# POPULATION STATUS, HABITAT PREFERENCES AND CROP DEPREDATION BY BLACKBUCK (*Antilope cervicapra*, LINNEAUS 1758) IN BLACKBUCK CONSERVATION AREA (BCA), NEPAL.

Geeta Sharma

T.U. Registration No: 5-2-0037-0972-2011

T.U. Examination Roll No: 314/2072

Batch: 2072

A thesis submitted

In partial fulfilment of the requirements for the award of the degree of Master of Science

in Zoology with special paper Ecology

Submitted to

Central Department of Zoology

Institute of Science and Technology

Tribhuvan University

Kirtipur, Kathmandu

Nepal

August, 2019

TRIBHUVAN UNIVERSITY

# CENTRAL DEPARTMENT OF ZOOLOGY

Kirtipur, Kathmandu, Nepal.

☎ 01-4331896

Ref.No.:

## RECOMMENDATION

This is to recommend that the thesis entitled "**POPULATION STATUS, HABITAT PREFERENCES AND CROP DEPREDATION BY BLACKBUCK** (*Antilope cervicapra*, **LINNEAUS 1758) IN BLACKBUCK CONSERVATION AREA (BCA), NEPAL**" has been carried out by Geeta Sharma for the partial fulfilment of Master's Degree of Science in Zoology with special paper Ecology. This is her original work and has been carried out under my supervision. To the best of my knowledge, this thesis work has not been submitted for any other degree in any institutions.

Date: Aug. 2, 2019

Dr. Nanda Bahadur Singh
Professor
Central Department of Zoology
Tribhuvan University
Kirtipur, Kathmandu, Nepal

ii

## LETTER OF APPROVAL

On the recommendation of supervisor "Dr. Nanda Bahadur Singh" this thesis Submitted by Geeta Sharma **"POPULATION STATUS, HABITAT PREFERENCES AND CROP DEPREDATION BY BLACKBUCK (***Antilope cervicapra***, LINNEAUS 1758) IN BLACKBUCK CONSERVATION AREA (BCA), NEPAL"** is approved for the examination and submitted to the Tribhuvan University in partial fulfilment of the requirements for Master's Degree of Science in Zoology with special paper Ecology.

Date: Aug 2, 2019

..........................................

Dr. Tej Bahadur Thapa

Head of Department

Central Department of Zoology

Tribhuvan University

Kirtipur, Kathmandu, Nepal

TRIBHUVAN UNIVERSITY ☎ 01-4331896

# CENTRAL DEPARTMENT OF ZOOLOGY

Kirtipur, Kathmandu, Nepal.

Ref.No.:

## CERTIFICATE OF ACCEPTANCE

This thesis work submitted by Geeta Sharma entitled "**POPULATION STATUS, HABITAT PREFERENCES AND CROP DEPREDATION BY BLACKBUCK** (*Antilope cervicapra*, **LINNEAUS 1758) IN BLACKBUCK CONSERVATION AREA (BCA), NEPAL**" has been accepted as a partial fulfilment for the requirements of Master's Degree of Science in Zoology with special paper Ecology.

### EVALUATION COMMITTEE

Supervisor
Dr. Nanda Bahadur Singh
Professor
Central Department of Zoology
Tribhuvan University
Kirtipur, Nepal

Head of Department
Dr. Tej Bahadur Thapa
Professor
Central Department of Zoology
Tribhuvan University
Kirtipur, Nepal

External examiner
Dr. Ramesh Prasad Sapkota
Assistant Professor
Central Department of Environmental Science
Tribhuvan University
Kirtipur, Nepal

Internal Examiner
Dr. Laxman Khanal
Assistant Professor
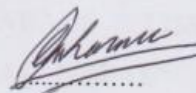Central Department of Zoology
Tribhuvan University
Kirtipur, Nepal

Aug. 6, 2019

iv

# DECLARATION

I hereby declare that the work presented in this thesis has been done by myself, and has not been submitted elsewhere for the award of any degree. All sources of information have been specifically acknowledged by reference to the author (s) or institution (s).

Date: 2 August 2019

Geeta Sharma

# ACKNOWLEDGMENTS

# ABSTRACT

Population status, habitat preferences and crop depredation by Blackbuck (*Antilope cervicapra*, Linneaus 1758) which is one of the protected mammals of Nepal known as Krishnasar, inhabits in semi-arid open habitat with grassland in Blackbuck Conservation Area (BCA) Nepal was done from January-May, 2018. Study was studied by using direct observation and questionnaire methods by using some simple instrument like GPS, camera, binoculars and measuring tape. In the area of 5.25 $km^2$, maximum (253) Blackbucks were recorded in winter season and 240 were recorded in summer season. The ecological and crude density in winter was found to be 142.93 individuals / $km^2$ and 48.19 individuals / km; respectively. Similarly, it was 135.59 individuals / $km^2$ and 45.71 individuals / $km^2$ in summer. Male to female sex ratio was 1:1.67 and 1:2.05 in summer and winter; respectively. The average herd size of 17.14 individuals was recorded on 14 herds during the summer. Similarly, 17 herds were in winter with average 14.88 individuals during the winter. Total Pellets were recorded in 24 spots throughout the study period inside the BCA, Khairapur of which maximum 37.5% were recorded in block A, 33.33% in D, 25% in E and remaining 4.17% in block F. In this study, 23 species of flora from 14 different families were recorded of which, 13 species were herbs, 4 species shrubs and 6 species trees. Perennial grasses like *Cynodon dactylon* and *Imperata cylindrica* was dominated. Block A was most preferred followed by block D, E and F. Crop loss by Blackbuck was observed mostly in summer season. The mostly depredated crops were lentils, followed by mustard, vegetable in winter whereas paddy in summer. Estimated crop loss was $2920.45 per annum in both seasons. Blackbuck was the most encountered wildlife in the field that caused most of the damage to the crops. 78% farmers found that Blackbucks were active in the fields at nights for crop depredation, and 22% specify that Blackbucks raided their fields at daytime. Some commonly used methods were shouting and using noise making tools as clappers and drums, scaring device like scarecrow, guarding at nights, using fire and electric lights in the fields and throwing stones and, Machen forming.

**Key word: Blackbuck, Status, Habitat assessment, Crop depredation, Protective measures**

**TABLE OF CONTENTS**

# LIST OF TABLES

# LIST OF FIGURES

# ABBREVIATION

BCA= Blackbuck Conservation Area

BNP= Bardiya National Park

BUC= Babai User Commeette

CA= Conservation Area

CITES= Convention on International Trade in Endangered Species

DFO= Divisional Forest Officer

DNPWC= Department of National Parks and Wildlife conservation

GIS= Geographic Information System

GPS= Global Positioning System

IUCN= International Union for Conservation of Nature

$Km^2$= Square kilometer

KrCA= Krishnashar Conservation Area

NPWC= National Parks and Wildlife Conservation

PA= Protected Areas

PBCA= Protected Blackbuck Conservation Area

RD= Relative Density

TATR= Tadoba-Andhari Tiger Reserve

VNP= Velavadar National Park

# 1    INTRODUCTION

## 1.1    Species introduction

The Blackbuck (*Antilope cervicapra*, Linneaus 1758), locally known as Krishnasar, is one of the 27 protected mammals of Nepal (NPWC Act 1973).It is an elegant gazelle like antelope belongs to the member of family "Bovidae", subfamily "Antilopinae" and order "Artiodactyla", is medium sized antelope native to Indian sub-continent. India has largest Blackbuck population with estimated 50,000 Blackbucks and its population is gradually increasing in recent decades. But in Nepal Blackbucks are confined in a tiny single population in southern Bardiya known as Khairapur (Khanal 2002). Government has already declared it as conservation area targeting conservation of the last remaining population and site for Blackbuck (DNPWC, 2014). The scientific name Antelope is restricted to Blackbuck only. It is classed as protected under the National Parks and Wildlife Conservation Act 1973 in Nepal. It is nationally assessed as Critically Endangered (CR) in Nepal (Jnawali *et al*. 2011). Mungal (1978) described four species of *Antilope cervicapra* according to the coat, color, length and the shape of the horn with distribution. They are; *Antilope cervicapra cervicapra* (South India), *A. cervicapra centralis* (Central India), *A. cervicapra rupicapra* (North India and Nepal) and *A. cervicapra rajputane* (North-West India and Pakistan)

## 1.2    Distribution

The Blackbuck in Nepal was once considered extinct fromits former habitats until reports (Dinerstein 1975) and (Wegge and Welson 1976) revealed at least two separate populations in Banke and Bardiya districts. The main causes of loss of Blackbuck have been attributed to encroachment, fragmentation, habitat loss, habitat degradation, hunting and poaching (Shrestha 1997, Bista 1987; Majupuria and Majupuria, 2006). When the last remaining herd of Blackbuck was sighted at Khairapur area (Bardiya) in 1975, a team of five staff members (1 staff and 4 armed guards) were assigned with the task of protecting the area. Prior to the establishment of BCA in 2009, there was a continued joint effort on the part of the District Forest Office (DFO) of Bardiya and BNP (then Wildlife reserve) since 1975 for the conservation of Blackbuck. As directed by late King Birendra, a compensation of NRs. 100 per month was provided to affected local households to

compensate crop damage caused by Blackbucks (K. M. Shrestha Then Warden of BNP, pers.com).

Blackbuck (*Antilope cervicapra*) is native to parts of Nepal, India and Pakistan. Globally, there are 4 species of Blackbuck but in Nepal only one species i.e. *Antilope cervicapra* is found. Prior to the 19[th]century, Blackbuck was one of the most abundant ungulates in the Indian sub-continent with an estimated population of around 4 million (Long 2003).The main habitat of Blackbuck is open grasslands, dry thorn, bush lands and scrubland and its distribution occur throughout west Pakistan along the foothills of the Himalays from Punjab (Pakistan) through Uttar Pradesh (India) and Nepal to West Bangal (India) and East Pakistan (Lydekker 1924 and Chand 1999).Blackbucks are now restricted to isolated small area of Khairapur, Bardiya in a very limited number and remains in the situation of extinction. Increased human pressure and isolation of habitat has led to decrease Blackbuck population in Nepal (Khanal 2002).Historically in Nepal, Blackbuck roamed throughout terai commonly found in Eastern and Western region of Kanchanpur and Bardiya of Nepal (Pradhan *et al*. 1999) but later their population was declined and, they are confined in small pocket in Khairapur of Bardiya district. Small and isolated populations of wild animals are vulnerable to extinction through different factors like demographic, environmental and genetic stochasticity and catastrophes such as disease epidemics. Thus, this research work aims to find the population status and habitat use of Blackbuck in Blackbuck conservation Area (BCA).At the end of September 2015, population of Blackbuck was estimated to be 241 in Blackbuck Conservation Area, Khairapur Bardiya (Monthly count, BCA Bardiya). Because of restriction in very small isolated area of Khairapur, the gene pool of this species must be improved by exchanging populations from elsewhere for the existence in future.That's why, at present time, Blackbucks are reintroduced to Hirapurphanta of Shuklaphanta Wildlife Reserve, Kanchanpur (DNPWC, 2012). Few are in captive in central zoo, Mahendra Park, Nepalgunj mini zoo and semi-captive enclosures at Mrigasthali forest, Kathmandu (Khanal 2006).

## 1.3   Ecology, Morphology and Behaviour

Blackbuck is one of the few antelope species that exhibit pronounced sexual dimorphism (Grzimek 1972). Male have black and white pelage and large spiraling horns (Shrestha 2003). The brown areas in the males gradually darken with age finally becoming black (Prater 1965).  Its weight varies between 31 to 45 kg, that of adult female between 31 to

39 kg. Both sexes have white under parts, as well as a white ring surrounding the eyes and a white chin consisting of short tail (Ranjitsingh 1989). Male Blackbucks consist of horns which are marked with rings make these to force spirals in adults (Schaller 1967). They are mainly diurnal, but sometimes nocturnal and lives in groups. Matting is throughout the year with two peaks rutting season (July-August and February-March). Females are sexually mature at approximately 15 months and give birth to one fawn and gestation period lasts for a period of 6 months. Lifespan can be up to 18 years in the wild (Long 2003).

## 1.4    Population status of Blackbuck in Nepal

In 1967-68, two populations were sighted, one in Banke district close to Rapti river and the other in Mainapokhar area, about 15 km east of the Khairapur, Bardiya. Wegge and Wilson (1976) and Dinerstein (1975) observed two small separate herds of Blackbuck, in Bhagawanpur and Jamuni of Banke and the other at Khairapur, Bardiya. According to Bauer and Ellenberg (1988) population raised to a maximum of 190 individuals and then a decline in population started as the counts were162 (Subedi, 1991), and 92 in 1993 (Nepal, 1994). The chaotic fluctuation in the population of the Blackbuck at Khairapur continued, population increased to 102 in 1995 and 111 individuals in 1996 (Tamang and Shrestha, 1998) that again declined to 94 in 1998 (Chand, 1999), 40 in2000 (Khanal, 2002). However, after 2000 it started to grow number slowly up to 2002 while shooted up 109 2005. The population continuously increased to 133 and jumped to 184 in a year 2007, while a few increased in number in 2008 and reaches to 216 until 2009. The population then started to increase at slow rate and became 53 in 2001 (Khanal, 2002). Khanal (2006) recorded 133 Blackbucks. In 2011 there were 264 individuals according to Annual report, BCA and DNPWC 2012. Ban (2012) also recorded 264 species in BCA. Because of this, it is necessary to find out the actual habitat preferences of the Blackbuck that have major role in population fluctuation.
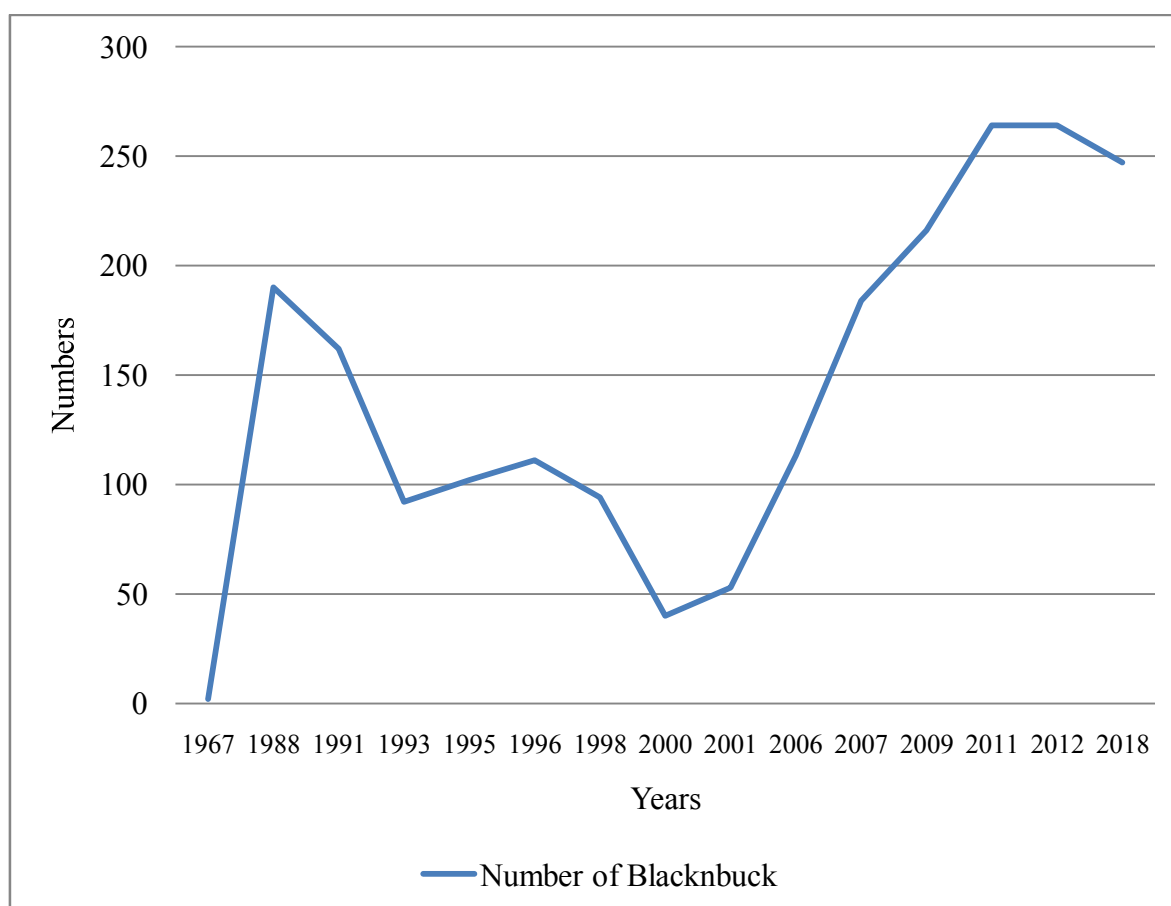
Figure 1: Population trend of Blackbuck (1967-2018)

## 1.5 Habitat preferences

Mainly, habitat is an ecological or environmental area that is inhabited by a particular species of animals or plants from where they obtain food, shelter, protection and mates for reproduction. It lives in open plains with low growing grasses and avoids hilly and dense forested areas (Ranjitsingh, 1989). So, population status of Blackbuck in Khairapur Bardiya is changes over time. So, it is necessary to do deep study about all type of habitat parameters and preferences in that Area.

## 1.6 Crop depredation

Human illegally graze livestock, collect firewood, grass and other forest products from the BCA. That's why, Blackbuck are forced to go to the human crop field. There was a total crop loss of 58883 kg by weight and a total economic loss of Rs. 2046779 per annum. Increased number of Blackbucks, food and water scarcity, search of palatable food by the Blackbucks and fodder harvest by the human, limiting factor like encroachment and fragmentation are the major causes of conflicts (Kafle 1998).

4

Blackbucks mostly raid crops during the nights. Shouting, making noise, guarding during nights, using fire, kerosene lamps and electric lights in the fields and throwing stones are mostly used techniques by the local people to minimize crop raid (Kunwar *et al* . 2015).

## 1.7 Objectives

**General objectives**

The aim of the study was to assess the population status, habitat preferences and crop depredation by Blackbuck (*Antilope cervicapra*, Linneaus 1758) in Blackbuck conservation area (BCA) Nepal.

**Specific objectives**
- ➢ To census the population status of Blackbuck species in the study area.
- ➢ To identify the habitat preferences of Blackbuck in the study area.
- ➢ To assess the crop damage and explore the protective measures for crop depredation by Blackbuck in study area.

## 1.8 Rationale of study

The recent population scenario of Blackbuck in BCA shows fluctuating trend, which is restricted within a small area of core habitat. The area is heavily encroached by human settlements, agricultural lands and community forests. The busy cart road also fragments the small habitat of Blackbuck and other small foot trails. Anthropogenic disturbances and livestock grazing are the other external forces that confine the distribution of Blackbuck to small area and increase Blackbuck-human conflicts. The threat of extinction increases as it is the only surviving population in their natural habitat in Nepal and can easily collapse due to habitat encroachment and fragmentation, disease epidemics and inbreeding. The knowledge on ecological valuation of Blackbuck and its beneficial impacts to the local people is must for its conservation. Hence, along with ecological study, community-based approaches are crucial for conservation of this animal as well as create positive impression among local people towards its conservation.

Study shows the fluctuating types of population trend in Khairapur Bardiya because of some reason like habitat encroachment and fragmentation. So, this study encourages for the immediate habitat assessment and habitat prediction by estimating latest population status of Blackbuck and to find out the actual habitat preferences of Blackbuck. In

addition, this study actually finalizes the impacts of Blackbuck in the study area and encourages taking effective step for the protection of crop as well as conservation of Blackbuck and finally it decreases the threats of extinction. Blackbuck has important ecological roles in grassland ecosystem. It has genetic, medicinal (horns and skin to cure liver and heart disease), scientific, aesthetic and recreational values.

## 1.9 Limitations of the study

➢ Night observation was not made due to security and technical problems.

➢ Sex of infant cannot be identified from far distance.

➢ Low visibility in winter season hampers the survey.

# 2    LITERATURE REVIEW

Wildlife and wilderness contribute the biodiversity within a certain ecosystem. Conservation strategies of wildlife involve the protection, preservation and judicious control of rare species in their natural habitats (Robert 1996). Overall, it ensures the protection of global ecosystem. Understanding and predicting wildlife-habitat relationship and identifying and protecting suitable ecological areas and landscapes to ensure the viability of wild populations is a foundation of wildlife management. The conservation and management of wildlife species is highly reliant on the geographic location of potential habitat.

Arockianathan and Balasundaram (2018) revealed the total sightings of 1112 total animals  with  203 Male adult, 657 Female adult, 126 Young males, 126 Young females and  animals were sighted  in  14.87 Sq.kms of Ranebennur Black Buck Sanctuary is located in Ranebennur Taluk of Haveri District, Karnataka. This study also revealed more number of Black bucks from (June to January) may be because, it was rainy and winter season, there was abundance of food and the habitat condition also congenial.  Gradual decline in the number of density of Black bucks in the months (February to May) may be due to scarcity of food and water, during hot months and hence there was a less citation of animals. Debata (2017) estimated population sizes and age structure of Blackbucks in an unprotected site of 61.21km² in Odisha over a period of one year (October 2012 to October 2013).  A total of 7,134 individuals in 366 herds were documented ranging from a single individual to the largest herd of 51 animals.  Average herd size was 19.49±0.03 (SE) and ranged from 13.34±0.06 in summer to 31.86±0.07 during the monsoon.  Sex ratio was skewed towards females by 3:1. The large population of Blackbuck was estimated outside the protected are. Baskaran *et al*. (2016) studies, Spatial and dietary overlap between Blackbuck (*Antilope cervicapra*) and feral horse (*Equus caballus*) at Point Calimere Wildlife Sanctuary, Southern India: between December 2012 and June 2013, if the ecological conditions in the study site favour competition between these two species by assessing their spatial distribution pattern, population density, and estimated Population density of 50 (95% CI 41.6–60.6) Blackbucks and 21 (15.2–30.0) feral horses per km2 of the sanctuary. Similarly, he found food plants such as *Cloris parpata*, a grass species, and herb *Desmodiam* dry florae, the principal food of Blackbuck. Mohammed *et al*. (2016) studied the crop damage by Blackbuck in and around Chitta Reserve forest of

Bidar, Karnataka. The result of this study was the Blackbuck frequently raid the agricultural fields and causes extensive damage. The most affected crops are sugarcane, pigeon pea and vegetables; particularly in summer months. The farmers in the area are facing loss of cash crop. Isyaran (2007) found Group size varied extensively both among and within populations. Analyses of spatial variation in-group size suggested that both forage and habitat structure influence group size: large-scale, among-population variation in-group size was primarily related to habitat structure, while small-scale, within-population variation was most closely related to forage abundance. Analyses of individual behavior suggested that larger groups incur greater travel costs while foraging. Jhala and Isyaran (2016) found, Blackbuck are primarily grazers and can survive on seasonally low-quality diets (crude protein <3 %) by catabolizing proteins, and reducing movement and forage intake during summer. Blackbuck responds to an arid environment by producing concentrated alkaline urine and dry feces. However, they need to drink when forage water content is below 30 %. Blackbuck social organization is highly variable and appears to be strongly influenced by habitat. Blackbuck is suggestive of an antelope highly specialized to the short grass semi-arid biome. Ban (2012) studied the population status, seasonal habitat preference, conservation threats of Blackbuck and the crop loss by Blackbuck in marginal agricultural lands in BCA at Khairapur, Bardiya by direct count, indirect count, field survey and questionnaire method. She divided the realized habitat of Blackbuck (1.74 square kilometer) into 3 blocks A, B, C. In her study, it was observed that bock A was mostly used by animal followed by block C and block B respectively. The study focuses in the implementation of controlled and rotational livestock grazing in BCA as an effective wildlife management tool. Kunwar *et al.* (2015) studied the distribution probability of the species and predicted very few suitable habitats that only found in the Tarai region of Nepal. Suitable habitat mostly occurred in and around Blackbuck Conservation Area, around Bansgadi of Bardiya and south of it towards border of India. In Kanchanpur, grassland for Blackbuck was moderately favourable. Their analysis did not predict Hirapurphanta to be suitable for Blackbuck, where Blackbucks were translocated by the Government to be suitable for Blackbuck. Pachaskhalla, Pataha and Turantpur were most affected by the activities of Blackbucks. There was a total crop loss of 58883 kg by weight and a total economic loss of Rs. 2046779 per annum. Shouting and making noise are mostly used techniques by the people to minimize crop raid.

An early description of Blackbuck behaviour and activity was made by Schaller (1967), based on his observations of a Central Indian population (Kanha National Park, Madhya

Pradesh) who reported two rutting (lekking and display of males) and two calving seasons of Blackbuck in a year. Mungal (1978) monograph presented a review of research done by workers in different parts of the world on captive and introduced, free-ranging Blackbuck. It is the most comprehensive report yet available on the biology of Blackbuck. She detailed descriptions of age classification (from dentition and field observations), activity, anatomy, and lactation, and presented some information on certain aspects of physiology (e.g. oestrus cycle), based on her studies on introduced populations in Texas, U. S. A. Later, Ranjithsingh (1989) reviewed the distribution and population status of Blackbuck in India, based on personal observations and from Forest Department records. Rahmani (1991) compiled information on distribution and populations of Blackbuck in India based on information collected during the Great Indian bustard (*Ardeotis nigriceps*) survey that he had undertaken, and from Forest Department records and various literature.

Studies on aspects of Blackbuck ecology and behavior that are relevant to this study are summarized here. Prasad (1987) examined the activity budgets of a Blackbuck population occupying an agrarian landscape in Mudmal, Andhra Pradesh. Some times of the day in certain seasons were not sampled during that study and his observations seem to have been made largely opportunistically. He did not find any seasonal variation in time investment in feeding by Blackbuck. Feeding activity constituted the greatest proportion; however, it was much lower than what has been generally reported for ruminant ungulates in the tropics (Owen-Smith 2002). Chattopadhyay and Bhattacharya (1986) studied the seasonal diet of Blackbuck population in Ballavpur in West Bengal, India, based on fecal pellet analysis. They reported seasonal shifts in diet of Blackbuck, similar to that reported by Schaller (1967) in Kanha National Park and Mungal (1978) in Texas. Howery *et al.* (1989) reported that the Blackbuck in Texas calved throughout the year, without any distinct monthly or seasonal pattern. Jhala (1991) studied the habitat and population dynamics of wolf and Blackbuck in VNP. He studied the nutritional ecology of Blackbuck in VNP using feeding trials (Jhala 1997), and made detailed observations on captive animals, complementary to field observations. He found seasonal changes in digestibility of forage, in addition to seasonal changes in their diet in VNP. Isvaran and Jhala (2016) studied the lekking behaviour of Blackbuck in VNP and assessed the mating strategy in Blackbuck and reported lekking to be a flexible mating system in Blackbuck. With this background of information that was available on Blackbuck behavioural ecology, this study was planned. Its focus was on reproductive seasonality in Blackbuck,

activity patterns and time investment in different activities, and the effects of harvesting and grazing on grassland productivity and quality in VNP

Ungulates divide a day's time for various activities that include foraging, resting, travelling, vigilance, and other social interactions (Jarman 1974). The daily activity pattern of an ungulate is influenced by energy requirements, distribution of food, predators and thermal stress (Bunell and Gillingham 1985). The time spent by ungulates in different activities is influenced by two major factors: the energy demands of the ungulate and the constraints that the ungulate encounters (Bunnell and Gillingham 1985). The former would be influenced by age, sex, weight, and physiological state of an ungulate. The latter would encompass daylight time, ambient temperature, anatomical (such as type of mouth parts and size of rumen) and metabolic attributes, potential predation, time demands of social interactions such as displays and motheryoung interactions (Jarman and Jarman 1973). Importantly, abundance, quality, and distribution of forage, in time and space, would greatly influence the activity patterns and time investment of ungulates in different activities (Arnold 1985). Low abundance of food would result in higher time spent searching for it and low quality of food would lead to lower energy gained per unit food ingested, and also higher would be the time invested in searching for appropriate food (Arnold 1985, Bunnell and Gillingham 1985 , Owen-Smith 2002). The spatial distribution of forage would affect the movement of ungulates from one patch to another and also the time spent searching for these patches (Owen-Smith 2002). This search for food patches may lead them to areas of high predation risk and thereby they might need to invest more time being vigilant against predators.

 High ambient temperature could place thermal stress on ungulates and may affect their daily activity patterns, and in particular, their foraging activity (Parker and Robbins 1985). Foraging increases thermal load through muscular activity and exposure to direct and indirect solar radiation. The higher the ambient temperature over body temperature, the more difficult it is to dissipate heat (Schmidt-Nielsen 1997). In ruminant ungulates, body size determines the rumen size and capacity (Demment and Van Soest 1985). The rumen capacity limits the amount of food an ungulate can ingest at any given time. Therefore, once the rumen is full, the ungulate would not be able to ingest more food until the rumen can accommodate more food.

Dinersetin (1975) and Wegge and Wilson (1976) revealed the existence of two small remnant population of Blackbuck in the Bardiya and Banke districts respectively, of the Western Terai in Nepal. Ranjitsinh (1989) estimated 45000 animals in India. He

estimated the weight of Blackbuck which varied between 35-45 kg in males; adult female was between 31-39 kg. The male Blackbuck measured 70-80 cm in shoulder region. Bhandari (1994) assessed the food habitat of Blackbuck in BCA, the result showed that the average intake of crops in winter season were much higher (45%) than during summer season (33%). Utilization of grasses in the summer season was 68% and during the winter, it constituted 46%. He also recorded that number of livestock in Blackbuck habitat increased to 1100-1200.Baur and Ellenberger (1988) recorded the total livestock grazed in the Blackbuck habitat at Khairapur were 811 (671 Cows, 108 Buffaloes and 32 Goats).Prasad (1987) investigated the territoriality in Blackbuck, for two years in 6 individually identified territorial bucks at Mudmal, Andhra Pradesh. The territory size varied from 3.33 ha -16.55 ha with mean size of 9.19ha. Minimum territorial period was five weeks, while the maximum was 9.5 months. All territories had characteristics "Scrapes" i.e. shallow depression about 20 cm deep, 80 cm long and 30 cm wide dug by males with the hooves of the forelegs, digging 2-3 times each with the first one and then the other.

Schaller (1967) reported that short grasses, such as *Chrysopogon, Paspalum* and *Sporobolas* composed the bulk of the diet for Blackbuck in Kanha National Park. He reported that, grazing is more frequent in females than in male Blackbuck which concede with Nair (1975) statement, lying out period was more frequent in males than in females. He also reported that the breeding season is a minor peak in April and more intense peak from August to October. Rahmani (1989) mentions that crop damage by Blackbuck are a major issue. He also recommended the translocation of wildlife from the locally abundant population to provide genetic vigor to depleted population as an important management tool in future. Bharucha and Asher (1993) reported that the herd size and structure of Blackbuck is in a constant state of flux. The activity pattern of ungulates is influenced by the age, sex, pasture and climatic condition. He also included that in protected areas where Blackbuck population show an upward trend, they become increasingly dependent on adjacent cropland, leading to increasing man-animal conflict due to localized intense crop damage. According to him, the general principle for the Blackbuck habitat management should aim at encouraging the animals into smaller interlinked populations rather than into single, fragmented, highly density aggregations. Kafle (1998) studied the conflict between Blackbuck and local people in Khairapur village and found that the people living within 1km distance received the maximum loss, 91% of the respondents claimed that pulses were totally destroyed by Blackbuck. Khanal (2002) has conducted

the research on habitat options for the conservation of the last remaining Blackbuck population in Nepal with the help of field survey, direct observation and questionnaire methods and identified different location as the potential translocation sites in the Suklaphanta Wildlife Reserve of Kanchanpur district. All together 32 species with 12 species of forbs, 9 species of grass, 4 species of shrubs and 7 species of tree were recorded inside BCA. According to the study, total estimated population of Blackbuck was 65 with male to female ratio of 1:1.95. Khanal (2006) studied the population status of Blackbuck at Khairapur, Bardiya by the direct observation method from April to July 2006 for detail. The total population of Blackbuck during that period was 133 with the crude population density of 25.33 individuals/ $Km^2$ and the ecological density of 75.14 individuals/ $Km^2$ at the core habitat. The average herd size was computed to be of 7.64 individuals per herd. The male to female sex ratio was 1: 1. 29.

# 3 MATERIALS AND METHODS

## 3.1 Study Area

The study was done in Blackbuck Conservation Area in the western Terai of Khairapur ward no. 2, 3, 4 and 5 of Gulariya Municipality in Bardiya district Nepal which is the only Conservation Area in lowland of Nepal. It is located between 28.25056-28.25284N and 81.332375-81.329805E at a distance of 30km east of Bardiya National Park.
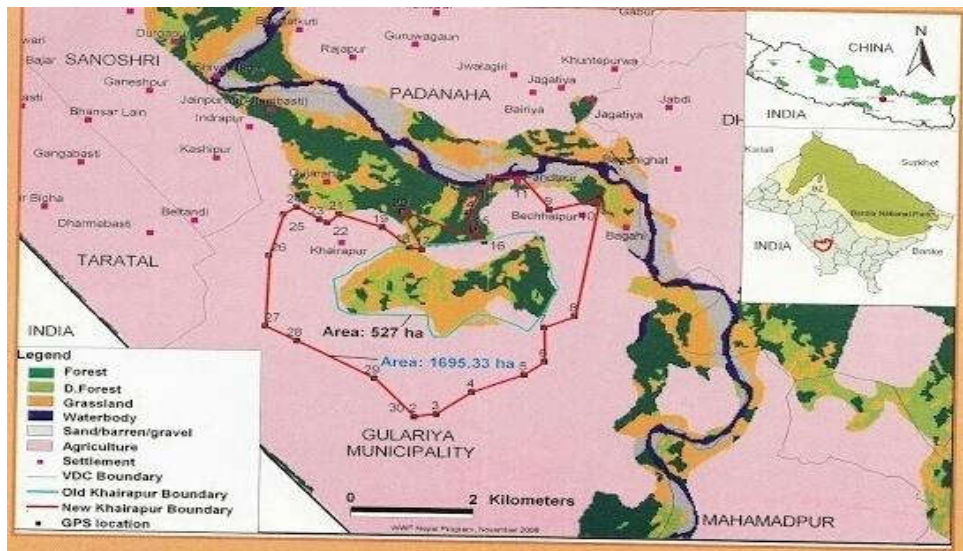


Figure 2: Map of BCA, Khairapur, Bardiya (Source: DNPWC, 2009)

It was established in 2009 and covers an area of 16.95km$^2$ which includes the core habitat of 5.25km$^2$ and peripheral area of villages and settlements spreading over 11.68 km$^2$.

## 3.1.1 Topography and Drainage

The old Babai riverbed, locally known as 'Sarju Nadi', runs along the west, north and south of the study area. The area mostly contains marginal agricultural land and grazing land bordered on the 3 sides by the old riverbed and on the other side by scrub jungle (Lehmkuhl 1979). Topography of the study area is more or less flat land, sloping towards the South with an elevation of average 146m above mean sea level. The Blackbuck habitat is situated at thick bow bend of old babai riverbed, locally known as Pataha phanta.

13

### 3.1.2 Climate

The climate is tropical monsoonal receiving monsoon rain coming from the Bay of Bangal. BCA has a tropical monsoon climate. The rain-bearing wind blows from the east and the western Terai generally receives less rain and tends to have a shorter monsoon, normally lasting from June to September. Three distinct seasons have been identified here: hot season (mid-Feb to mid-June), monsoon season (mid June to late Sept) and cool, dry season (Oct to mid-Feb).

#### 3.1.2.1 Rainfall pattern

Average annual rainfall is 1155mm (Ban 2012). The mean annual rainfall at Rani Jaruwa Nursery of Bardiya, as recorded for 1 year shows the mean annual rainfall during monsoon season (June September) was recorded high.
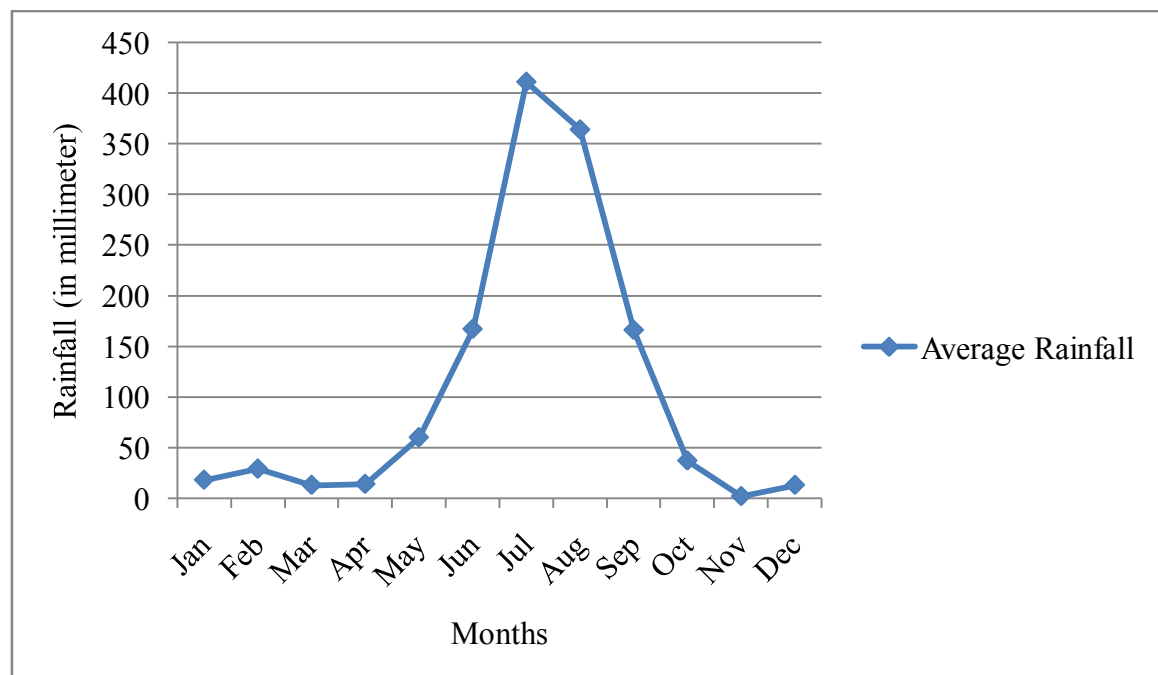


Source: Department of Hydrology and Metrology, GoN, 2018.

Figure 3: Mean annual maximum and minimum rainfall in Bardiya district Nepal

#### 3.1.2.2 Temperature

The average annual maximum and minimum temperatures recorded in 2017 were 38.8º C and 12.3º C, respectively.

### 3.1.2.3 Water resources

The area is generally flat with a gentle slope towards the south. Stagnant water is available in the old riverbed of Babai River (Sarju Nadi) almost throughout the year. Many of the water bodies, however, dry up during summer (March-June).

### 3.1.3 Flora and Fauna

The study area consist of few patches of forest land which include Khair (*Acacia catechu*), Sissoo (*Dalbergia sissoo*), Simal (*Bombax ceiba*) and Bamboo (*Bambusa vulgaris*) and open grazing land that include *Imperata cylindrica*, *Desmodium* as dominant and other important species are *Cynodon dactylon, Cyperus sps, Seteria glauca, Rotala* sps (Ban, 2012).

Similarly, fauna found in the study area are Blackbuck (*Antilope cervicapra),* Common Leopard (*Panthera pardus*), Palm Squirrel (*Funambulus pennati*), Brown Hare (*Lepus nigricollis*), Stripped Hyena (*Hyaena hyaena*), Jackal, Rhodents, birds like Black Ibis (*Pseudoidis papillosa*), Pond Heron *(Ardeola grayii*), Little Egret (*Egretta garaetta*), and Common Peafowl (*Pavo cristatus*)

### 3.2 Materials

1. Binoculars (20x50mm)     2. Digital Camera
3. Measuring Tape           4.GPS

### 3.3 Methods

The study was carried out through direct field observation and questionnaires.

### 3.3.1 Population status

Intensive, field work was carried out for two times. Initial survey was done in second week of January, 2018 for one week and second visit was done in month of May of the same year. From this detailed field survey, population status in potential area was estimated by direct observation and count method. The intensive grazing of Blackbuck was observed and population was counted in the morning (6am-9am), day (12pm-2pm) and in evening (4pm-6pm). The study area was divided into six blocks. In each block, direct observation was done by recording GPS readings. During survey attempts was not only to count Blackbuck number but also sex differentiation, habitat in which they are

found, vegetation they feed was also recorded too. Hiding in bush, climbing trees and observation from view tower was done to avoid the disturbance. Herd size was estimated by dividing the total number of Black bucks counted during the observation period by the total number of herds observed.

### 3.3.2 Habitat preferences

Habitat preferences survey was made by recording vegetation and Blackbuck signs such as footprints, pellets. In addition, binoculars were used to observe the animal from the far distance to record the grazing pattern and plants they feed. Vegetation sampling was done randomly in six blocks, based on recorded pellets. Floristic composition of the Blackbuck habitat was done by vegetation analysis. Vegetation analysis was done by laying quadrates in pellets recorded areas. Quadrates of 50x50m was used for trees, 20x20m was for shrubs and 1x1m for herbs.

### 3.3.3 Questionnaire survey

Informal interview with 150 individuals was conducted to know in depth of the crop depredation and to explore protective measures. The key informants included elderly persons, local leaders, community forest chairpersons or other committee members, school teachers etc. Mainly affected villages like Jainpur Bhagar tole, Sukumbasi Basti, Kaire post, Nimkathiya village Khairapur and Pachaskhalla Phanta were visited for questionnaire survey. Questionnaire survey data were summarized in Excel to get useful information and presented as tables or paragraphs in Microsoft Word.

### 3.3.4 Secondary data collection

Secondary data was collected from various published report and unpublished documents, thesis, internet.

### 3.4 Data analysis

Data collected from field were analyzed using different methods described below.

### 3.4.1 Estimation for Population status and distribution

Population status and distribution of Blackbuck was done by mapping geographic location of observed group or individuals with the help of GPS (Garmen Ertx 30). The recorded coordinates were later used to prepare distribution maps using Arc GIS v9.3.

### 3.4.2 Group size

The group size was calculated by the method described by Marten (1977). Total numbers of Blackbuck observed during the study period divided by a total number of groups observed.

### 3.4.3 Habitat preferences

Habitat preference of animal was determined on the basis of direct field observation. Presence of animals and their sign in different blocks was calculated for habitat preferences. Vegetation of different block was analyzed as described below.

### 3.4.4 Vegetation analysis

➢ **Density and relative density** (Zobel *et al*. 1987)

$$\text{Density hectare}^{-1} = \frac{\text{no.of individuals of species X 1000}}{Size of plot X total no . of plot sampled}$$

$$\text{Relative density (RD)} = \frac{\text{no.of individuals of species X 100}}{Total No . of individuals of all species}$$

➢ **Shannon's index of diversity**

It is a measure that takes into account species richness and proportion of each species within a zone. It is denoted by 'H'. Its equation is;

H' = - ƐPi (lnPi)

Where, H' = Shannon Index of Diversity

      Ɛ = Sum of species i to species R

      R = number of species

      Pi = fraction of entire population (N) made up of species I(n)

Since, the log of fraction is negative; the minus sign is inserted in the formula to convert the sum to a positive number. H ranges between 0-4.6. High values of H represents more diverse community.

# 4 RESULTS

## 4.1 Population status

Total individuals of Blackbuck in BCA were counted to be 247. Total 253Blackbuck were found in the month of January 2018, in winter season and 240in the month of May, in summer season. The total study area was 5.25 km$^2$;therefore, the crude density was 48.19 individuals / km$^2$ in January and 45.71 individuals / km$^2$ in May. However, the area of core habitat of Blackbuck in Pataha Phanta is only 1.77 km$^2$without the encroached residential and cultivated area; therefore, the ecological density of Blackbuck population in the study area was calculated 142.93 individuals / km$^2$ in January and 135.59 individuals / km$^2$ in May.
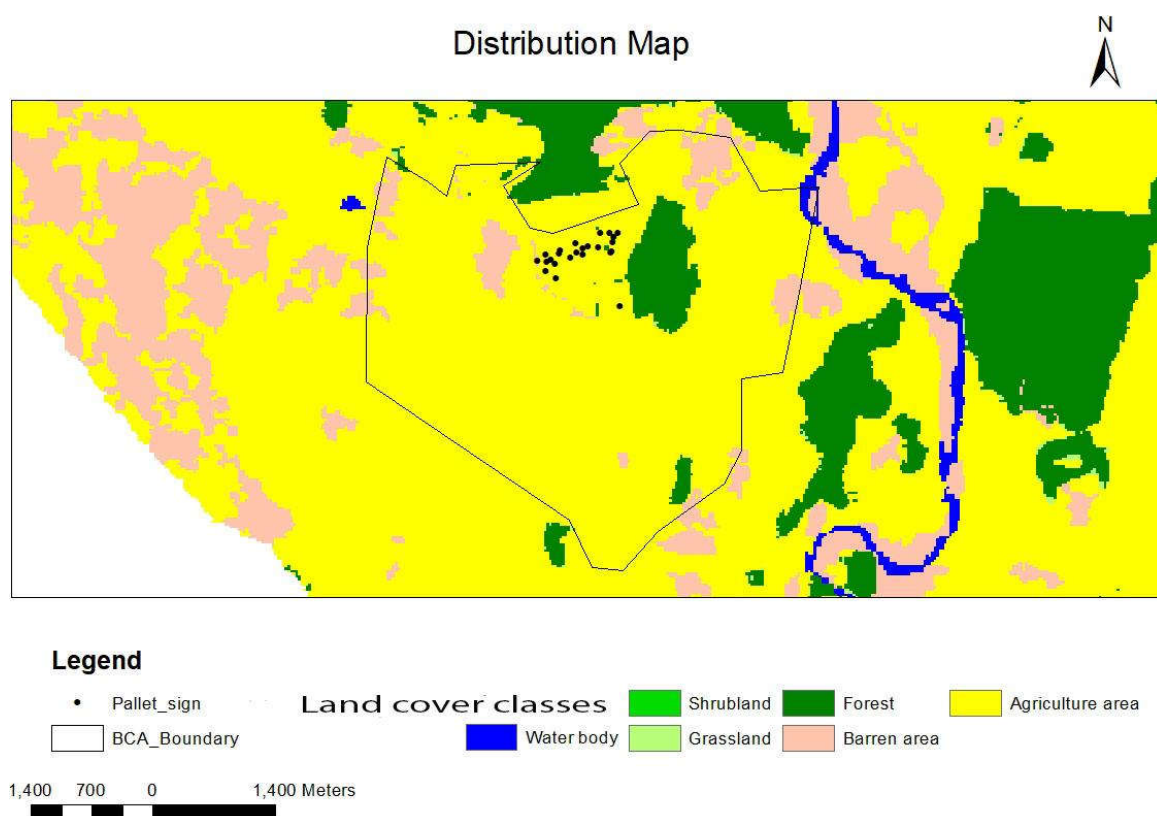


Figure 4: Pellets of Blackbucks recorded spots in BCA.

## 4.1.1 Age and Sex structure

Out of total population of Blackbuck in the summer (May), males were counted 81 (33.75%) and females were 136 (66.25%) thus, male to female ratio was computed to be 1:1.67. Among total recorded individuals of Blackbuck in summer, infants counted were 23 (9.58%). Similarly, in the winter season (January), males counted were 69 (27.27%) and female were 142 (56.13%).The sex ratio was 1:2.05 between male and female. The

variance (10.44) to mean (40) ratio was less than one (0.26) indicated uniform dispersion of Blackbuck in summer. Similarly, variance (7.9) to mean (42.166) ratio was less than one (0.18) in winter also indicated uniform dispersion. In both seasons wild population of Blackbuck in BCA, females were significantly more than males.

Table 1: Total population count of Black buck in BCA for two seasons

| Season | Particular | Block number | | | | | | Total |
|--------|-----------|----|----|----|----|----|----|-------|
| | | A | B | C | D | E | F | |
| summer | Male | 12 | 8 | 12 | 18 | 18 | 13 | 81 |
| | Female | 22 | 19 | 28 | 33 | 22 | 12 | 136 |
| | Infant | 3 | 5 | 0 | 5 | 10 | 0 | 23 |
| | Herd number | 2 | 1 | 3 | 2 | 5 | 1 | 14 |
| | Total | 37 | 32 | 40 | 56 | 50 | 25 | 240 |
| winter | Male | 14 | 5 | 10 | 15 | 12 | 13 | 69 |
| | Female | 28 | 22 | 23 | 35 | 22 | 12 | 142 |
| | Infant | 10 | 8 | 5 | 2 | 9 | 8 | 42 |
| | Herd number | 3 | 5 | 2 | 3 | 2 | 2 | 17 |
| | Total | 52 | 35 | 38 | 52 | 43 | 33 | 253 |

Total number of Blackbuck in 6 different blocks was 240 in summer season. In this season, 81 male Blackbuck, 136 female Blackbuck and 23 infants were recorded. Total herd size in this season was 14 (Table 1). Similarly, the total number of Blackbuck in 6 different blocks was 253 in winter season. In this season, 69 male Blackbuck, 142 female Blackbuck and 42 infants were found. Total herd size in this season was 17. The total number of Blackbucks in summer season was 240 (Table 1). Among them, almost in every block the populations of female Blackbuck are higher than the Male Blackbuck. In block A, the number of male is 12, female are 22 and infant is 3. In block B, the number of male is 8, female are 19 and infant is 5. In block C, the number of male is 12, female is 28 and infant were not found in this block. In block D, the number of male is 18, female are 33 and infant is 5. In block E, the number of male is 18, female are 22 and infant is 10. In block F, the number of male is 13, female is 12 and infant were not found in this block. In addition, large number of Blackbuck was found in block D (Table 1). During

summer 240 individuals of Blackbuck were counted thus the herd size of 17.14individuals was computed from 14 herds (Table 1). Similarly, 253 individuals were recorded in winter season thus the herd size of 14.88 individuals was found from 17 herds.

## 4.2 Habitat preferences

Total Pellets were recorded in 24 spots throughout the study period inside the BCA, Khairapur of which maximum 37.5% were recorded in block A, 33.33% in block D, 25% in block E and remaining 4.17% in block F; but no any pellets were recorded in both block B and C.

Table 2: Pellets recorded in spots of different blocks

| Blocks | Pellets recorded spots |
|--------|------------------------|
| A | 9 |
| B | - |
| C | - |
| D | 8 |
| E | 6 |
| F | 1 |
| Total | 24 |

### 4.2.1 Vegetation analysis

A total of 6 families of herbs were recorded which include 13 species and total number of herbs were 428 out of which maximum (n= 172) numbers of individuals were in family cyperaceae and minimum (n= 3) were in family Malvaceae. Similarly, 160 were in Gramineae, 65 in Euphorbiaceae, 19 in Leguminosae and 9 in Rutaceae.

| | Legumin osae | Euphorbi aceae | Gramine ae | Cyperac eae | Rutacea e | Malvace ae |
|---|---|---|---|---|---|---|
| ■ Numbers of various species | 19 | 65 | 160 | 172 | 9 | 3 |
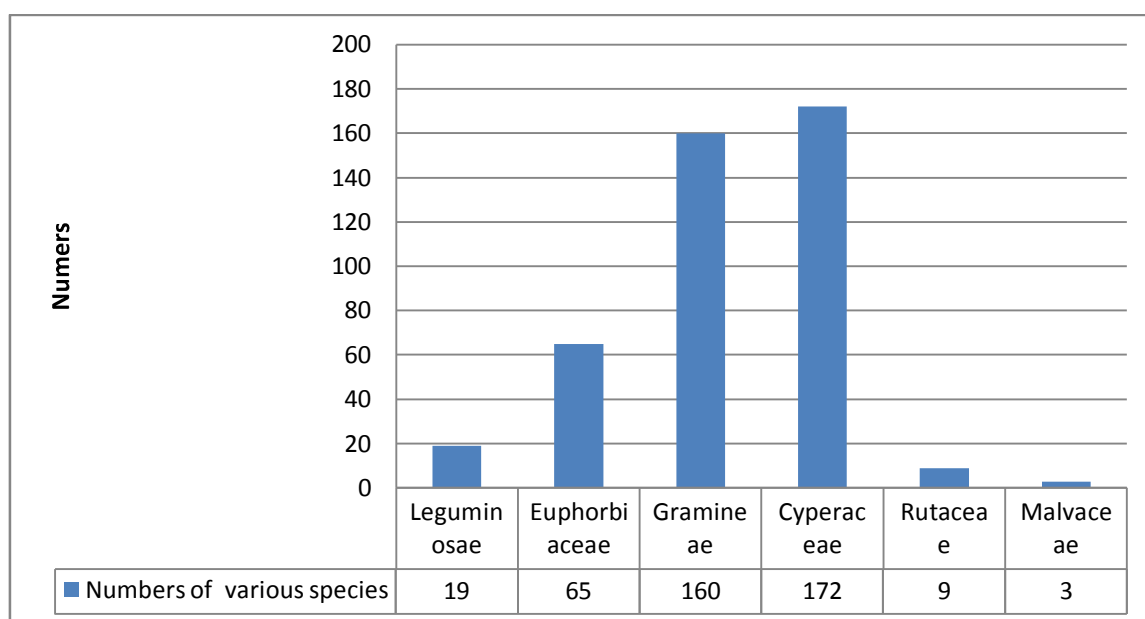
Figure 5: Herbs family and combine number of various recorded species

Family Euphorbiaceae consist only one species *Euphorbia hirta* ;Leguminosae consist of 3 species ; *Medicago lupulina, Medicago denticulre, Alysicarpus vaginalis;* Gramineae consist of 4 species; *Vetiveria zizonoides, Saccharum spontaneum, Echinocloa colonum, Digitaria adscendens;* Cyperaceae consist of 3 species;  *Imperata cylindrica, Cyperus cephalotus, Cynodon dactylon;* Rutaceae and Malvaceae consist of only one species; *Glycosmis pentaphylla, Sida cordata* respectively

Table 3: Density and relative density of herbs recorded in BCA, 2018.

| Family | Species | Number of species | Density per hectare (Individual/hectar) | RD | Shannon diversity index |
|---|---|---|---|---|---|
| Euphorbiaceae | *Euphorbia hirta* | 19 | 791.66 | 4.44 | |
| Leguminosae | *Medicago lupulina* | 22 | 916.66 | 5.14 | |
| | *Medicago denticulre* | 37 | 1541.66 | 8.64 | |

21

| | | | | |
|---|---|---|---|---|
| | *Alysicarpus vaginalis* | 6 | 250 | 1.40 | |
| Gramineae | *Vetiveria zizonoides* | 36 | 1500 | 8.41 | 2.2830 |
| | *Saccharum spontaneum* | 65 | 2708.33 | 15.18 | |
| | *Echinocloa colonum* | 37 | 1541.66 | 8.64 | |
| | *Digitaria adscendens* | 22 | 916.66 | 5.14 | |
| Cyperaceae | *Imperata cylindrica* | 89 | 3708.33 | 20.79 | |
| | *Cyperus cephalotus* | 18 | 750 | 4.20 | |
| | *Cynodon dactylon* | 65 | 2708.33 | 15.18 | |
| Rutaceae | *Glycosmis pentaphylla* | 9 | 375 | 2.10 | |
| Malvaceae | *Sida cordata* | 3 | 125 | 0.70 | |
| Total | | 13 | 428 | | |

Total 13 herbs species belonging to 6 different families were recorded. *Imperata cylindrica* has maximum (3708.33, individual/hectare) density with relative density 20.79

individual/hectare. The minimum (125, individual/hectare) density was of *Sida cordata* with Relative density 0.7, individual/hectare.

Table 4 : Density and relative density of Shrubs recorded in BCA, 2018

| Family | Species | Number of individuals | Density per hectare (Individuals/hectare) | RD | Shannon's diversity index |
|---|---|---|---|---|---|
| Rutaceae | *Glycosmis pentaphylla* | 8 | 16.66 | 12.90 | |
| Primulaceae | *Anagallis arvensis* | 19 | 39.58 | 30.64 | 1.3984 |
| Rhamnaceae | *Zizyphus mauritiana* | 32 | 66.66 | 51.61 | |
| Urticaceae | *Canabis sativa* | 3 | 6.25 | 4.83 | |
| Total | | 62 | | | |

A total of 4 family of shrubs were recorded, out of which maximum (n= 32) numbers of individuals were in family Rhamnaceae and minimum (n= 3) were in family Urticaceae. Similarly, 19 were in Primulaceae family and 8 were in Rutaceae family respectively.

All 4 Family consists of only one type of species likes Rutaceae; *Glycosmis pentaphylla*, Primulaceae; *Anagallis arvensis*, Rhamnaceae; *Zizyphus mauritiana,* Urticaceae; *Cannabis sativa* respectively. A total of 4 shrubs species belonging to 4 different families were recorded. *Zizyphus mauritiana* has maximum (66.66, individual/hectare) density with relative density 51.61individual/hectare. The minimum (6.25, individual/hectare) density was of *Cannabis sativa* with Relative density 4.83, individual/hectare.

Table 5: Density and relative density of Trees recorded in BCA, 2018

| Family | Species | Number of individuals. | Density per hectare (Individuals/hectare) | RD | Shannon's diversity index |
|---|---|---|---|---|---|
| Fabaceae | *Acacia catechu* | 2 | 1.66 | 8.33 | |
| | *Dalbergia sissoo* | 13 | 10.83 | 54.16 | |
| | *Acacia nilotica* | 1 | 0.83 | 4.16 | 1.1146 |
| Myrtaceae | *Syzygium cumini* | 2 | 1.66 | 8.33 | |
| Meliaceae | *Azadirachta indica* | 3 | 2.5 | 12.5 | |
| Malvaceae | *Bombax ceiba* | 3 | 2.5 | 12.5 | |

A total of 4 family of Trees were recorded, out of which maximum (n= 13) numbers of individuals were in family fabaceae and minimum (n= 2) were in family Myrtaceae. Similarly, 3 were in Meliaceae and Malvaceae family; respectively.

Family Fabaceae consist 3 species *Acacia catechu, Dalbergia sissoo, Acacia nilotica;* Meliaceae consists of only one species; *Azadirachta indica;* Malvaceae also consist of only one species; *Bombax ceiba;* Myrtaceae also consists of only one species; *Syzygium cumini,* respectively. A total of 6 trees species belonging to 4 different families were recorded. *Dalbergia sissoo* has maximum (10.83, individual/hectare) density with relative density 54.16 individual/hectar. The minimum (0.83, individual/hectare) density was of *Acacia nilotica* with Relative density 4.16, individual/hectare.

## 4.3 Crop depredation

Blackbuck raided all the croplands inside the Conservation area (CA) and to some extent to those that surrounded the CA boundary. Villages inside the Conservation area; Pachaskhalla, Pataha was most affected by the activities of Blackbucks. While outside the CA, Bhagartaal and Nimkothia were most raided villages by this species.

Humans, on the other hand illegally graze livestock, collect firewood, grass and other forest products, and use the habitat of Blackbuck as road and ride bicycles and motorcycles as means of transportation inside the CA to reach to their residents. Among 150 households, agriculture was the only source of livelihood for 18% % households whereas 66.66 % households were dependent on agriculture and livestock for their living. The 15.33 % households were serving in other sectors in nearby industrial towns or district headquarters.
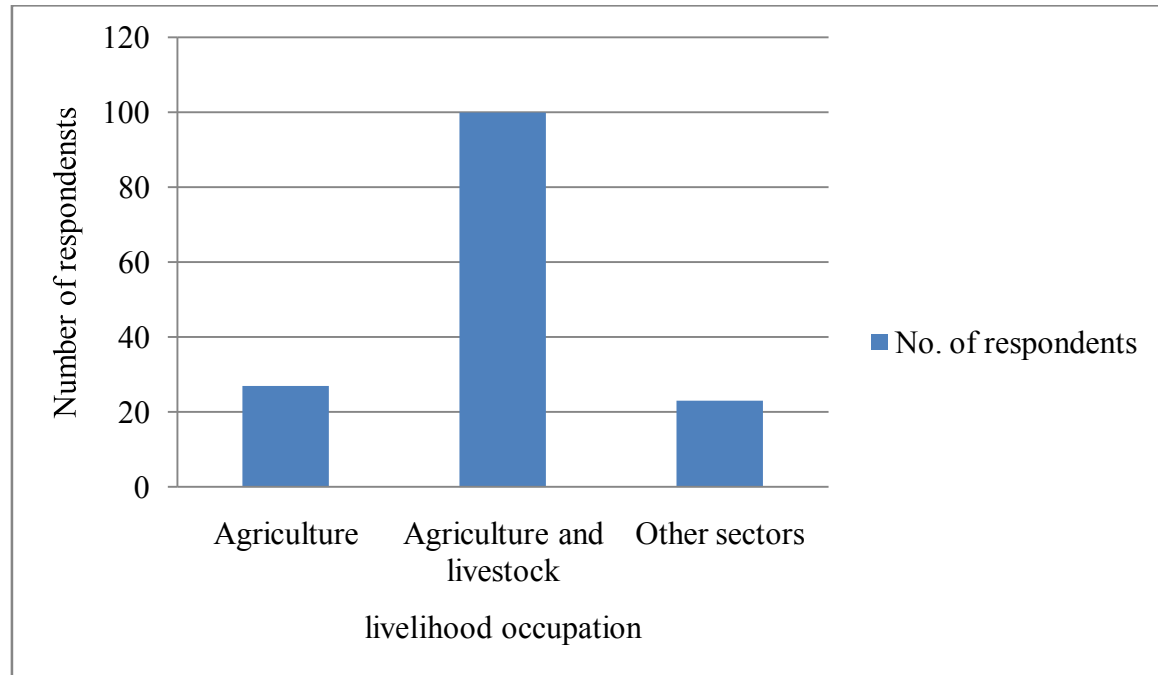


Figure 6: Livelihood occupation of respondents according to their views

### 4.3.1   Crop damage by Blackbuck

Most of the people around BCA are engaged in agriculture. The major crops grown are wheat, rice, mustard, maize, pulses and vegetables. Paddy and maize were planted only in summer season and remaining crops like wheat, mustard and pulses in winter season. Whereas vegetables was grown in both season. In BCA, wheat was planted in 967.4 Kattha (N= 137 respondents), paddy in 1452.7 Kattha (N= 147respondents), maize in 460 Kattha (N=53), pulses in 752.4 Kattha (N= 121), mustard in 220.8 Kattha (N=57).Vegetable was grown in 86 Kattha (N=12) in winter season and 35 Katha (N= 22) in summer season.

Table 6: Quantity of crop and economic loss due to wildlife in Blackbuck Conservation Area

| Season | Name of crop | Land cover (Kattha)* | Total loss (Kg) | Rate | Total Loss (NRs) |
|--------|--------------|----------------------|-----------------|------|------------------|
| Summer | Paddy | 1452.7 | 9650 | Nrs 20/Kg | 193000 |
| | Maize | 460 | 750 | Nrs 27/Kg | 20250 |
| | vegetables | 35 | 120 | Nrs 35/Kg | 4200 |
| Winter | Wheat | 967.4 | 480 | Nrs 22/Kg | 10560 |
| | Mustard | 220.8 | 470 | Nrs 82/Kg | 38540 |
| | Pulses | 752.4 | 550 | Nrs 64/Kg | 35200 |
| | Vegetables | 86 | 650 | | 19500 |
| | **Total** | **3,974.3** | **12,670** | | **3,21,250 ($2920.45)** |

*20 Kattha= 1 Bigaha, 20 Bigaha=0.68 hectar

* 1$= Nrs 110

Paddy was mostly damaged in summer followed by maize and vegetables. Similarly, wheat was mostly damaged in winter followed by mustard, pulses and vegetables.

### 4.3.2 Valuation of damage

Pachaskhall and Pataha were most damaged areas by the activities of Blackbucks. While outside the CA, Bhagartol and Nimkothia were most raided villages by this species. Blackbucks are habituated to raid the crops because of the easy access and availability of palatable crops in and around the CA boundary. The affected people estimated a total loss of $2920.45 per annum (Table 6). No compensation was provided to the victims so far by the Conservation Area. Since their settlements and farming is illegal, so they were not provided with compensation. Domestic cattle and human beings had also caused higher value of damage towards the reserve. The economic loss was high in summer (68%) than winter (32%).
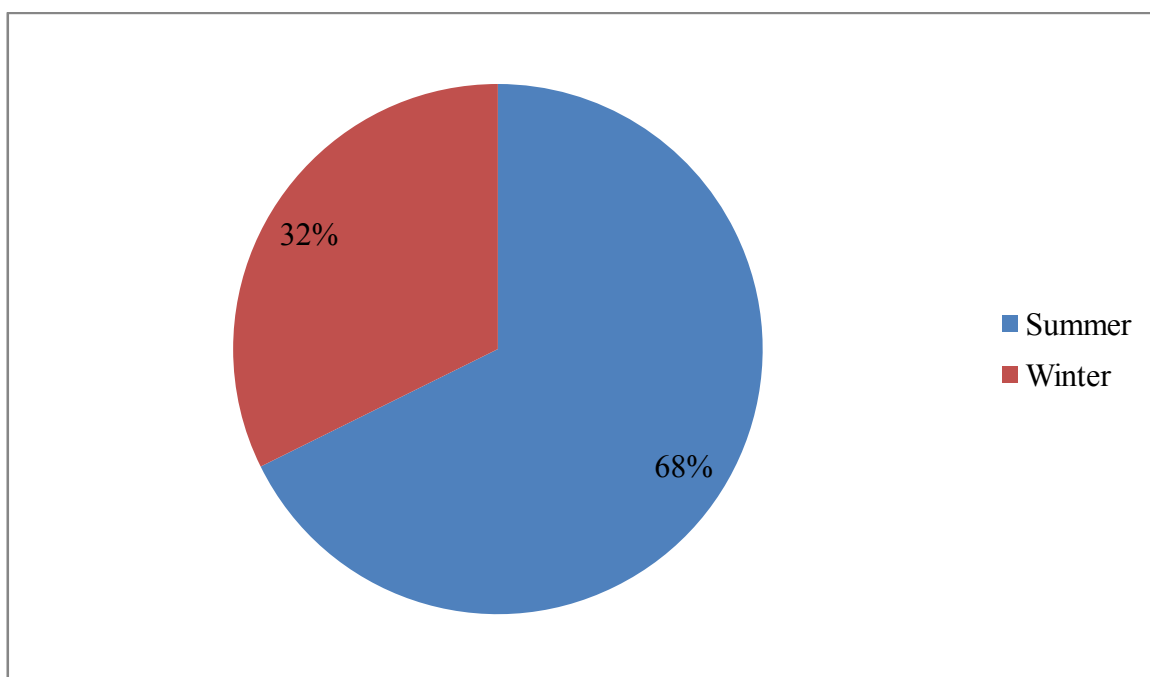
Figure 7: Valuation of crop depredation by Blackbuck in Khairapur, Bardiya

### 4.3.3  Time of crop raid by Blackbuck

Questionnaire survey showed that most of the respondents encountered with the wild animals several times. Blackbuck was the most encountered wildlife in the field that caused most of the Damage to the crops. Among 150 questionnaires, 78% farmers found that Blackbucks were active in the fields at nights for crop depredation, and 22% specify that Blackbucks raided their fields at daytime. Crop raiding is habituated behavior of the Blackbuck as crops are easily available inside their habitat. Furthermore, by the beginning of winter, the food plants available in the fields dry up and become less nutritive to fulfill their nutritional needs. Therefore, Blackbucks switch their feeding to easily available and palatable crops.
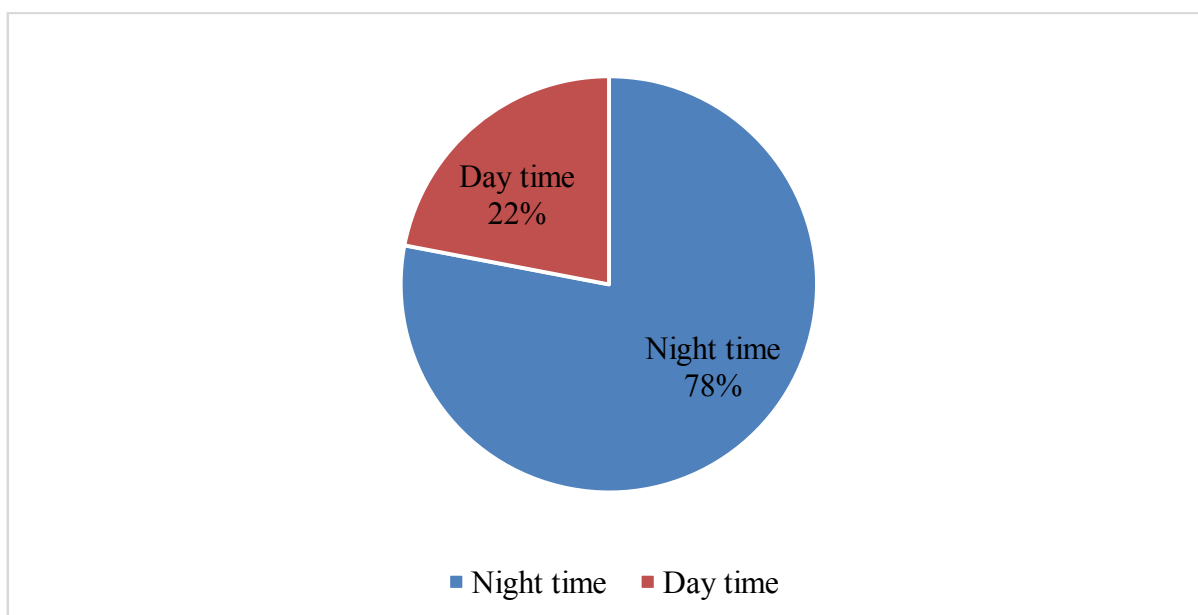
Figure 8:  Time of visit of Blackbucks in the fields in Blackbuck Conservation Area

### 4.3.4   Protective Measures

People used a number of protective measures against raiding Blackbucks. Some commonly used methods were shouting and using noise making tools as clappers and drums, scaring device like scarecrow, guarding during nights, using fire, kerosene lamps and electric lights in the fields and throwing stones, making of Machen.
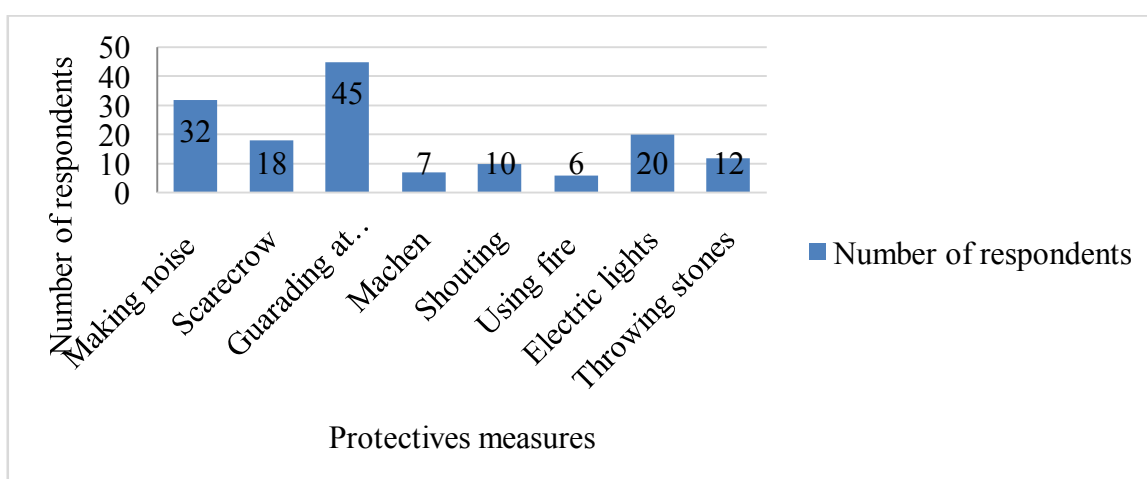


Figure 9: Protective measures against crop depredation by Blackbuck

# 5  DISCUSSION

## 5.1  Population status

The total estimated population of Blackbuck in summer during this study was 240 with male to female ratio of 1:1.67 showing an increase of 7900% from initial population (n= 3) but it is less than Ban (2012), who recorded 264 individuals with 87males and 143 females. The increase in population was improvement of habitat, increased awareness of local people, decrease in competition for grazing with domestic livestock, and finally the emergency period and curfew, may be beneficial for Blackbuck for grazing in agricultural field of surrounding, people.  Similarly, Khanal (2002) estimated 65 male with male to female ratio of 1:1.95 showing an increase of 2166.66 % (3 individual) about 1973 and decrease about 292.30 % (190 individual) concerning 1990.

Debata (2017) estimated population sizes and age structure of Blackbucks in an unprotected site of 61.21km² in Odisha over a period of one year (October 2012 to October 2013) and found to be 7,134 individuals. Arockianathan and Balasundaram (2018) revealed the total sightings of   1112 total animals with 203 Male adult, 657 Female adult, 126 Young males, 126 Young females and  animals were sighted  in  14.87 Sq.kms of Ranebennur Black Buck Sanctuary is located in Ranebennur Taluk of Haveri District, Karnataka. Prashant *et al.* (2016) found the occupancy of Blackbuck was positively correlated with areas lying within the PA, but the encounter rate of Blackbuck was significantly higher in areas outside the PA.

Deepak (2018) conducted opinion survey of 134 inhabitants of village Dhansu and 171 inhabitants of village Dobhi in India and revealed that Blackbuck population is decreased in comparison to last 10 years as reported by a majority of 46.27% and 50.88% of the contacted persons in both the study sites respectively. The present study reported increased crude density in winter and summer season, 48.19 individuals / $km^2$ and 45.71 individuals / $km^2$ respectively.  The increased crude density in summer than winter might be breeding period of Blackbuck as they breed generally during March and April. The high number might be because, it was rainy and winter season, there was abundance of food and the habitat condition congenial.  Gradual decline in the number of density of Black bucks in the months (February to May) may be due to scarcity of food and water, during hot months and hence there was a less citation of animals. Nepal (1994) reported the crude density of Blackbuck population at Khairapur to be 17.52 individuals/$km^2$. Chand (1999) found it to be 17 individuals/$km^2$ and Khanal (2002) found it be 12.38

individuals/km$^2$ again Khanal (2006) found it to be 25.33 individuals/km$^2$. Ban (2012) found it to be 50.09 individuals/km$^{2.}$

The ecological density, considering only the Pataha Phanta (1.71 km$^2$) was 135.59 individuals/km$^2$ in summer and 142.93 individuals / km$^2$ in winter. The realized ecological density indicates crowd situation in natural habitat. It will not fair symptoms in a limited habitat area that could lead catastrophic event in future if proper management of dispersal of population could not practice. Baskaran *et al* , (2016) studies, Spatial and dietary overlap between Blackbuck (*Antilope cervicapra*) and feral horse (*Equus caballus*) at Point Calimere Wildlife Sanctuary, Southern India and estimated population density and estimated Population density of 50 (95% CI 41.660.6) per km$^2$ of the sanctuary.

The sex ratio is defined as the population of males in population. In population of many unisex organisms there are almost equal numbers of males and females (Pianka, 1974). The sex ratio of Blackbuck in the present study was found to be 1:1.67 in summer and 1:2.05 in winter. Debata (2017) recorded 366 herds in Odisha, India and herd documented ranging from a single individual to the largest herd of 51 animals. Average herd size was 19.49±0.03 (SE) and ranged from 13.34±0.06 in summer to 31.86±0.07 during the monsoon. Sex ratio was skewed towards females by 3:1 which was higher than present study.

Nepal (1994) recorded 30 males per 100 females indicating male to female ratio was 1: 2.9, Chand (1999) gave the male to female ratio of 1:4 indicating 25 males per 100 females which are higher than present study but Khanal (2002) gave the sex ratio of 1:1.95 indicating 51.26 males per 100 females in the same study area which was high than sex ratio of summer season but low than winter of present study. Ban (2012) gave the male to female sex ratio of 1:1.64. It was also less than winter sex ratio but less than summer sex ratio in the same study area. More unequal sex ratio indicates the higher rates of genetic drift in the population. Differences in the sex ratio found by various author can be attributed to many factors, such as mortality due to natural causes or poachers/ hunters general preference for male. Schaller (1967) found uneven sex ratio favoring the females at Chilka Lake and Keoladeo Sanctuary but captive population at Sikandra which had been reported to have a male to female ratio of 1:0.8. The Blackbuck population in VNP is considered to be a high-density population (approximately 30 Blackbuck/km2 for the whole area of VNP (Ranjithsinh 1989, Jhala 1999, Gujarat Forest Dept. Management Plan for Velavadar National Park 2002).

The average herd size of Blackbuck in the present study of winter was found to be 17.14 individuals which is less than the estimates by Bharucha and Asher (1993) and Nair (1975) which was 21 and 23 respectively. The average herd size of Blackbuck at Khairapur was recorded to be 7.64 individuals by Khanal (2006), 9.8 to 10.55 individuals by Chand (1999), 4.4 to 6.9 animals by Tamang and Shrestha (1998) which are less than present study. The male to female ratio seems to be decreased since 1998 indicating the close approach of 1:1 sex ratio of diocious animal, Blackbuck in PBCA. The decreasing number of males and less number of infant indicates as in other herbivore either adult males poached (for horns, skin, etc) or competition among them lead to decrease extra males and no room for new infants. The herd size never remained constant indicating a weak social relationship among individuals. Tamang and Shrestha (1998) accounted a mean herd size ranging from 4.4 to 6.9 animals and Chand (1999) recorded the average herd size of 9.8 to 10.55 individuals in the same study area. Herd size varied considerably with the season, time of the day, availability of food and nature of disturbances from activities of visitors, tear passers, livestock and livestock grazers. Among-population variation in-group size was primarily related to habitat structure, while small-scale, within-population variation was most closely related to forage abundance (Isyaran, 2007 and Jhala and Isyaran, 2016).

## 5.2 Habitat preferences

Blackbuck inhabits arid and semi-arid areas, which are characterized by seasonal, low and annually highly variable rainfall (Singh and Joshi 1979). Consequently, semi-arid grassland holds a large population (approximately 1200) of wild Blackbuck (Rahmani 1991). Grass growth in BCA may be highly dependent on monsoon rains and consequently the forage availability and quality may have a marked seasonality. For instance, Jhala (1997) reported seasonal lows (dry as compared to wet season) in forage quality (crude protein content) in Velavadar National Park (VNP), Gujarat, western India, conducted from October 1999 to January 2003and suggested that this caused low forage consumption and nutrient digestibility of Blackbuck in that season of low forage quality. Group size varied extensively both among and within populations (Isyaran, 2007). He also analyzed spatial variation in-group size suggested that both forage and habitat structure influence group size: large-scale, among-population variation in-group size was primarily related to habitat structure, while small-scale, within-population

variation was most closely related to forage abundance. Analyses of individual behavior suggested that larger groups incur greater travel costs while foraging

In this study, 23 species of flora from 14 different families were recorded of which, 13 species are herbs, 4 species shrubs and 6 species trees but Khanal (2002) recorded 32 species of flora in the same habitat which was more than present finding. Khanal (2002) found all together 32 species with 12 species of forbs, 9 species of grass, 4 species of shrub and 7 species of tree were recorded inside PBCA. Perennial grasses like *Cynodon dactylon* and *Imperata cylindrica* dominated the Savanna grassland habitat compromises the present finding. Similarly, Baskaran *et al* (2016) found food plants such as *Cloris parpata,* a grass species, and herb *Desmodiam* dryflorae, the principal food of Blackbuck in Calimere Wildlife Sanctuary, Southern India Grassland habitat dominated with *Dicanthium annulayum* and and pods of the exotic shrubs *Prosopis juliflora* were mainly used for grazing grazing. Jhala (1997) concedes with present finding. Forage consumption and nutrient digestibility were high in monsoon and winter seasons, but low in summer. Jhala and Isyaran (2016)Blackbuck are primarily grazers and can survive on seasonally low-quality diets (crude protein <3 %) by catabolizing proteins, and reducing movement and forage intake during summer. Blackbuck responds to an arid environment by producing concentrated alkaline urine and dry feces. However, they need to drink when forage water content is below 30 %. Blackbuck social organization is highly variable and appears to be strongly influenced by habitat. Blackbuck are suggestive of an antelope highly specialized to the short grass semi-arid biome.

Pellets were recorded in 24 spots throughout the study period inside the BCA. Maximum 37.5% were recorded in block A, 33.33% in block D, 25% in block E and remaining 4.17% in block F but no any pellets were recorded in both block B and C. The maximum preferences to Block A might be due to the location of that block as it was located in the core area (Pataha phanta) of Blackbuck as shown by previous studies and also contains maximum Kass. *Imperata cylindrical* has maximum(3708.33, individual/hectare) density with relative density 20.79 individual/hectare. The minimum (125, individual/hectare) density was of *Sida cordata* with Relative density 0.7, individual/hectare. Total 13 species of herbs belonging to six families were recorded. Maximum (n= 172) numbers of individuals were in family cyperaceae and minimum (n= 3) were in family Malvaceae. Total of 4 shrubs species belonging to 4 different families were recorded. *Zizyphus mauritiana* has maximum (66.66, individual/hectare) density with relative density 51.61 individual/hectare. The minimum (6.25, individual/hectare) density was of *Canabis sativa*

with Relative density 4.83%, individual/hectare. *Zizyphus* was preferred to graze by Blackbuck (Baskaran *et al.* 2016). Four family of Trees were recorded, out of which *Dalbergia sissoo* has maximum (10.83, individual/hectare) density with relative density 54.16 individual/hectare. The minimum (0.83, individual/hectare) density was of *Acacia nilotica* with Relative density 4.16, individual/hectare. The presence of low tree density makes the habitat open. Blackbuck mostly prefers such habitat for grazing, also it enable them to escape from predator.

## 5.3 Crop depredation

Crop depredation is one of the main problems faced by nearby surrounding places of conservation area. Crop depredation by wildlife was a function of several factors, such as the distance of the farmland from the park, the size of the crop raiding animals and the frequency of attacks on the farmland, and the type of crops (Thapa 2010).Wild animals often destroy standing crops and prey on livestock, causing economic losses to farmers. Crop and wildlife damage are becoming serious for many Indian protected areas (Sekhar 1998).Crop loss by Blackbuck was observed mostly in winter season. The crops preferred were lentils, followed mustard, vegetable in winter whereas paddy was mostly depredated. Altogether crop loss was estimated to be Nrs 321250 per annum. Concedes with Mohammed *et al.* (2016) who found extensive damage of sugarcane, pigeon pea and vegetables; particularly in summer months in and around Chitta Reserve forest of Bidar, Karnataka. The farmers in the area are facing loss of cash crop. Bhandari (1994) made an assessment of the food habitat of Blackbuck in BCA, the result showed that the average intake of crops in winter season were much higher (45%) than during summer season (33%). Utilization of grasses in the summer season was 68% and during the winter, it constituted 46% which also concedes with present findings.

Crop raiding by wild herbivores close to an area of protected wildlife is a serious problem that can potentially undermine conservation efforts. Since there is orders of magnitude difference between farmers' perception of damage and the compensation given by the government, an objective and realistic estimate of damage. Damage of over 50% for the fields adjacent to the forest of western boundary of Tadoba-Andhari Tiger Reserve (TATR), Central India was reported that gradually reduce in intensity with distance was observed by Bayani *et al*. (2016)  Deepak (2018) also found the crop raiding by Blackbuck in and around Hisar, Haryana (India). Rahmani (1989) mentions that crop damage by Blackbuck are a major issue during the study period; economic loss was high

in summer (68%) than winter (32%). The high economic loss is due to cultivation of paddy in large surrounding areas of BCA and the protective measure adopted were not significant in the summer than the winter season beside this the local farmers used less protective measure during summer season compared to winter season. This economic loss was high than the Ban (2015) who had estimated economic loss of Nrs. 212260 in the same area. The high economic loss during this study period might be due to human encroachment inside BCA or lack or green grasses inside BCA. Similarly, Jhala (1993) estimated the population of 300 Blackbuck in the vicinity of Latuda and Katuda villages, Surendranagar district,' Gujarat, was to be responsible for a maximum potential loss of 48 600 kg of the *Sorghum* crop for one season valued at about Rs.29000 in 1989.

### 5.3.1   Protective measures

People used a number of protective measures against raiding Blackbucks. Some commonly used methods were shouting and using noise making tools as clappers and drums, scaring device like scarecrow, guarding during nights, using fire, kerosene lamps and electric lights in the fields and throwing stones, making of Machen conside with Kunwar *et al.* (2015).

# 6 CONCLUSION AND RECOMMENDATIONS

## 6.1 Conclusion

### 6.1.1 Population status

Total individuals of Blackbuck in BCA were counted to be 247. Maximum (n= 253) Blackbucks were found in winter season as compared to summer season (n= 240). Since the breeding period of Blackbucks is June – May. Thus, more Blackbucks were recorded in January. Also, more infant (n= 42) were recorded in winter than summer (n= 23). The total study area was 5.25 km$^2$; therefore, the crude density was 48.19 individuals / km$^2$ in January and 45.71 individuals / km$^2$ in May. However, the area of core habitat of Blackbuck in Pataha Phanta is only 1.77 km$^2$ without the encroached residential and cultivated area; therefore, the ecological density of Blackbuck population in the study area was calculated 142.93 individuals / km$^2$ in January and 135.59 individuals / km$^2$ in May. This shows an increase in both ecological and crude density of Blackbucks in BCA than previous findings. The number of Blackbuck is in increasing ratio with maximum female than previous year. Male to female ratio was 1:2.05 in winter and 1:1.67 in summer indicating significant more female in both seasons. Blackbucks inhabits in the colony as maximum herd size of 17 was found among 31 herds.

### 6.1.2 Habitat Preferences

Total Pellets were recorded in 24 spots throughout the study period inside the BCA, Khairapur of which maximum 9 were recorded in block A, 8 in block D, 6 in block E and remaining 1 in block F; but no any pellets were recorded in both block B and C. Maximum preferences to both blocks A and D was due to presence of perennial herbs like *Imperata cylindrica* and *Cynodon dactylon*. BCA contain 23 species of flora of which 13 were herbs, 4 shrubs and remaining 6 were trees species. Maximum (3708.33) density was of *Imperata cylindrica*. Similarly, Herbs has maximum (2.283) Shannon diversity index as compared to shrubs (1.3984) and trees (1.1146). The maximum Shannon diversity index of herbs makes the habitat suitable for the Blackbucks for grazing forbs.

### 6.1.3   Crop depredations

Blackbucks raided on almost all the croplands inside the Blackbucks Conservation area (CA) and to some extent to those that surrounded the CA boundary. Villages inside the Conservation area; Pachaskhalla, Pataha was most affected by the activities of Blackbucks. While outside the CA, Bhagar tol and Nimkothia were most raided villages by this species. It caused annual loss of $ 2920.45. The main crops depredated in winter were wheat followed by mustard, pulses and vegetables whereas in summer the paddy was mostly depredated. The questionnaire survey revealed that crop depredation was high in nights.  Some commonly used methods were shouting and using noise making tools as clappers and drums, scaring device like scarecrow, guarding during nights, using fire, kerosene lamps and electric lights in the fields and throwing stones, making of Machen.

### 6.2   Recommendations

- ➢ Compensation must be provided to the victims (outside of BCA).
- ➢ Boundary can be constructed around the BCA to avoid crop depredation.
- ➢ Human encroachments must be strictly stopped inside BCA along this livestock grazing must be banned.

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# Photo plates



Plate 1: Herd of Blackbuck



Plate 2: Questionnaire survey



Plate 3: pellets of Blackbuck
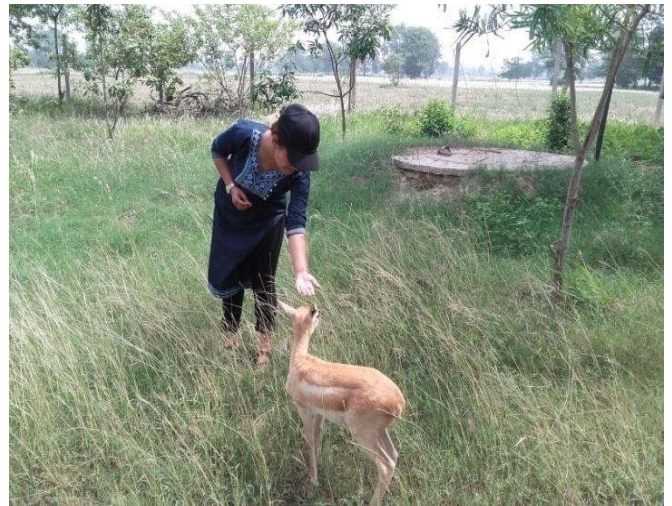


Plate 4: infant Blackbuck



Plate 5: Observing Blackbucks with binocular



Plate 6: Taking GPS coordinates

# Questionnaire survey

Name of User committee ………………………

Adress……………VDC/Municipality……………..Ward No…………….

1. Name of Respondents …………………Age………………Sex……………

2. How many members do you have in your family?

Male……………Female…………………..Total………………….

3. How much land do you have?

………………Bigha……………………..Katthha…………………..Dhur………………

4. What are the winter crops that you grow?

………………………              …………………………………….

……………………………              …………………………………….

………………………              ……………………………………

5. What are the summer crops that you grow?

………………………              …………………………………….

……………………………              ……………………………………….

………………………              ……………………………………

6. Does Blackbuck cause damage to your crops?

a. Yes                              b. No

7. What methods do you adopt to prevent the crop damage by Blackbuck?

   a) Chasing
   b) Shouting
   c) Guarding filed at night
   d) Fencing
   e) Making scare crows in field

f) Beating drums

g) Others………….

8. Please specify the total expected yield of winter crops and crop loss by Blackbuck

| Winter crops | Cultivated land | Total expected yield | Loss by Blackbuck |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

9. Please specify the total expected yield summer crops and crop loss by Blackbuck

| summer crops | Cultivated land | Total expected yield | Loss by Blackbuck |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

10. Do you have any livestock?

a. yes                                          b. No

If yes how many?

| Livestock | Numbers |
|---|---|
| Cow | |
| Buffalo | |
| Goat | |
| Sheep | |
| Others | |

11. At what time Blackbuck comes in your field for crop depredation

a) At night

b) At day

12. Do you have got any compensation for crop depredation caused by Blackbuck?

    a. yes                       b. No

    if yes, how much had you got?

13. What opinion do you have on the population of Blackbuck in BCA?

a. they are in increasing trend

b. they are decreasing

c. they are constant in number

14. If they are increasing. What might be reason?

    a. habitat management

    b. poaching is stopped

## ANNEX 1 : Herbs species recorded in different block inside BCA .

| Blocks | Herbs | | | |
|---|---|---|---|---|
| | Scientific name | Local name | Family | No. of individual |
| A | *Euphorbia hirta* | Dudhe Jhar | Euphorbiaceae | 3 |
| | *Sida cordata* | Pan paatae | Malvaceae | 3 |
| | *Medicago lupulina* | Kalo Jhar | Leguminosae | 6 |
| | *Imperata cylindrica* | Siru | Cyperaceae | 25 |
| | *Cynodon dactylon* | Dubo | Cyperaceae | 22 |
| | *Saccharum spontaneum* | Kaasa | Gramineae | 18 |
| | *Echinocloa colonum* | Moto Bansoo | Gramineae | 22 |
| D | *Imperata cylindrica* | Siru | Cyperaceae | 8 |
| | *Cynodon dactylon* | Dubo | Cyperaceae | 22 |
| | *Alysicarpus vaginalis* | Titilo | Leguminosae | 6 |
| | *Vetiveria zizonoides* | Jove | Gramineae | 5 |
| | *Cyperus cephalotus* | Mothei | Cyperaceae | 9 |
| | *Digitaria adscendens* | Ban China | Gramineae | 7 |
| | *Glycosmis pentaphylla* | Gutuhuru | Rutaceae | 9 |
| | *Medicago denticulre* | Chari amilo | Leguminosae | 18 |
| E | *Cynodon dactylon* | Dubo | Cyperaceae | 21 |
| | *Vetiveria* | Jove | Gramineae | 8 |

| | | | | |
|---|---|---|---|---|
| | *zizonoides* | | | |
| | *Imperata cylindrica* | Siru | Cyperaceae | **26** |
| | *Digitaria adscendens* | Ban China | Gramineae | 15 |
| | *Saccharum spontaneum* | Kaasa | Gramineae | 21 |
| | *Medicago lupulina* | Kalo Jhar | Leguminosae | 8 |
| | *Euphorbia hirta* | Dudhei Jhar | Euphorbiaceae | 16 |
| | *Echinocloa colonum* | Moto Bansoo | Gramineae | 15 |
| | *Cyperus cephalotus* | Mothei | Cyperaceae | 9 |
| **F** | *Saccharum spontaneum* | Kaasa | Gramineae | 26 |
| | *Imperata cylindrica* | Siru | Cyperaceae | 30 |
| | *Vetiveria zizonoides* | Jove | Gramineae | 23 |
| | *Medicago lupulina* | Kalo Jhar | Leguminosae | 8 |
| | *Medicago denticulre* | Chari amilo | Leguminosae | 19 |
| **Total** | | | | 428 |

**ANNEX 2: Trees species recorded in different block inside BCA .**

| Blocks | Scientific name | Local name | Family | Number of individuals |
|---|---|---|---|---|
| A | *Dalbergia sissoo* | Sisoo | Fabaceae | 8 |
| | *Bombax ceiba* | Simal | Malvaceae | 3 |
| | | | | |
| D | *Dalbergia sissoo* | Sisoo | Fabaceae | 5 |
| E | *Syzygium cumini* | Jamun | Myrtaceae | 2 |
| | *Azadirachta indica* | Nim | Meliaceae | 3 |
| F | *Acacia catechu* | Khair | Fabaceae | 2 |
| | *Acacia nilotica* | Babun | Fabaceae | 1 |
| Total | | | | 24 |

**ANNEX 3: Shrubs species recorded in different block inside BCA .**

| Blocks | Scientific Name | Local name | Family | No. of individuals |
|---|---|---|---|---|
| A | *Glycosmis pentaphylla* | Gutuhuru (Shrub) | Rutaceae | 4 |
| | *Anagallis arvensis* | Kuro Ghas | Primulaceae | 6 |
| | *Zizyphus mauritiana* | Bayar | Rhamnaceae | 12 |
| | *Canabis sativa* | Bhang | Urticaceae | 3 |
| | | | | |
| D | *Anagallis arvensis* | Kuro Ghas | Primulaceae | 13 |
| | *Zizyphus* | Bayar | Rhamnaceae | 11 |

| | | | | |
|---|---|---|---|---|
| | *mauritiana* | | | |
| E | *Zizyphus mauritiana* | Bayar | Rhamnaceae | 9 |
| | | | | |
| F | *Glycosmis pentaphylla* | Gutuhuru (Shrub) | Rutaceae | 4 |
| Total | | | | 62 |

**ANNEX 4: Shannon diversity for herbs species**

| S.N | Number of herbs species in different blocks | Pi | LnPi | Pi(LnPi) |
|---|---|---|---|---|
| 1 | 19 | 0.0444 | 3.1145 | 0.1383 |
| 2 | 22 | 0.0514 | 2.9681 | 0.1526 |
| 3 | 37 | 0.0864 | 2.4488 | 0.2116 |
| 4 | 6 | 0.0140 | 4.2687 | 0.0598 |
| 5 | 36 | 0.0841 | 2.4757 | 0.2082 |
| 6 | 65 | 0.1519 | 1.8845 | 0.2863 |
| 7 | 37 | 0.0864 | 2.4488 | 0.2116 |
| 8 | 22 | 0.0514 | 2.9681 | 0.1526 |
| 9 | 89 | 0.2079 | 1.5707 | 0.3265 |
| 10 | 18 | 0.0421 | 3.1677 | 0.1334 |
| 11 | 65 | 0.1519 | 1.8845 | 0.2863 |
| 12 | 9 | 0.0210 | 3.8632 | 0.0811 |
| 13 | 3 | 0.0070 | 4.9618 | 0.0347 |
| **Total** | **428** | | | **2.2830** |

**ANNEX 5: Shannon diversity for trees species**

| S.N | Number of herbs species in different blocks | Pi | LnPi | Pi(LnPi) |
|---|---|---|---|---|
| 1 | 2 | 0.0833 | 2.4853 | 0.2070 |
| 2 | 13 | 0.5417 | 0.6130 | 0.3321 |
| 3 | 1 | 0.0417 | 3.1773 | 0.1325 |
| 4 | 2 | 0.0833 | 2.4853 | 0.2070 |
| 5 | 3 | 0.1250 | 2.0794 | 0.2599 |
| 6 | 3 | 0.1250 | 2.0794 | 0.2599 |
| **Total** | **24** | | | **1.1146** |

**ANNEX 6: Shannon diversity for shrubs**

| S.N | Number of herbs species in different blocks | Pi | LnPi | Pi(LnPi) |
|---|---|---|---|---|
| | 8 | 0.1290 | 2.0479 | 0.2642 |
| | 19 | 0.3065 | 1.1825 | 0.3624 |
| | 32 | 0.5161 | 0.6615 | 0.3414 |
| | 3 | 0.0484 | 3.0283 | 0.1466 |
| **Total** | 62 | | | **1.3984** |