.N.	Grass species	Frequency	RF	Density	RD
1.	*Saccharum spontaneum*	47	14.27	11.85	12.63
2.	*Imperata cylindrica*	56	17.00	11.92	15.05
3.	*Saccharum arundinacea*	17.16	4.85	3.38	4.57
4.	*Narenga porphyrocoma*	84	25.50	15.21	19.88
5.	*Saccharum munja*	38.37	11.65	9.30	9.88
6.	*Desmostachya bipinata*	11.23	3.40	5.0	8.57
7.	*Themeda arundinacea*	19.61	5.95	6.59	7.21
8.	*Cymbopogan citrates*	20.14	6.11	4.51	6.o8
9.	*Cynodon doctylon*	37	11.23	6.97	9.43

V. Table 7 : Pipariya site`s Grass species Analysis of Winter season

S.N.	Grass species	Frequency	RF	Density	RD
1.	*Saccharum spontaneum*	65	15.24	13.48	14.15
2.	*Imperata cylindrica*	97	22.75	14.62	15.34
3.	*Phaagmiteskarka*	25	5.86	7.78	8.16
4.	*Narenga porphyrocoma*	100	32.45	17.08	17.92
5.	*Saccharum munja*	38	8.91	10.51	11.03
6.	*Saccharum arundinacea*	42	9.85	10.86	11.40
7.	*Themeda arundiniace*	6.33	1.48	5.10	5.36
8.	*Cyperus rotundus*	27	6.33	8.13	8.53
9.	*Cynodon doctylon*	26	6.09	7.70	8.08

VI. Table 8 : Pipariya site`s Grass species Analysis of Summer season

S.N.	Grass species	Frequency	RF	Density	RD
1.	*Saccharum spontaneum*	95.52	23.21	20.97	17.35
2.	*Imperata cylindrica*	98	23.89	22.16	18.34
3.	*Pharagmites karka*	21.56	5.25	9.28	7.68
4.	*Narenga porphyrocoma*	81	19.74	16.92	14.00
5.	*Saccharum munja*	27	6.58	10.09	8.35
6.	*Saccharum arundinacea*	33.34	8.12	8.11	4.72
7.	*Themeda arundiniace*	3.44	0.83	3.35	2.77
8.	*Cyperus rotundus*	22	5.36	5.71	5.81
9.	*Cynodon doctylon*	29	7.06	17.16	14.20

VII. Table 9 :Hirapurphanta site`s Grass species Analysis of Winter season

S.N.	Grass species	Frequency	RF	Density	RD
1	*Imperata cylindrica*	100	41.01	30.05	38.21
2	*Saccharumspontaneu*	59	24.19	14.16	18.00
3	*Cynodon doctylon*	34.11	13.98	11.16	14.19
4	*Desmostachya bipinata*	27	11.07	8.72	11.09
5	*Themeda arundiniace*	14.31	5.86	7.91	10.06
6	*Saccharum arundinacea*	9.4	3.85	6.62	8.41

VIII. Table 10 : Hirapurphanta site`s Grass species Analysis of Summer season

S.N.	Grass species	Frequency	RF	Density	RD
1	*Imperata cylindrica*	100	34.0	38.09	36.17
2	*Cynodon doctylon*	80	27.21	19.71	18.72
3	*Saccharumspontenum*	45.32	15.41	16	15.19
4	*Desmostachya bipinata*	32.14	10.93	10.09	9.58
5	*Themeda arundiniace*	21.30	7.24	9.26	8.79
6	*Saccharum arundinacea*	15.19	5.16	6.	6.44

Form No

ANNEX-2

DATA SHEET OF PELLET SURVEY

Date: **Name of the Range post:** **Transect (20X2m belt)**

GPS: **Elevation:** **Distance to water: …m**

1. Specific Place: Habitat type: Plant species: ___

2. Soil Status- (a) Dry (b) Wet c) color d) texture e) Characters

3. Threats causes realized- (a) Cattle grazing (b) Grass harvesting(c) Fire/burning d) Weed invasion (e) Hunting (f) Others_____

4. Animal pellet info

S. N.	Status				No of Pellet	REMARKS (Size, shape, color, texture, arrangements)
	Very old	Old	Fresh	Very Fresh		
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

Other info_____

DATASHEET OF VEGETATION SURVEY

Form No **Date:**

Name of the Range post: **Transect (20X2m belt) No.** **GPS:**
Altitude: **Distance to water:** **m**

1. General habitat type- (a) Tall grassland (b) Short grassland ☐ (c) Open grassland ☐

(d) Forest (e) Others_____

2. A list of plant species and their items eaten by hare (inside quadrates)

S.N.	Plant name	Scientific name	Parts used	No. of plant	Remarks

QUESTIONNARIRE SURVEYABOUT THE HISPID HARE& ATTITUDE

Form No. Date

Name:_____ Sex: M/F/ Yrs.House Owner_____Sex: M/F

Occupation:_____Address: _____VDC/municipality, Village_____

Have you seen the HISPID HARE? YESNO; if yes, where_____number

What are pour perception about the hare, wildlife and national park_____

_____

Is the hare frequently seen and abundant ? Yes __No____; if yes, where (area & habitat)_____

_____

If no, why_____

Causes: Poaching_____, Fire__, Flood, disease_, others_____

Park management effect any ?_____

Who is responsible for its management ?if Park, how it should be_____

Are you aware of the wildlife importance and park regulations? (Describe)_____

_____

If Park management is okay, what should be promoted further? Local initiation?How_____

_____

Why it should be conserve? Any benefit?_____

What are your suggestions to conserve the species?_____

_____

What is your view for wildlife for examples:

S.N.	Animal species	Killed	Conserve	Cant's say	Remarks
1	Swamp deer				
2	Spotted deer				
3	Wild bore				
4	Elephant				
5	Hispid hare				
6	Blackbuck				

Population Status and Habitat preference of…….

……. Nepal.

TEMPERASTURE & WEATHER SHEET 2015

Date	Time	Temperature		Weather				Remarks of the day / Night
		Max.	Min.	Morning	Noon	Evening	Night	

Population Status and Habitat preference of…….

…… Nepal.

Q. Size 1x1 Quadrate plant lists Date

Common Name	Scientific Name	DBH	Height	Crown cover	Remarks