

**DISTRIBUTION AND POPULATION STRUCTURE OF CHITAL
(*Axis axis* Erxleben, 1777) IN BABAI VALLEY, BARDIA
NATIONAL PARK, NEPAL**



Entry 54

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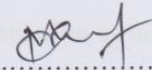
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July 2020

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 other degree. All the sources of the information have been specifically acknowledged by references to the authors or the institutions.

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RECOMMENDATIONS

This is to recommend that the thesis entitled "**Distribution and population structure of Chital (*Axis axis* Erxleben, 1777) in Babai valley, Bardia National Park, Nepal**" has been carried out by Mr. Mohammad Yunus for partial fulfillment of the requirement for Master's Degree in Zoology with the special paper of Ecology. This is his original work and has been carried out under my supervision. To the best of my knowledge, this work has not been submitted for any other degree in any institutions.

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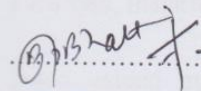


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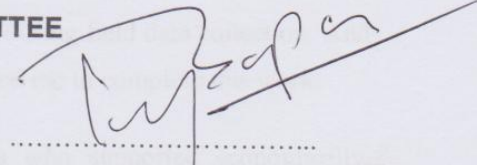
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EVALUATION COMMITTEE


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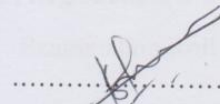
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Table of Contents

| | |
|--|------|
| DECLARATION | II |
| RECOMMENDATIONS..... | III |
| LETTER OF APPROVAL | IV |
| CERTIFICATE OF ACCEPTANCE | V |
| ACKNOWLEDGEMENTS | VI |
| LIST OF TABLES | IX |
| LIST OF FIGURES..... | X |
| LIST OF PHOTOGRAHS | XI |
| LIST OF ABBREVIATIONS..... | XII |
| ABSTRACT..... | XIII |
| 1. INTRODUCTION..... | 1 |
| 1.1 Background | 1 |
| 1.2 Population status of Chital | 1 |
| 1.3 Population structure of Chital | 2 |
| 1.4 Distribution of Chital..... | 2 |
| 1.5 Factors affecting the distribution of Chital | 4 |
| 1.6 Rationale of the study | 5 |
| 1.7 Objectives of the Study..... | 5 |
| 2. LITERATURE REVIEW | 6 |
| 2.1 Population status of Chital | 6 |
| 2.2 Population structure of Chital | 6 |
| 2.3 Distribution of Chital..... | 7 |
| 2.4 Factors affecting the distribution of Chital | 8 |
| 3. MATERIALS AND METHODS | 10 |
| 3.1 Study area..... | 10 |
| 3.1.1 Climate | 11 |
| 3.1.2 Flora..... | 11 |
| 3.1.3 Fauna..... | 12 |
| 3.2 Materials | 13 |
| 3.3 Methods of data collection..... | 13 |
| 3.3.1 Preliminary survey..... | 13 |
| 3.3.2 Line transect method..... | 14 |
| 3.3.3 Population status..... | 14 |

| | |
|--|----|
| 3.3.5 Environmental variables | 16 |
| 3.3.6 Questionnaire survey | 16 |
| 3.4 Data analysis | 16 |
| 3.4.1 Population estimation | 16 |
| 3.4.1.1 Population density | 16 |
| 3.4.2 Population structure | 17 |
| 3.4.3 Distribution | 17 |
| 3.4.4 Factors affecting distribution | 17 |
| 3.4.4.1 Species environmental variable relation | 17 |
| 4. RESULTS | 18 |
| 4.1 Population status of Chital | 18 |
| 4.1.1 Population density of Chital..... | 19 |
| 4.2 Population structure of Chital in Babai Valley Bardia National Park..... | 19 |
| 4.2.1 Age and Sex Composition..... | 19 |
| 4.2.2 Herd Size and Composition | 20 |
| 4.2.2.1 Group size of Chital in different habitats of BNP | 22 |
| 4.3 Distribution pattern of Chital in different habitats of BNP..... | 24 |
| 4.4 Factors affecting the distribution of Chital | 26 |
| 5. DISCUSSION | 29 |
| 5.1 Population status of Chital | 29 |
| 5.2 Population structure of Chital | 30 |
| 5.3 Distribution of Chital..... | 31 |
| 5.4 Factors affecting distribution of Chital..... | 32 |
| 6. CONCLUSION AND RECOMMENDATIONS..... | 34 |
| 6.1 Conclusion | 34 |
| 6.2 Recommendations | 35 |
| REFERENCES..... | 36 |
| APPENDICES | 45 |
| APPENDIX I- Questionnaire Survey Data Sheet..... | 45 |
| APPENDIX II- GPS points of Field | 46 |
| APPENDIX III- Species of different habitats..... | 47 |
| APPENDIX IV- Data sheet | 48 |
| APPENDIX V- Photo Plates..... | 49 |

LIST OF TABLES

| Tables | Title of Tables | Pages |
|---------------|---|--------------|
| 1 | Population status of Chital from different blocks of BNP | 18 |
| 2 | Population density of Chital in Babai valley BNP in 2019 | 19 |
| 3 | Age and sex composition of Chital in the BNP | 20 |
| 4 | Generalized Linear Model (GLM) result showing the relationship between environmental variables and Chital | 27 |

LIST OF FIGURES

| Figures | Title of figures | Pages |
|----------------|---|--------------|
| 1 | Global distribution map of Chital | 3 |
| 2 | Distribution of Chital in Nepal | 3 |
| 3 | Map of the study area showing line transects | 10 |
| 4 | Detection probability of Chital in Babai Valley Bardia National Park | 19 |
| 5 | Age class of chital in Babai Valley of Bardia National Park | 20 |
| 6 | Contribution of population structure of Chital on the formation Of different sizes group(solitary, very small, small, medium, large and very large) | 21 |
| 7 | Group size of Chital in riverine forest of Bardia National Park in 2019 | 22 |
| 8 | Group size of Chital in sal forest of Bardia National Park in 2019 | 23 |
| 9 | Group size of Chital in grassland of Bardia National Park in 2019 | 23 |
| 10 | Group size of Chital in mixed-hardwood forest of Bardia National Park in 2019 | 23 |
| 11 | Number of observed Chital responses to different habitats | 25 |
| 12 | Distribution map of Chital in Bardia National Park | 25 |
| 13 | GLM result showing the most significant variables that had most influence on the Chital distribution | 27 |
| 14 | Perception about threats to Chital in Bardia National Park | 28 |

LIST OF PHOTOGRAHS

| Photographs | Title of Photographs | Pages |
|--------------------|---|--------------|
| 1 | A matured male Chital | 49 |
| 2 | Yearling female in alert posture | 49 |
| 3 | A mature female Chital | 49 |
| 4 | Female-fawn herd in alert posture | 49 |
| 5 | Herds of Chital at grassland in cool-dry season | 49 |
| 6 | Langur-Chital association in study area | 49 |
| 7 | Herds of Chital in grassland | 50 |
| 8 | Observation of Chital | 50 |
| 9 | Antler of Chital | 50 |
| 10 | Questionnaire survey with villager | 50 |
| 11 | Artificial waterhole construction inside the Park | 50 |
| 12 | Skull of Chital | 50 |

LIST OF ABBREVIATIONS

| Abbreviated form | Details of abbreviations |
|-------------------------|--|
| ANOVA | Analysis of Variance |
| BNP | Bardia National Park |
| CITES | Convention on International Trade in Endangered Species of Wild Fauna and Flora |
| CNP | Chitawan National Park |
| CRP | Chepang Range Post |
| DNPWC | Department of National Parks and Wildlife Conservation |
| GBZCF | Ghailaghari Buffer Zone Community Forest |
| GIS | Geographic Information System |
| GLM | Generalized Linear Model |
| GPS | Global Positioning System |
| IUCN | International Union for Conservation of Nature and Natural Resources |
| Km | Kilometer |
| KTWR | Koshi Tappu Wildlife Reserve |
| m | Meter |
| MHF | Mixed Hardwood Forest |
| PNP | Parsa National Park |
| RF | Riverine Forest |
| SF | Sal Forest |
| SNP | Suklaphanta Natonal Park |

ABSTRACT

This study aimed to explore the distribution and population structure of Chital in Chepang Babai Valley BNP, Nepal. Riverine forest, sal forest, grassland and mixed-hardwood forest were selected as a major habitat for intensive study sites and survey was carried out in October and November, 2019. Line transect method, age and sex composition, environmental variables and questionnaire survey were applied to record the data on distribution, population structure and factors affecting the distribution of Chital. A total of 23 line transects were laid in four major habitats of eight blocks which covers a total of four kilometers in length and each transects were walked three times that covered a total of 12 km. All the data were analyzed by using Microsoft excel 2016 and Past 3.26. The population status of Chital was recorded from different study blocks whereas (Chi-square $\chi^2 = 19.29$, $df = 7$, $P = 0.007$) revealed that significant difference in population status of Chital within different study blocks. The density of Chital was 43.39 individuals per km^2 in the study area. The overall male to female sex ratio was 1:2.5 showing the ratio of 47.88 bucks to 100 does with more females than the males within all blocks and time period. The distribution pattern of Chital was found to be clumped type within about 20 km^2 of the total study area. Generalized Linear Model revealed that tree canopy cover ($P < 0.01$), ground cover ($P < 0.01$) and distance to road ($P > 0.01$) were positively associated with Chital distribution. Based on questionnaire survey, poaching, habitat loss, forest fire and feral dogs were the major probable threats. Further research should be conducted to find out more interesting relation between Chital and its distribution and habitats throughout Babai Valley of Bardia National Park. This study can be effective in conservation and management to enhance long-term survival of this species in the study area.

1. INTRODUCTION

1.1 Background

Chital or spotted deer (*Axis axis* Erxleben, 1777), a Cervidae, is one of the common artiodactyls native to the tropical and sub-tropical forests of South Asia. It is locally known as chital in Nepal (Shrestha 2003). It belongs to the order Artiodactyla and the family Cervidae. Its coat is rufous brown and covered with white spots. A dark stripe runs down the back from the nape to the tip of the tail. The other parts of the body such as abdomen, rump, throat and inside of the legs, tail and ear are white. Old buck is more brownish in colour and darker than does. There is no seasonal difference in the colour of the coat, except that during the cool season it is somewhat glossier darker and thicker than during the hot and wet season (Prater 1993, Schaller 1998, Shrestha 2003). According to IUCN Red List Category it is listed as Least Concern because it occurs over a very wide range with large populations (Duckworth et al. 2008).

The head is short, the body is compact and tail varies from long to medium long. The eyes are large and the upper lids have long lashes. A well-built stag stands 90 cm at the shoulder and weighs about 85 kg (Prater 1971). The antlers are reddish brown. The beam curves backward and outward in the lyre-shaped formation which is usually 60 cm (Brander 1982). The first set of antler in yearling consist simple spikes less than 5 inches long.

1.2 Population status of Chital

The term population has its origin in the Latin word 'Populas', meaning people. A population refers to a collective group of organisms of the same species (or other groups within which individuals may exchange genetic information) occupying a particular space (Odum 1996). The nature of population is determined by such factors as density, sex ratio, birth and death rates, emigration and immigration (Martin 1999). These population characteristics are although best expressed as statistical functions, are the unique possession of the group and are not characteristics of the individuals in the group (Odum 1996). But the population parameters result from the summation of individual characteristics (Krebs 1994). Study of population status of recently common animals such as Chital becomes important in the sense that their existing conditions will not convert into rare and endangered; and thereby extinct category in near future by their proper monitoring, conservation and management.

1.3 Population structure of Chital

Age and sex-wise population composition of an area indicates the viability and the growing trend of the population of that species, which is one of the main indicators of its management (Khanal 2006). Population structure means the 'make up' or composition of a population that shows how the population is divided up between males and females of different age groups. Population structure in ungulates is usually biased towards females, which is attributed to sexual selection (Clutton- Brock et al. 1982). Age structure of a population is useful for understanding dynamics of population growth and estimating life history parameters (Spillet 1966, Stearns 1992). Age structure of a population expressed as the distribution of the number of individuals in each age group reflects fecundity, mortality, reproductive status and population increase. It is an important measure of demographical change over time (Caughley 1977). High percentage of Young as compared to adults generally indicates a fast growing or thriving population in contrast to a relatively smaller percentage of young that usually indicates a sluggish rate of population increase. A population with more females than males generally has a higher reproductive potential than the one that is predominantly composed of males (De & Spillet 1966).

1.4 Distribution of Chital

Chital is indigenous to Srilanka, India, Bangladesh and Nepal. In India it is found in the forest at the base of Himalaya and practically throughout the Peninsula and Ceylon where there is jungle combined with good grazing and a plentiful supply of water. It is found in Assam in the Goal Park, Kamrup and Darrang district (Prater 1993). The chital occurs over 8-30°N in India (including Sikkim), Nepal, Bhutan, Bangladesh and Srilanka (Grubb 2005, Raman 2013). Chital occur throughout the rest of peninsular India sporadically in the forested areas (Sankar & Acharya 2004). The main distribution area in Nepal is throughout Terai, with major concentrations in parks and reserves (Mishra 1982). The definitive research on these species on the other parts of the world such as Hawaii (Graf & Nichols 1996), Texas (Ables & Ramsey 1974), Argentina and Australia (Lever 1985). Deer populations flourished on Oahu, Molokai and Lanai. On Molokai, the population increased to 1000 within 20 years and reached nearly 7500 (Tomich 1986). The Chital is distributed up to the elevation of 2150 m (7000 ft) or higher along the south, west and north-west borders of Haleakala National Park and in the Waikamoi Preserve managed by the Nature Conservancy (Waring 1996).



Figure 1. Global distribution map of Chital (Source: IUCN)

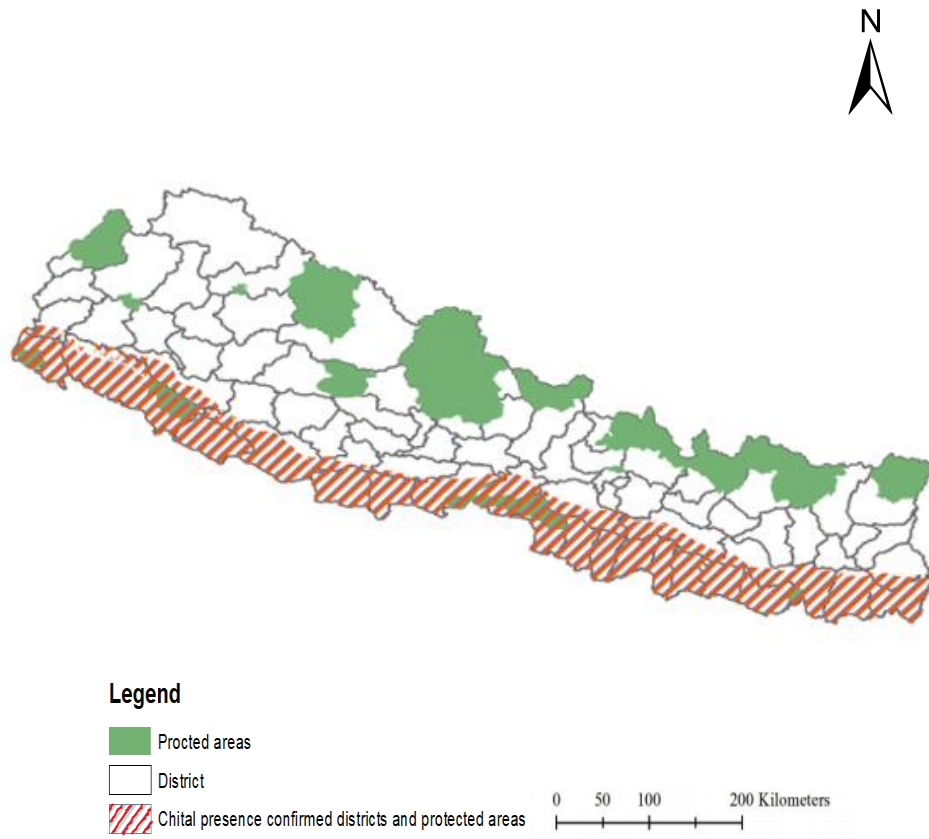


Figure 2. Distribution of Chital in Nepal (Source: Jnawali et al. 2011)

Chital inhabits in scrub forest and grass lands along the forest edges bordering on cultivation and grassland at altitude less than 1000 m. This species is widely distributed along the Terai-Bhabar region of Nepal and within all the protected areas of the low land, Bardia National Park, Chitwan National Park, Suklaphanta National Park, Parsa National Park, Koshi Tappu Wildlife Reserve and adjoining forest. It is also reported from the districts of Bara, Bardia, Kailali, Jhapa, Sunsari, Saptari, Nawalparasi, Rupandehi, Chitwan, Mahottari, Kapilbastu, Dang, Banke and Kanchanpur (Majupuria & Majupuria 2006). But the exact population of Chital is not recorded in any National Park, Wildlife Reserve and other forests. In this reference, at least 2000 Chital might be possible in Terai area (Chalise 2001). They are found scattered in lower number in the mid-hill, warmer Valleys and forest areas (Chalise 2001, 2013). Chital are found rarely above an altitude of 1160 m (3500 ft) in their native Asian habitats, including Nepal (Schaller 1967).

1.5 Factors affecting the distribution of Chital

Fragmentation and loss of habitat are recognized as the greatest existing threats to biodiversity (Fahrig 2003). Human caused habitat fragmentation precipitates biodiversity decline because it destroys species, disrupts community interactions and interrupts evolutionary processes (Ehrlich & Ehrlich 1981, Erb et al. 2012). Human settlements, directly or indirectly influenced biodiversity. Human settlements inside the forest area frequently used natural resources, caused natural habitat destruction and their economy was mainly based on agriculture (Rajawat & Chandra 2019). A group is defined as the number of individuals interacting with each other, behaving in a coordinated manner during foraging or moving, or in close proximity to each other (<10 m apart) when first observed (Dar et al. 2012). A group of the ungulates is defined as a cluster of animals maximally 30 m from each other, showing a coordinated movement (Bhattarai & Kindlmann 2012). The environmental factors which are responsible for the occurrence of different group size and distribution of Chital: 1) distance to nearest water sources, 2) distance to nearest human settlements, 3) distance to road, and 4) habitat types. The population structure or distribution of Chital is affected by principal environmental factors, such as habitat structure, predation and human disturbances. Chital population have decreased due to excessive poaching throughout the county during early twentieth century but poaching has been strictly banned in late twentieth century under the laws (Abson & Termansen 2010). The present distribution of the Chital has been greatly affected by the elimination of its habitat for agricultural purpose (Chalise 2001).

1.6 Rationale of the study

Many works have been carried out about this species for proper management and conservation by many researchers (De & Spillet 1966, Tamang et al. 1976, Naess & Andersen 1993, Biswas & Sankar 2001, Srinivasula 2001, Pokhrel 2005, Dar et al. 2012) in different parts of world. Different studies have been conducted throughout the World on this species but these animals facing the problem due to different anthropogenic and natural causes like poaching, habitat loss and degradation due to human encroachment, flood and forest fire. No any studied have been carried out in Babai Valley BNP. This study helps to trace out the population distribution and structure of the Chital on present scenario of the species status which provides baseline information for effective conservation and management to enhance long-term survival of the Chital in the study area. This study aimed to understand distribution and population structure of Chital which covers the Babai valley BNP. Although the checklist for overall Chital species of BNP has been published (Naess & Andersen 1993, Gautam 2013) but the study focusing distribution of Chital and population structure has not been conducted yet within the study. Studying the distribution of Chital not only helps to determine the species present in the area but later it will also assist in determining the factors affecting the group size and distribution of Chital in the study area. This study will be helpful in providing a checklist of Chital in the study area with Babai Valley BNP which will assist as a basis for monitoring of deer species in future and has implication of conservation efforts.

1.7 Objectives of the Study

General Objective

The main objective of the study was to explore the distribution and population structure of Chital in Babai Valley Bardia National park, Nepal.

Specific Objectives

The specific objectives of the study were as follows:

- To estimate the population status and structure of Chital in Bardia National Park.
- To determine the factors affecting distribution of Chital within the study area.

2. LITERATURE REVIEW

2.1 Population status of Chital

De and Spillet (1966) found the population of Chital in Corbett National Park. They found 1906 individual of Chital in 520.8 km² area. Sharatchandra and Gadgil (1975) reported 800 Chital in Bandipur National Park in Karnataka in 874 km² area. They also mentioned that May to August was the main rutting season. They also noticed that large herd of more than 100 individuals was formed in monsoon season but it was break up into smaller herd at dry season. Srinivasulu (2001) recorded only 383 individuals of Chital in Nallamala hills of Eastern Ghats, India. Sharma (2013) found 352 individuals of Chital in Ghailaghari Buffer Zone Community forest. Kuikel (2003) also reported 357 individuals of Chital in 543.19 km².

Biswas and Sankar (2001) estimated 80.7 individuals per km² density of Chital in Pench National Park in Central India. Dave and Jhala (2011) estimate the density of Chital in Gir forest India. It was found to be 44.8±7.1 individuals per km². Naess and Andersen (1993) estimated the density of Chital in Bardia National Park. It was found to be 225.3-384 individuals per km². Verman and Sukumar (1995) observed that the density of Chital along road were significantly different from those of interior of the forest in Tropical deciduous forest in India. Sharma (2013) estimated 51 individuals per km² density of Chital in GBZCF. Parajuli (2007) estimated 28 individuals per km² density of Chital in Bardia National Park.

2.2 Population structure of Chital

Spillet et al. (1967) reported that the large herd consists of 44 individuals and the ratio of female: young was 1.6:1. Silva and Silva (2001) reported that the average group size of Chital was 11 and it was varied with season. According to them the herd size of Chital was 15.36 in rainy season, 7.76 in wet season and 5.76 in dry season. They also noticed one largest group of Chital having 179 individuals. They also reported that the male: female ratio was 0.59:1 and the ratio of young and female was 0.47:1. Schaller (1967) estimated the sex ratio of Chital in Corbett National park. The sex ratio of male: female was 70:100. Nichols (1960) reported that the sex ratio of adult male to female was 77:100 in Hawaii. The sex ratio of male: female was 0.72:1 in Nagararahole (Karanth & Sunquist 1992) and 1:0.2 in Gir (Khan 1996). The average male: female: fawn ratio was 0.57:1:0.53 in Karnali Bardia (Dinersein 1980), 0.66:1:0.49 in Bandipur (Johnsingh 1983), 0.47:1:0.22 in Sariska

(Sankar 1994), 0.50:1:0.27 in Pench (Acharya et al. 2007) and 0.61:1:0.15 in Mundumalai (Ramesh 2010).

Bagchi et al. (2008) reported that the mean and typical size of Chital were 4.7 to 9.2 in winter and 4.5 to 7.9 in summer in Tropical forest in Western India. The ratio of male and female was 86.4:100 and the ratio of young to adult Chital was 28:100. He also reported that the grouping pattern was differentiated according to the habitat. Ramesh et al. (2011) reported that the mean group size and crowding for Chital was 13.1 ± 0.50 ($n=1020$) and 33.3 respectively. The average ratio of adult male and female mean group size of Chital varied significantly between seasons in Western Ghats, India. Khan et al. (1995) reported that mean group size of Chital was 6.03 ± 5.9 . The adult males to female ratio was 41:100 females. The result agreed broadly with findings from other wildlife areas in the Indian sub-continent. Dar et al. (2012) estimated that the highest mean group size of Chital was 7.74 ± 1.19 in Shivalik ecosystem Uttarakhanda. They also reported that the group size was varied significantly across season in comparison to the other ungulates. Mishra (1982) reported that mean group size of Chital was 7.5 in Chitwan National Park where as in Sariska, Chital group size was 7.8 ± 8.3 (Sankar 1994). Barrette (1991) reported that Chital group in Wilpattu was 6.

Tamang et al. (1976) estimated the sex ratio of Chital in Chitwan National Park. The sex ratio of male: female was 59:100. Parajuli (2007) reported the sex ratio of Chital in Bardia National Park. The sex ratio was calculated as 49 bucks per 100 does. Sharma (2013) estimated the sex ratio of Chital in Ghailaghari Buffer Zone Community Forest. The sex ratio of male: female was 74:100. The average herd size was 20 in Parsa National Park (Sapkota 1999), 15 in GBZCF (Sharma 2013) and 17 in Bardia National Park (Parajuli 2007).

2.3 Distribution of Chital

Chital have been introduced to the former Yugoslavia, Western Republic of the former USSR, Andaman Islands, Australia, Hawaiian Islands and Texas (USA), Brazil, Argentina and Uruguay (Grubb 1992). The Chital is distributed up to the elevation of 2150 m (7000 ft) or higher along the south, west and north-west borders of Haleakala National Park and in the Waikamoi Preserve managed by The Nature Conservancy (Waring 1966). Chital are found rarely above an altitude of 1160 m (3500 ft) in their native Asian habitats, including Nepal (Schaller 1967).

Chital prefers secondary sal forest, riverine forest and grassland with good understory of grasses, forbs and tender shoots, over mature inferior forests (Thapa 2003). However, long back a census was initiated on Chitwan and found 500 in number. In this reference, at least 2000 Chital might be possible in Terai area (Chalise 2001). It is distributed in Bardia National Park, Chitwan National Park, Suklaphanta National Park, Parsa National Park and Koshi Tappu Wildlife Reserve. Chital is also reported from districts of Bara, Bardia, Kailali, Jhapa, Sunsari, Saptari, Nawalparasi, Rupandehi, Chitwan, Mahottari, Kapilbastu, Dang, Banke and Kanchanpur (Majupuria & Majupuria 2006). Sharma et al. (2012) recorded 182 individuals of Chital (*Axis axis*) in GBZCF and was more abundant than Sambar deer (*Cervus unicolor*), Wild boar (*Sus scrofa*), Northern red muntjac (*Muntiacus vaginalis*) and Rhino (*Rhinoceros unicornis*).

Verma and Asokan (2001) reported that the density of Chital was higher along road side than the dry deciduous forest in Mudumalai Wildlife Sanctuary, India. They also reported that the density of Chital was very low in riverine forest. Spillet (1966) counted 33 Chital (*Axis axis*) in the Nagerhole wildlife sanctuary. Chital (*Axis axis*) form largest among all wild ungulates in summer and contributes 92.7% of total wild ungulate density in Gir forest, India. Chital is most prevalent and widely dispersed in the forest (Dava 2008). Noor et al. (2013) reported that wood land was highly preferred habitat for Chital because of good availability of shrub and other ground vegetation in Keoladeo National Park, Rajasthan, India.

2.4 Factors affecting the distribution of Chital

For all the species of ungulates, the adult sex ratio was skewed towards females. It is common phenomenon in cervids (Khan et al. 1995) and is often interpreted in terms of sexual selection (Clutton- Brock et al. 1982). The larger groups of chital in the rich areas of predators showed that living in a group is an anti-predatory strategy, as smaller groups are less likely to be encountered by an ambush predator like Tiger in the dense forests, whilst in the open habitats, animals resorted to safety in large numbers (Raman 1997).

Grouping patterns of the ungulate species were significantly affected by open habitats, presence of predators and human disturbance (Bhattarai & Kindlmann 2018). Bhattarai and Kindlmann (2018) found that large and very large groups of Chital significantly preferred open habitats i.e. grasslands. Also, large groups significantly preferred plains areas.

In general terms, diversity, abundance, total biomass, and mean biomass of species tend to decrease with increasing human disturbance (Oberosler et al. 2017). Research on factors influencing the distribution of large mammals within a protected central African forest indicated that human activities significantly influence the distribution of large mammals, even within the protected areas (Blom et al. 2005). Human activity on trails and roads may lead to indirect habitat loss, further limiting available habitat (Rogala et al. 2011). Presence of wildlife from distance to roads and settlements also indicate the nature and tolerance of the wildlife towards sources of human disturbances.

Regular disturbances caused by human activities could offer a change in distribution and behaviour of mammals that consequently increases conflict with people (Cheyne et al. 2016, Adhikari et al. 2018). Hence, the habitat and prey preference of carnivores also depends on the degree of habitat disturbances in the human dominated landscapes (Bhattarai & Kindlmann 2018). The abundance of major prey species of common leopard and Bengal tiger except Primates was highly negatively associated with disturbances (Bhattarai & Kindlmann 2012). Adhikari et al. (2019) found that human disturbance played significantly negative role in detection probability of target species. Bhattarai and Kindlmann (2018) found that Solitary and small groups of Chital significantly avoided predators while large and very large groups occurred significantly more in presence of predators. Medium and large groups of Chital significantly avoided the areas disturbed by humans.

3. MATERIALS AND METHODS

3.1 Study area

Bardia National Park is the largest National Park in the Lowland Terai covering on area of 968 km² and established in 1976, lies in the west Terai (Lowland) in Bardia and Banke districts of Nepal (28° 0' – 28° 15' N, 81° 30' – 82° 15' E). It is one of the richest protected area of Nepal in terms of biodiversity, being covered by forestland, shrub land, grassland and others. The altitude ranges from 152 m to 1441 m with characteristic Churia ridges, rugged foot hills, Bhabar zones, Lowland plains and alluvial flood plains of the Karnali and Babai rivers. The study area lies in four major habitats namely Riverine Forest (RF), Sal Forest (SF), Grassland (G) and Mixed Hardwood Forest (MHF). Chepang Range Post (CRP) lies in eastern Babai Valley of Bardia National Park which is to one of the most potential Chital habitats of that area (Figure 3)

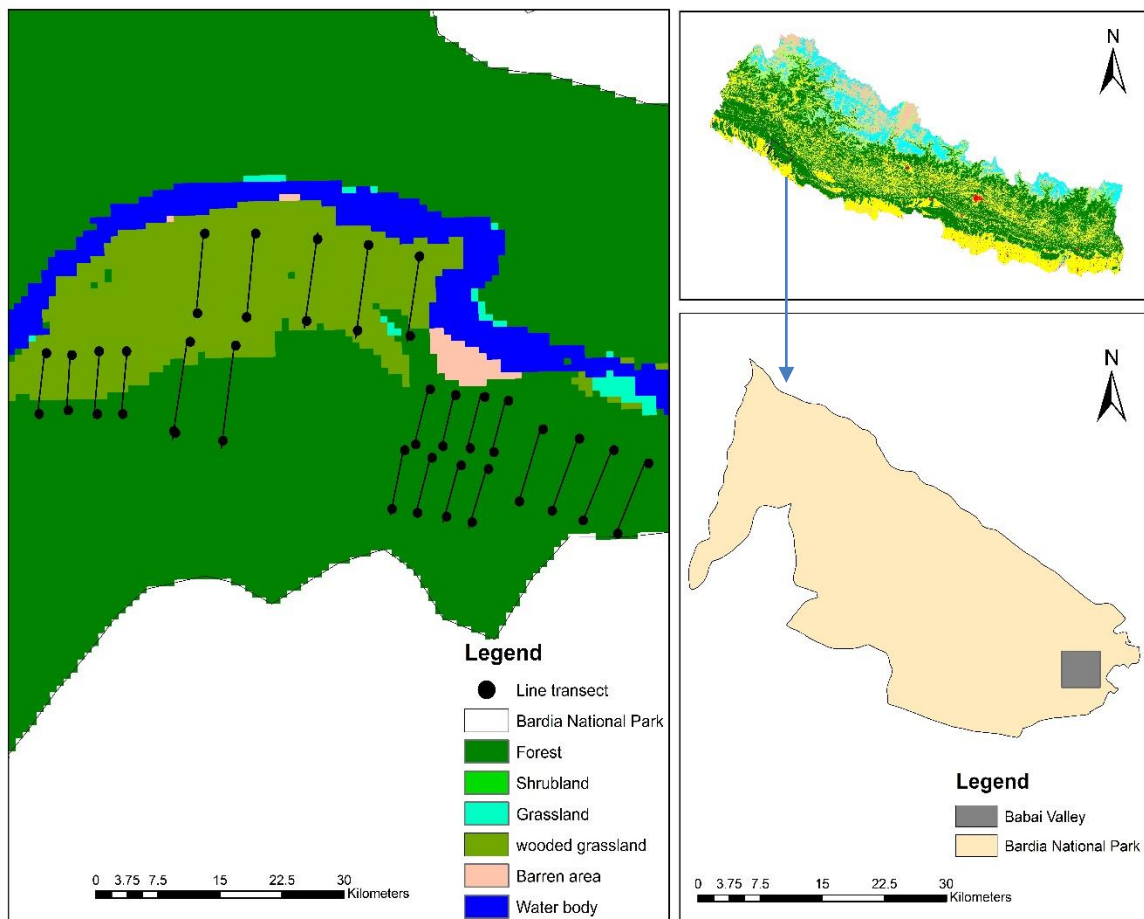


Figure 3. Map of the study area showing line transects

3.1.1 Climate

Climate plays a major role in species distribution. The BNP has a subtropical monsoonal climate with annual rain between June and September. The minimum temperature was 8°C in the January and maximum 39°C in the May. The minimum rainfall occurs in November (4 mm), however the highest rainfall occurs in July (474 mm) (DHM 2019).

3.1.2 Flora

The floodplain of Karnali and Babai Rivers composed of a dynamic interspersed of riverine forests, tall grasses and broad, sandy riverbanks. Small pockets of grasslands, locally known as Phantas are found within the forested areas. There are five major Phantas, all dominated by Siru *Imperata cylindrica* (Field visit 2019). These Phantas are the result of human settlements, cultivation and domestic grazing before to add a Babai (Chepang range Post) Valley in BNP. A total of 839 species of flora have been estimated in the park. Among these, 170 are estimated to be vascular plants. Eight pteridophytes, one Gymnosperms, 140 dicotyledons and 26 monocotyledons have been recorded (BPP 1995, Sharma 1999 and Park data base 2012) so far. The forest of BNP has been classified as “moist semi-deciduous forest” in the Bhabar zone (Stainton 1972, Chapman & Seth 1968). Later Dinerstein (1979) made a critical vegetation analysis and classified the park vegetation into six types. Jnawali and Wegge (1993) modified the Dinerstein’s classification of vegetation into seven types. They are: 1) Sal (*Shorea robusta*) forest, 2) Khair-sissoo (*Accacia catechu-Dalbergia sissoo*) forest, 3) Moist riverine forest, 4) Mixed-hardwood forest, 5) Wooded grassland, 6) Phanta and 7) Floodplain grassland.

a) Sal forest

Shorea robusta exists as the dominant species in “Sal forest” in the lower alluvial plain. There is also dominance of *Terminalia tomentosa* and *Buchanania latifolia* in association with *Shorea robusta*. Sal forest extends in dry bhabar Lowland and southern slopes of Churia hills. In the lowland sal forest, *Terminalia tomentosa* forms an important association with *Shorea robusta* in the eastern part while *Buchanania latifolia* in the western part of BNP.

b) Riverine forest

This forest is characterized by the domination of evergreen of tree species such as *Mallotus philippensis*, *Ehretia laevis*, *Ficus glomerata*, *Syzigium cumini*, *Trewia nudiflora* and even *Bombax ceiba*.

c) Wooded grassland

These grasslands are covered with less than 20% scattered tree species (Moe 1994). The features of the wooded grassland are more or less similar to the Savannah type. The common tree species are *Bombax ceiba*, *Adina cardifolia*, *Bauhinia malabarica*, *Mallotus philippensis* and *Carreya arborea*. Among the grass species *Imperata cylindrica* is most dominant and *Saccharum spontaneum*, *Vetiveria zizanioides*, *Cyperus kyllingia*, *Erianthus ravennae* are common.

d) Floodplain grassland

These are the grasslands with tall grass species such as *Saccharum spontaneum*, *Phragmites karka*, *Saccharum bengalensis* and *Narenga porphyrocoma*. They grow on the alluvial floodplain along the Babai River.

e) Mixed-hardwood forest

This type of forest grows in small patches and is originated due to human interference. *Casaria tomentosa* and *Schleichera trijuga* are dominant tree species of such forest. It is similar to riverine forest but differs by a higher density of the shrub layer and a more open grown tree layer. *Bombax ceiba*, *Garuga pinnata*, *Adina cardifolia*, and *Mitragyna parviflora* are other important associate tree species of mixed hardwood forest (Pokharel 1993).

3.1.3 Fauna

Bardia National Park is rich in faunal diversity. This Park provides important natural habitat for varieties of wildlife including endangered species of Terai-Nepal. There are 56 species of mammals, 438 species of birds, 52 species of herpetofauna and 121 species of fishes have been recorded from the Park area (BNP 2019). There are 22 species of mammals of the Park are enlisted in CITES Appendices. The Park is prime habitat for Bengal tiger (*Panthera tigris tigris*). Other symbolic mammalian species includes: Asian elephant (*Elephas maximus*), One-horned rhinoceros (*Rhinoceros unicornis*), Dolphin (*Platanista*

gangetica), Swamp deer (*Cervus duvaucelli*), Black buck (*Antelope cervicapra*), Hispid hare (*Caprologus hispidus*) and Leopard (*Panthera pardus*).

The Park is rich in ungulate diversity. Out of total six species of deer, five species such as Sambar deer (*Cervus unicolor*), Chital (*Axis axis*), Hog deer (*Axis porcinus*), Swamp deer (*Cervus duvaucelli*) and Northern red muntjac (*Muntiacus vaginalis*) are found in the Park. Chital is probably the most important prey species of the tiger population (Wegge et al. 1991). Langur (*Semnopithecus entellus*), Rhesus monkey (*Macaca mulatta*), Leopard (*Panthera pardus*), Jungle cat (*Felis chaus*), Fishing cat (*Felis viverrinus*), Palm civet (*Paguma larvata*), Mongoose (*Herpestes* spp), Large Indian civet (*Viverricula indica*), Wild dog (*Cuon alpinus*), Jackal (*Canis aureus*), Sloth bear (*Ursus ursinus*), Percupine (*Erethizon dorsatum*) etc are common mammals of BNP (BNP 2019).

Endangered Gharial crocodile (*Gavialis gangeticus*), Marsh mugger (*Crocodilus palustris*) and Burmese python (*Python molurus*) are symbolic reptiles of the Park. Bird species symbolic to the Park include the Endangered Bengal florican (*Houbaropsis bengalensis*) and Lesser florican (*Sypheotides indica*), Critically Endangered White-rumped vulture (*Gyps bengalensis*), Peacock (*Pavo cristatus*), Bar-headed goose (*Anser indicus*), Giant horn bill (*Buceros bicornis*), Eurasian eagle owl (*Bubo bubo*).

3.2 Materials

- GPS (Garmin GPSMAP® 64s)
- Camera (Cannon 800D)
- Topographic map
- Binoculars (10×50 mm Olympus)
- Measuring tape
- Field stationary
- Data sheet

3.3 Methods of data collection

A combination of preliminary surveys, intensive study based on direct observation of the animals and interviews were used to assess the distribution, population structure and threats to Chital.

3.3.1 Preliminary survey

A preliminary survey of the study area was conducted from 11 – 14th of February 2018 to establish the knowledge on major habitats of Chital. The field work was carried out in

October and November, 2019. After assessing the small area of North-Eastern part of Babai Valley of BNP, information collected from locals, Park staff, core study sites of different habitats were elected for more investigation of distribution and population structure of Chital.

3.3.2 Line transect method

After preliminary survey the whole study area was divided in to four major habitat type i.e. riverine forest, sal forest, grassland and mixed-hardwood forest. Among these four habitat type grassland had larger area. So to make the counting easier, each habitat was divided in to two blocks and the whole study area was divided in to eight blocks. Distance sampling method was used to determine population density and abundance of animals, mostly in ungulates. A total length of transect was estimated as suggested by (Burnham et al. 1980, Morrison & Kennedy 1989). The size and length of transects were varied according to the habitat types and size of forest patches. A total of 23 line transects of 150-200 m in length and each transects were walked three times that covered a total of 12 km in length. Transects points were recorded using Global Positioning System (GPS). The population was recorded by direct count method along the line transect. The location and length of transects were defined by the accessibility on foot. The data were collected by walking from three different time periods i.e. morning, day and evening time to see the change in group size. Counting was done from 7:00 am to 10:00 am in the morning, 12:00 pm to 3:00 pm in the day and 3:30 pm to 5:30 pm in the evening. During walking on transects, to be identified and recorded the species, total number of individuals, cluster size, age-sex, observer-animal distance using measuring tape and sighting angle using GPS compass and also, environmental variables.

3.3.3 Population status

3.3.3.1 Population density

The total number of individual of a species per unit area is known as population density. The line transects and modelled detection function were used to estimate the population density of Chital using program Distance 7.3 (Thomas 2010).

3.3.4 Population structure of Chital

Population structure were determined by observing animals through binoculars (10×50 mm) from a distance. Three age groups of Chital were distinguished as mentioned in (Schaller 1967).

a) Fawn (<1 year)

They have lighter brown colored coat with white spots, smaller size and always remain in association with their mothers. Size is equal or less to the height of the mother's belly.

b) Yearling (1 Year < 2 Years)

They are taller and longer than the fawns. The coat cover is comparatively darker brown than that of the fawns. The male possess spike antler without tines. They also possess less than 1 feet antler. The length varies from few centimeters to longer than the length of the ear. The yearling male has greater body size, neck and muzzle than the yearling female. The female is without spike antler and less dark brown than the male. The weight of female yearling is less than 30 kg.

c) Adult (> 2 Years)

Adult buck could be easily identified from the yearling males as they have antlers with tines. There is clear dorsal back stripe in both sexes while the male possesses black marking on face. They possess more than 1 ft antler. The adult buck has larger neck, muzzle and head than that of the adult female. The weight of adult female is greater than 30 kg.

3.3.4.1 Herd size and composition

A group of Chital were defined as a cluster of animals maximally 30 m from each other, showing a coordinated movement (Bhattarai & Kindlmann 2018). These groups were classified into six categories based on the number of individuals in a group: solitary (single individual), very small (2-5 individuals), small (6-10 individuals), medium (11-15 individuals), large (16-20 individuals) and very large (>20 individuals).

Herds were identified as the group of individuals-grazing, resting or moving together at the time of observation. Total number of Chital observed during the study period was divided by the total number of herds observed during the same time (Martin 1977).

$$\text{Average herd size} = \frac{\text{total number of individual observed}}{\text{total number of herds observed}}$$

3.3.5 Environmental variables

Topography and habitat variables were collected along the same transects where direct observation of Chital were found. Major habitats, most dominant vegetation, canopy cover, ground cover, distance to water sources were recorded during study area. The indicators of anthropogenic disturbances such as livestock grazing, number of lopped trees, number of logged trees, grass cutting sites, feces of livestock were explored in the study area. The human disturbance indicators were recorded within the circular plots of radius 5 m at the interval of 50 m along the line transect. The human presence indicators (number of lopped trees, logged trees) were identified along the line transect.

3.3.6 Questionnaire survey

Semi-structured questions were asked to the local people, Park staff, Tourist guides, Ranger, game scout and other peoples to determine the people perception towards the Chital. The questions were on the basis of threats towards the Chital in Bardia National Park (Appendix I).

3.4 Data analysis

The collected information was categorized and tabulated based on the information about the distribution and population structure of the Chital in Babai Valley Bardia National Park, Nepal. Data were manually processed and analyzed in descriptive way as well using statistical tools.

3.4.1 Population estimation

Population status of Chital were determined by using direct count method in line transect. During total count, total numbers of the Chital were different in different time at the same place. Data were manually processed and analyzed in descriptive way as well using statistical tools like tables and graphs. Population status data were analyzed by using Chi-square test for the significant difference in population of Chital in different blocks.

3.4.1.1 Population density

The distance sampling data were analyzed using “DISTANCE” software v. 7.3 (Thomas 2010) and the density of Chital were computed.

3.4.2 Population structure

The age and sex composition of Chital were also analyzed by using one-way ANOVA test for the significant contributions of age and sex of the Chital on the formation different sizes of group.

3.4.3 Distribution

Distribution map of Chital was shown with ArcGIS 10.4 software and the direct observation of the location points of Chital were overlaid as ArcGIS to prepare distribution map. The distribution pattern of Chital were analyzed by the statistical formula as described by Odum (1996) was used to calculate the ratio of variance to mean value $\left(\frac{s^2}{\bar{x}}\right)$.

If $\left(\frac{s^2}{\bar{x}}\right) = 1$, it refers random distribution of Chital in BNP.

If $\left(\frac{s^2}{\bar{x}}\right) < 1$, it refers to regular distribution of Chital in BNP.

If $\left(\frac{s^2}{\bar{x}}\right) > 1$, it refers to the clumped distribution of Chital in BNP.

Where, the variance $(s^2) = \frac{1}{n} \sum (x - \bar{x})^2$
 \bar{x} = mean value

Population distribution of Chital among different study blocks were analyzed by using Chi-square test to show the significant difference in population of Chital for different study blocks.

3.4.4 Factors affecting distribution

3.4.4.1 Species environmental variable relation

Five different variables (Tree canopy cover, ground cover, distance to road, distance to water source and people presence) were recorded from different plots which were used to perform Generalized Linear Model (Nelder 1972) with direct observation using Past (Hammer 2001).

4. RESULTS

4.1 Population status of Chital

A total number of 252 individuals of 27 herds of Chital were recorded in the Babai Valley, BNP. The highest recorded population was 68 individuals in F block while lowest was 11 individuals in H block (Table 1).

Table 1. Population status of Chital from different blocks of BNP

| S.N | Block | No. of Herds | Total Population | Habitats |
|-------|-------|--------------|------------------|-----------------------|
| 1 | A | 3 | 22 | Riverine forest |
| 2 | B | 5 | 15 | Riverine forest |
| 3 | C | 2 | 30 | Sal forest |
| 4 | D | 1 | 17 | Sal forest |
| 5 | E | 5 | 32 | Grassland |
| 6 | F | 4 | 68 | Grassland |
| 7 | G | 5 | 57 | Mixed hardwood forest |
| 8 | H | 2 | 11 | Mixed hardwood forest |
| Total | | 27 | 252 | |

Observation of Chital were recorded during different blocks in the study area. Among these different blocks, maximum presence of Chital was recorded in block F, 68 individuals (26.99%) and minimum population was found in H block, 11 individuals (4.37%).

Chi-square Contingency Test was used to test the significant differences in population status of Chital among different observed blocks. The calculated value of Chi-square at 7 degree of freedom and 0.05 level of significance was found i.e. 19.29 which is greater than that of tabulated value 14.067 ($P = 0.0073 < 0.05$). The higher calculated value of chi-square showed significant difference in population status of Chital among different study blocks of BNP.

4.1.1 Population density of Chital

The result revealed that density of Chital was 43.39 individuals/km² (Table 2).

Table 2. Population density of Chital in Babai Valley BNP in 2019

| Parameter | Estimate | %CV | df | 95% Confidence Interval |
|-----------|----------|-------|-------|-------------------------|
| DS | 24.092 | 19.56 | 43.66 | 16.302 35.604 |
| D | 43.395 | 21.34 | 58.46 | 28.445 66.204 |
| N | 84.000 | 21.34 | 58.46 | 55.000 128.00 |

The object was near from the line transect then, probability of Chital detection from perpendicular distance was maximum. But away from the line transect, detection probability was low.

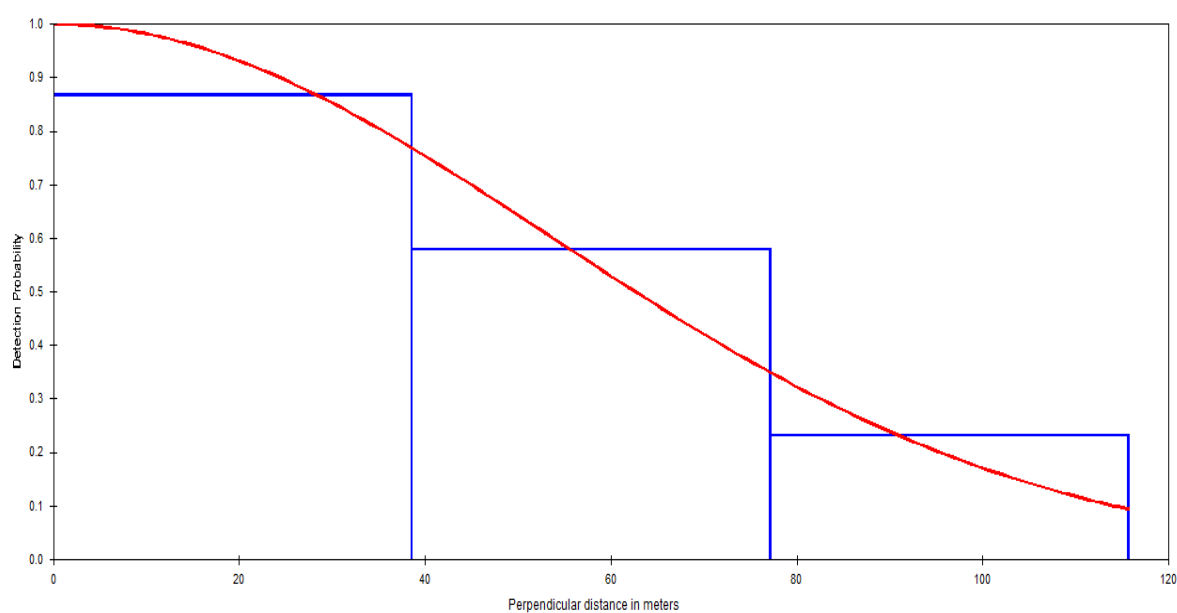


Figure 4. Detection probability of Chital in Babai Valley BNP

4.2 Population structure of Chital in Babai Valley Bardia National Park

4.2.1 Age and Sex Composition

The number of Chital observed in BNP was used to find out the age and sex ratio for BNP. Age and sex composition of Chital was identified in Babai Valley BNP (Table 3).

Table 3. Age and sex composition of Chital in the BNP

| Habitat type | Age and sex composition | | | | | | | | | | | | Total |
|-----------------|-------------------------|---|----|--------|----|----|-----------|---|----|-------|---|---|-------|
| | Male | | | Female | | | Sub-adult | | | Young | | | |
| | M | D | E | M | D | E | M | D | E | M | D | E | |
| Riverine forest | 1 | 2 | 4 | 5 | 2 | 8 | 3 | 0 | 2 | 6 | 1 | 3 | 37 |
| Sal forest | 0 | 4 | 4 | 4 | 5 | 9 | 3 | 5 | 5 | 2 | 3 | 3 | 47 |
| Grassland | 2 | 7 | 10 | 4 | 12 | 20 | 5 | 9 | 13 | 3 | 6 | 9 | 100 |
| Mixed forest | 2 | 4 | 5 | 7 | 11 | 7 | 6 | 8 | 4 | 5 | 6 | 3 | 68 |

(M = Morning, D = Day and E = Evening)

In BNP, the number of Chital observed was 252. Among them male was 45 (17.85%), female 94 (37.31%), sub-adults 63 (25%) and young 50 (19.85%). The male to female ratio was 1:2.5 showing a ratio of 47.88 bucks to 100 does. The young to female ratio was 1:1.89 showing the ratio of 53.20 young to 100 does (Figure 5).

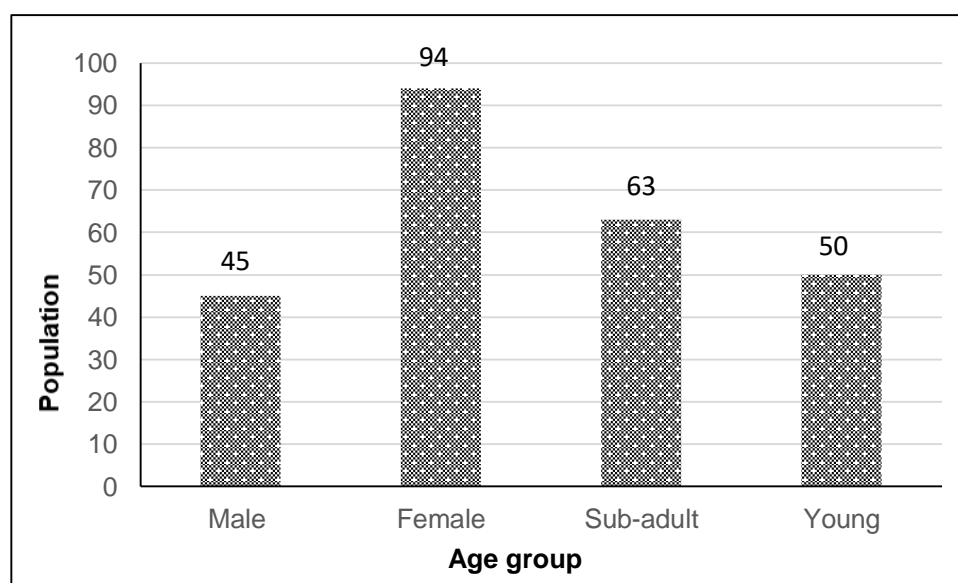


Figure 5. Age class of Chital in Babai Valley of BNP in 2019

4.2.2 Herd Size and Composition

The average herd (group) size of Chital was 9.33 individuals which was computed from 252 individuals observed among 27 herds during the study period. Among them the most common herds were mixed herds (95%), followed by female-fawn group (5%). Single isolated male or female were seen very low. The largest herd size of 40 individuals

including males, females, sub-adults and young of different ages were observed in grassland during the 17:20 hours evening of 20 October, 2019 (Figure 6). There was higher contribution of female individuals for the formation of the larger groups in all the size groups. The larger groups possess the more sub-adults and young. There were no male and young found in solitary groups except all groups. There was only female and sub-adult found in the solitary groups (Figure 6). The significant contributions of age and sex of Chital on the formation of different sizes of groups were analyzed by using one-way ANOVA test.

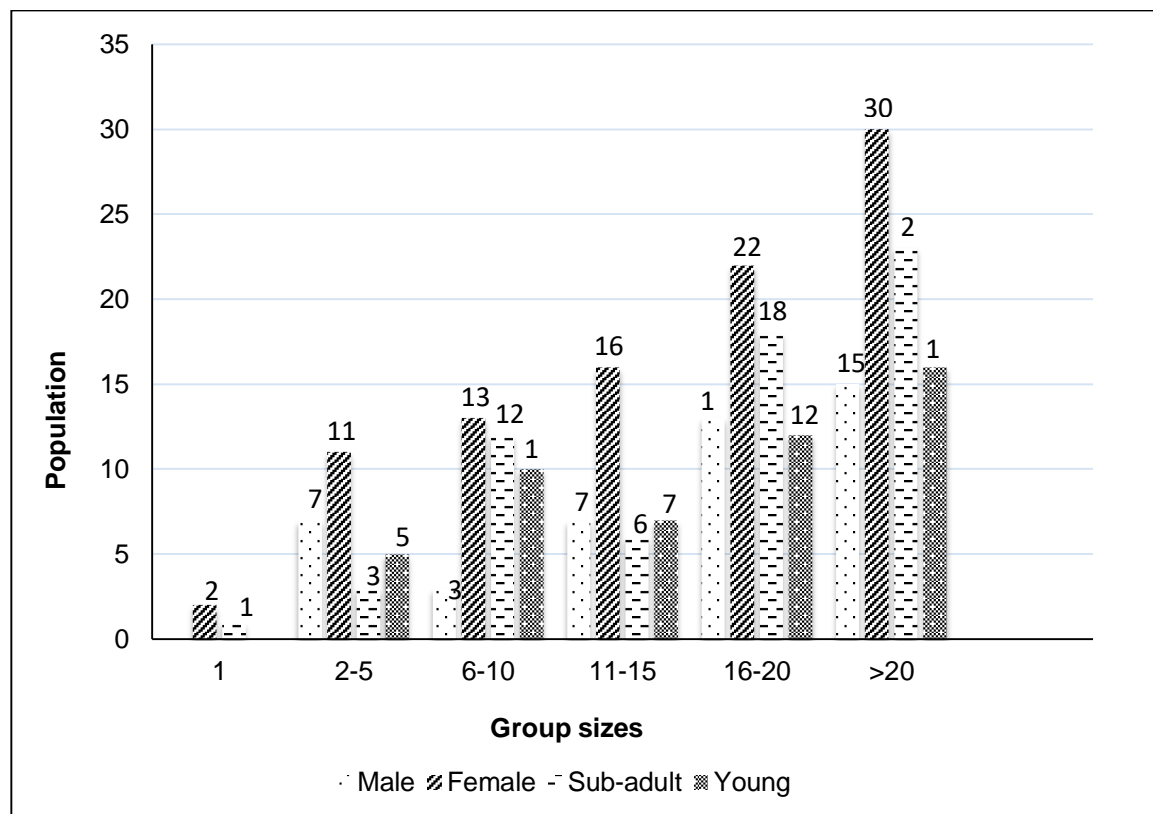


Figure 6. Contribution of population structure of Chital on the formation of different sizes of groups (solitary, very small, small, medium, large and very large)

Similarly, Contribution of population structure of Chital on the formation of different sizes of groups, the critical (tabulated) value of F ($d_1 = 5, d_2 = 18$) degree of freedom at 5% level of significance is 2.77. Since the calculated value of the test statistics $F = 9.880$ is greater than the tabulated value and ($P = 0.00 < 0.05$), null hypothesis is rejected i.e., there were significant contribution of age and sexes of Chital on the formation of different sizes of groups.

4.2.2.1 Group size of Chital in different habitats of BNP

Present results found that herds size of Chital in different habitats, the critical (tabulated) value of F ($d_1 = 2, d_2 = 8$) degree of freedom at 5% level of significance is 4.46. Since the calculated value of the test statistics $F = 0.752$ is less than the tabulated value and ($P = 0.501 > 0.05$), null hypothesis is accepted i.e., there were no significant difference within herds size of Chital across the different habitats.

In riverine forest, the number of Chital observed was 37. Among Population of Solitary group was 1 (2.71%), Very small 22 (59.46%), small 6 (16.21%), medium 14 (37.89%), large 0 and very large 0 (Figure 7).

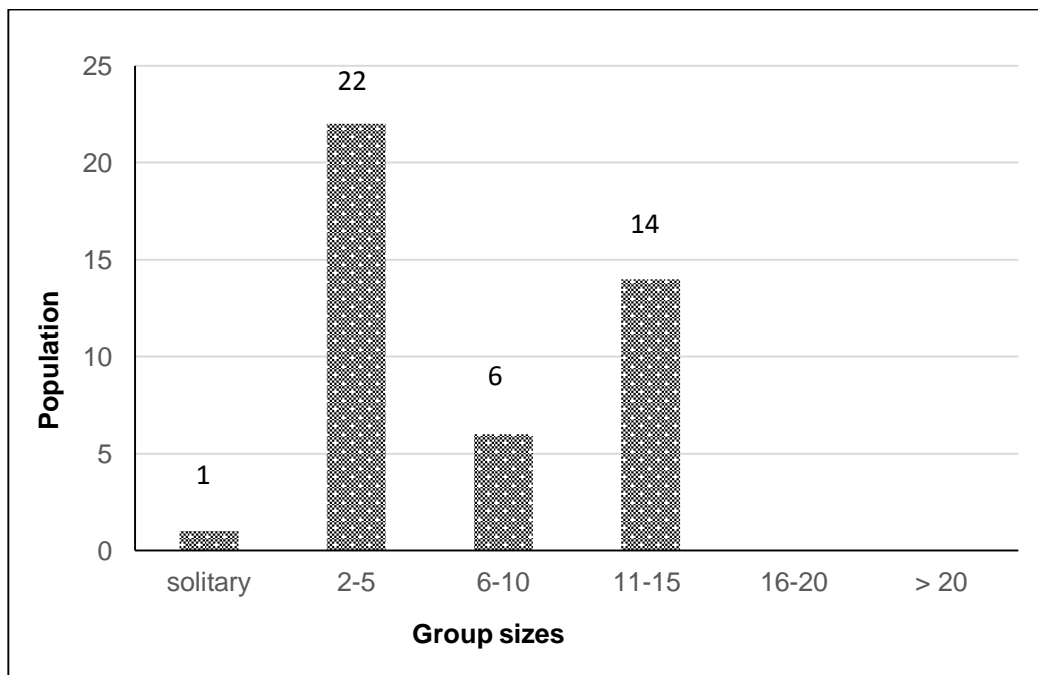


Figure 7. Group size of Chital in riverine forest of BNP in 2019

In sal forest, the number of individuals of Chital observed was 47. Among them Population of Solitary group was 0, very small 0, small 9 (19.15%) and medium 0, large 17 (36.18%) and very large was 21 (44.69%) (Figure 8).

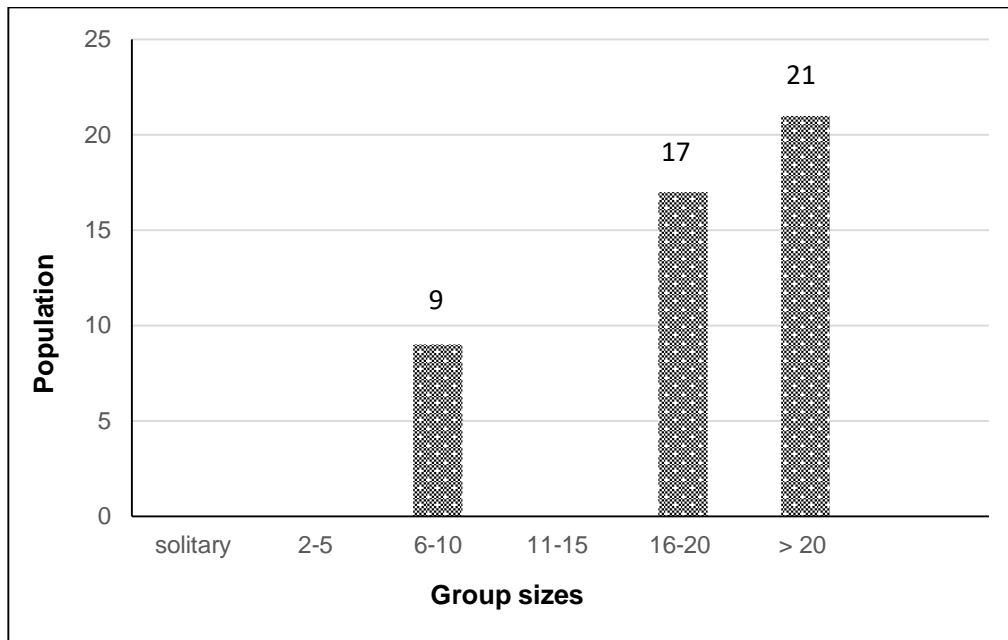


Figure 8. Group size of Chital in sal forest of BNP in 2019

In grassland, the number of Chital observed was 100. Among them Population of Solitary group was 1 (1%), very small 7 (7%), small 9 (9%), medium 11(11%), large 16 (16%) and very large was 40 (40%) (Figure 9).

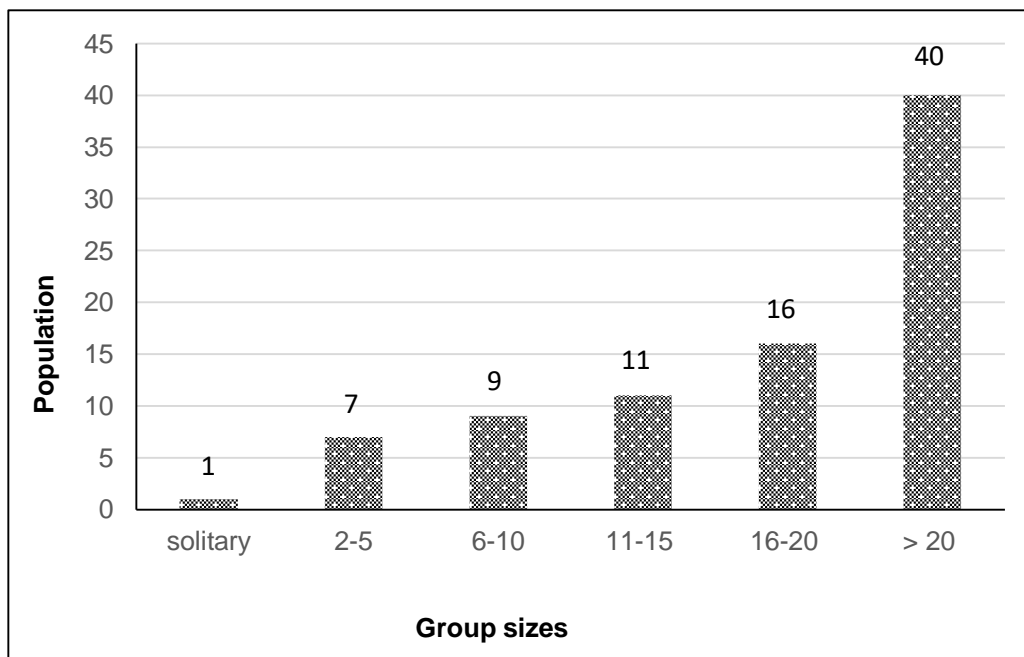


Figure 9. Group size of Chital in grassland of BNP in 2019

In mixed-hardwood forest, the number of Chital observed was 68. Among them Population of Solitary group was 1 (1.48%), very small 0, small 17 (25%), medium 11(16.18%), large 16 (23.53%) and very large was 23 (33.83%) (Figure 10).

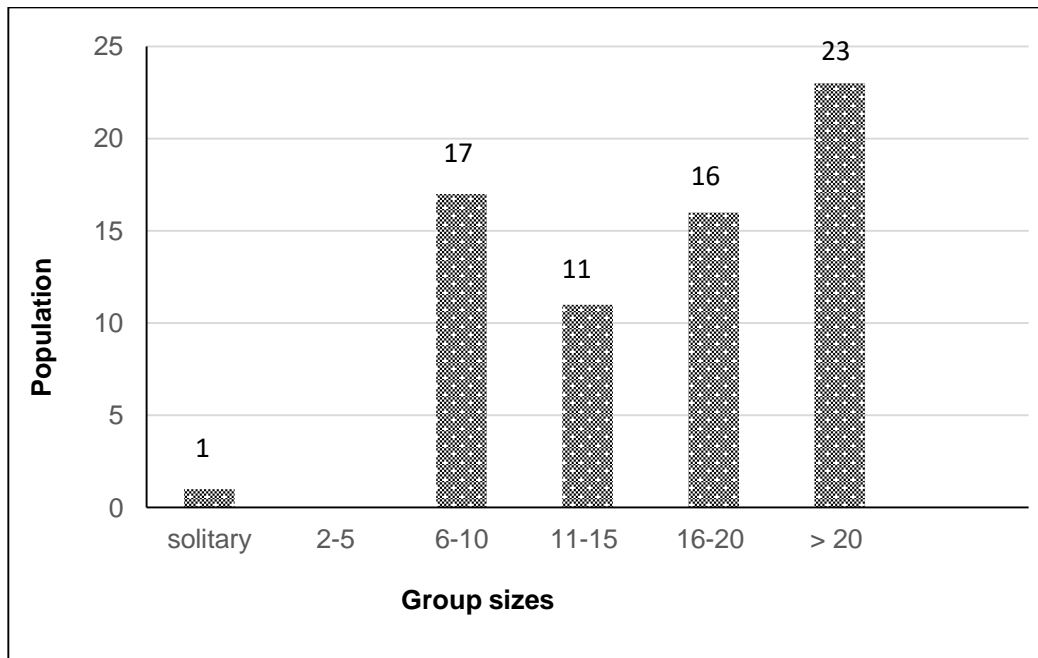


Figure 10. Group size of Chital in mixed-hardwood forest of BNP in 2019

4.3 Distribution pattern of Chital in different habitats of BNP

Population distribution of Chital were recorded in 23 different samples by line transect method from eight different location (Blocks) of four different habitats during the study period in Babai Valley BNP. Among them highest number of Chital were recorded as 100 individuals (39.68%) in grassland, followed by mixed hardwood forest 68 individuals (26.98%), sal forest 47 individuals (18.65%) and that of least in riverine forest 37 individuals (14.68%) (Figure 11).

The variance to mean ratio was used to determine the distribution pattern of Chital in all over the study samples with different habitats. The calculated value of variance to mean ratio was found to be 11.75. Since the value of $\left(\frac{s^2}{x}\right) > 1$, the result had shown clumped or uneven type distribution pattern of Chital in BNP (Figure 12).

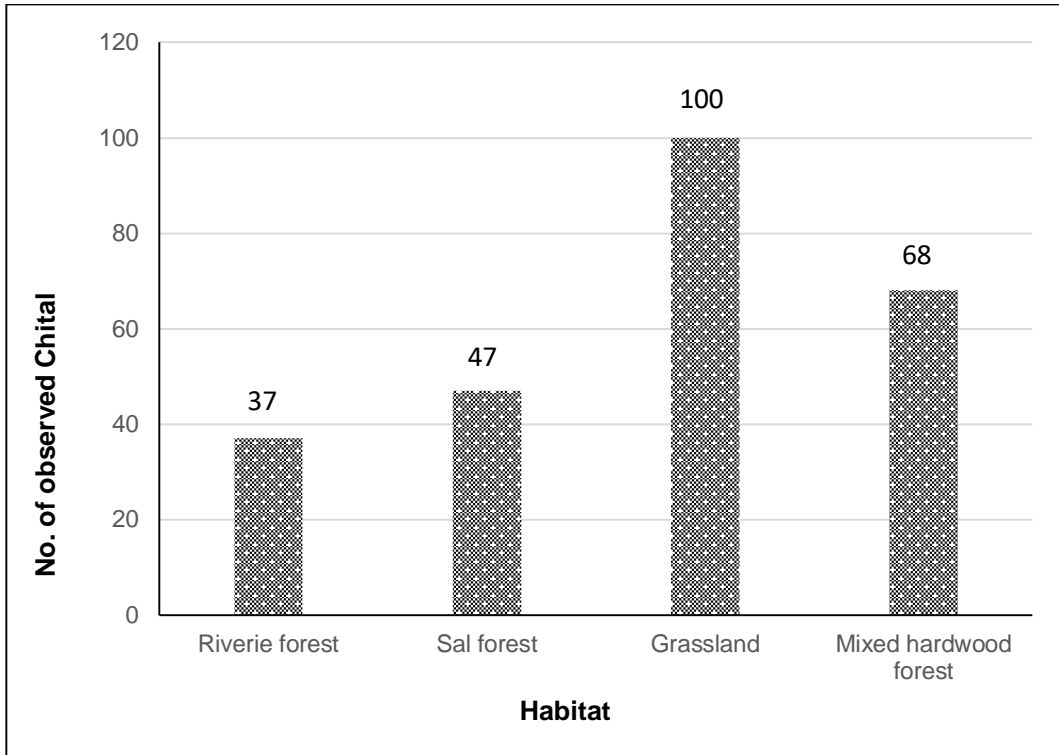


Figure 11. Number of observed Chital responses to different habitats

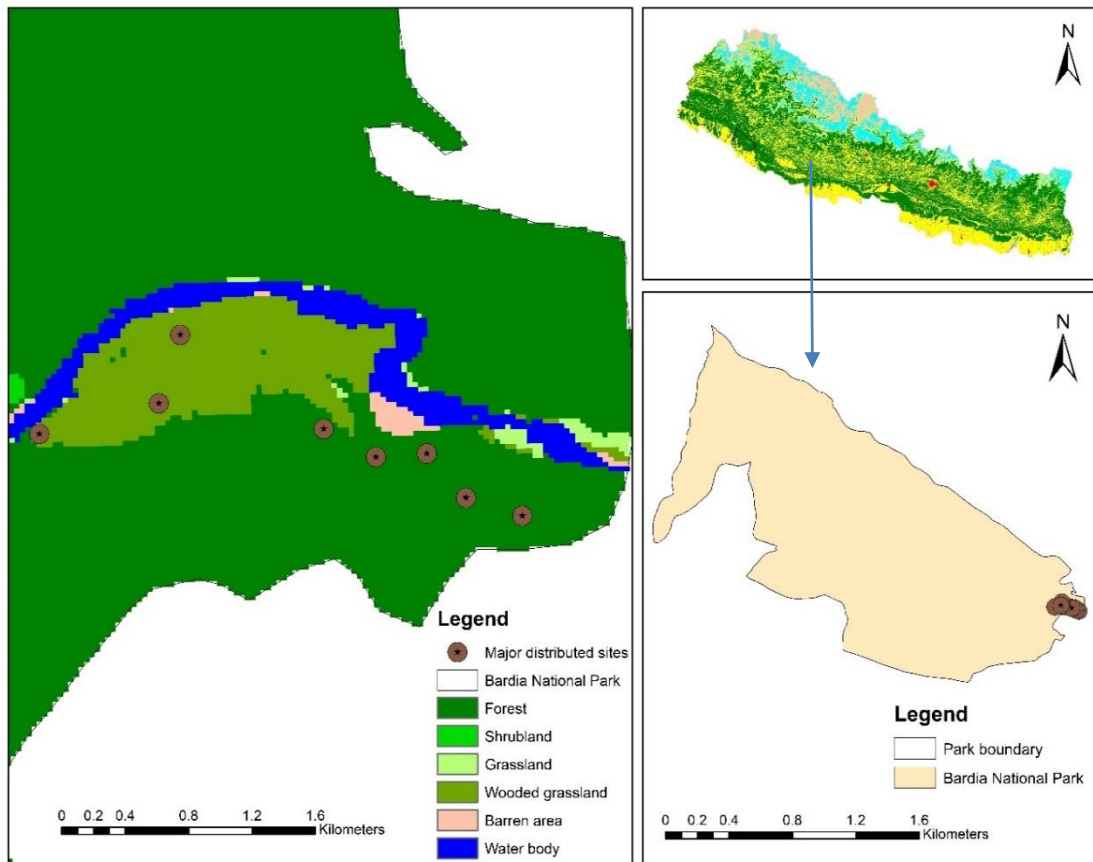
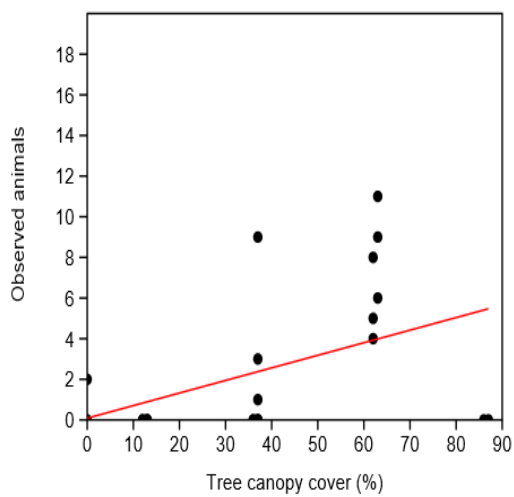


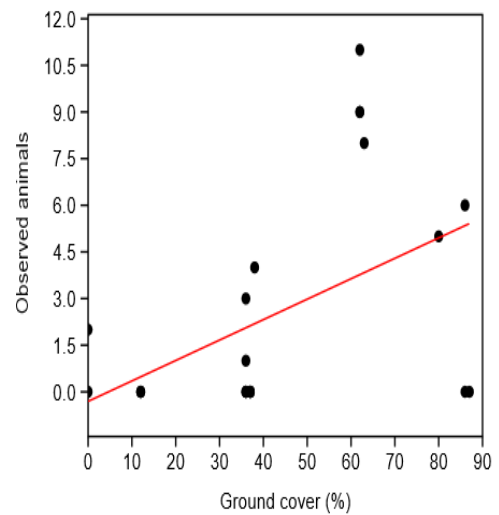
Figure 12. Distribution map of Chital in Bardia National Park

4.4 Factors affecting the distribution of Chital

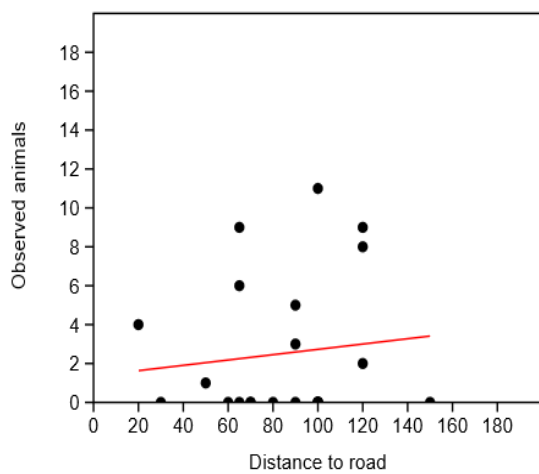
Five among variables (canopy cover, ground cover, distance to road, distance to water resources and presence of people). GLMs illustrated that only three variables including canopy cover ($P < 0.01$), ground cover ($P < 0.01$) and distance to water sources ($P < 0.01$) showed significant influence on the distribution of Chital. The major habitat factor causing significant impact on distribution of Chital was water source ($P < 0.01$) (Table 6). Tree canopy cover, ground cover, distance to road showed positive response indicating Chital increases with increase in tree canopy cover and ground cover. Similarly, distance to water sources and presence of people showed negative correlation with Chital distribution (Figure 13).



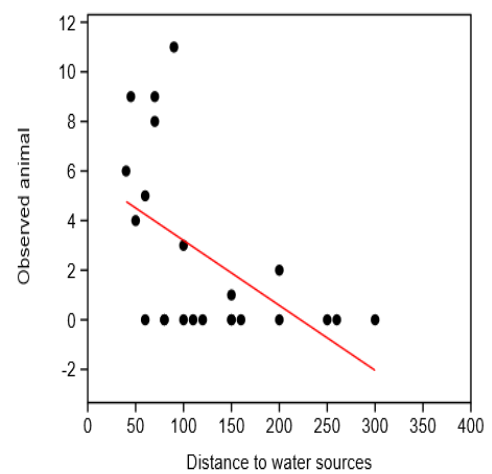
(a)



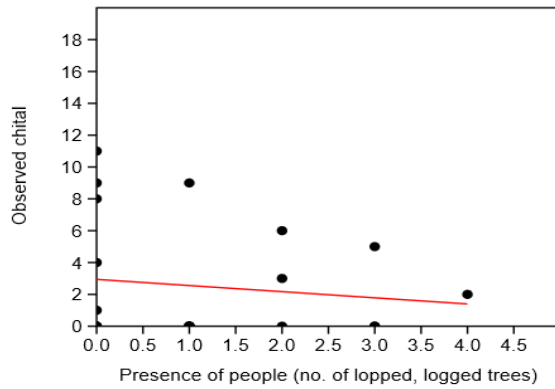
(b)



(c)



(d)



(e)

Figure 13. GLM result showing the relationship between observed Chital and (a) tree canopy cover ($y = 0.061883x + 0.086759$), (b) Ground cover ($y = 0.065725x - 0.30727$), (c) Distance to road (m) ($y = 0.013682x + 1.3588$), (d) Distance to water (m) ($y = -0.026191x + 5.8184$) and (e) Presence of people ($y = -0.3856x + 2.9409$)

Table 4. GLM result showing the relationship between environmental variables and Chital

| Environmental Variables | Intercept | Std. Error | P value |
|---|-----------|------------|-------------|
| Tree canopy cover | 0.086759 | 0.027977 | 0.02697* |
| Ground cover | -0.30727 | 0.0263 | 0.012453* |
| Distance to road | 82.623 | 1.7996 | 0.60042 |
| Distance to water source | 5.8184 | 0.00915156 | 0.0043966** |
| Presence of people | 2.9409 | 0.63531 | 0.54388 |
| Signif. Codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 | | | |

A total of 79 people participated in the questionnaire survey, described forest fire and human disturbances as the main threat to Chital. Some of them suggested that killed by feral dog also led to threats to the species like Chital. Remaining had described the human disturbance including disturbance to habitats and poaching as threats to Chital (Figure 14).

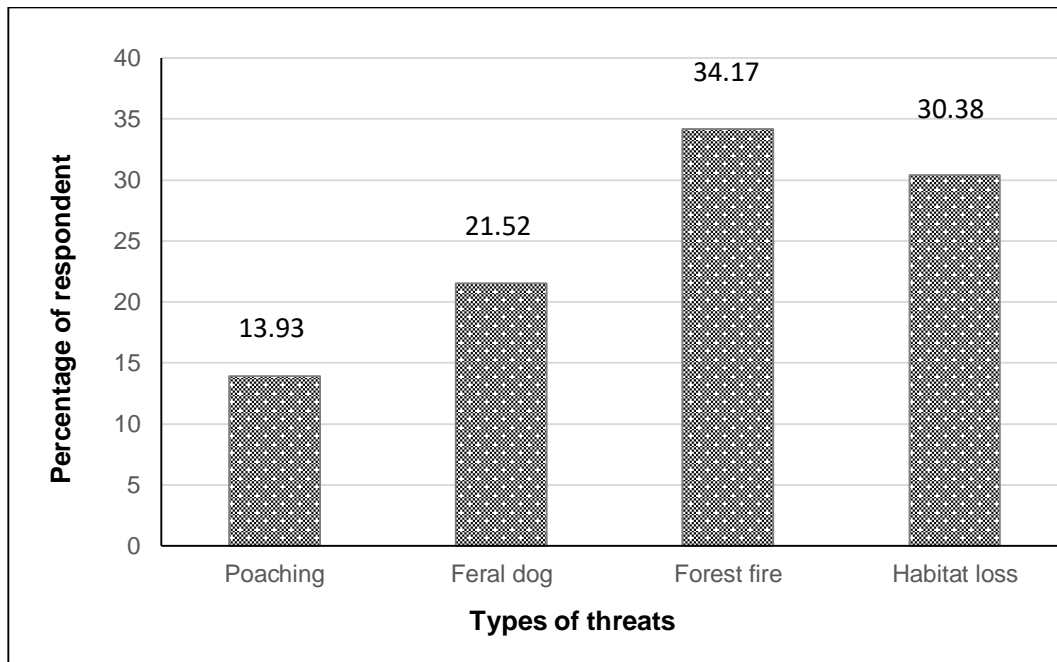


Figure 14. Perception about threats to Chital in Bardia National Park.

5. DISCUSSION

5.1 Population status of Chital

In this study area, a total number of 252 individuals of Chital were counted from eight different locations from about 20 km² area of north-eastern corner of the Park which include the major habitats and their adjoining areas on November 2019 through direct count method through line transect. But it was less than estimated by Kuikel (2003) in BNP, by Sharma (2013) in GBZCF which was 357 individuals of Chital in 543.19 km² and 352 individuals of Chital respectively. It may be due to seasonal variation and climate. This study was conducted in different blocks of habitats. However, forest dwelling and secretive nature of the animals were the major constraints in addition to climatic and disturbance factors for the visual count. Parajuli (2007) counted total of 832 individuals from different location from about 30 km² area of North- western corner of Bardia National Park, Nepal. De and Spillet (1996) estimated only 1906 individuals in 520.8 km² area in Corbett National Park. Schaller (1967) noted all-male herd of 23 individuals while Talk and Lamba (1984) recorded that of 92 individuals in Indian National Parks during the months of April. Moe (1994) found more than 100 individuals in a single herd in BNP.

There was significant difference in population of Chital among different study blocks of BNP. It may be due to the immigration and emigration of Chital from Babai Valley to nearby Bardia National Park and Buffer Zone and vice versa. This may be also the presence of different foods and habitats of Chital within the study blocks of BNP.

Present study showed the density of Chital was 43.39 individuals per km². But it was greater than estimated by Parajuli (2007) in Bardia National Park, which was 27.73 individuals per km². Similarly, which was also similar to the estimated by Schaller and Spillet (1966) in Keoladeo Ghana Sanctuary, by Dave and Jhala (2011) in Gir Forest, India, who record the crude density 45 individuals per km² and 44.8 ± 1.5 individuals per km². But it was less than the estimated by Naess and Andersen (1993) in Bardia National Park, Nepal, by Biswas and Sankar (2001) in Pench National Park in Central India and by Jathanna et al. (2003) in Tropical forest of India which was 225.3-384.5 individuals per km², 80.7 individuals per km² and 451 ± 1.5 individuals per km².

5.2 Population structure of Chital

Sex and age ratio indicate the existing status of the animal population. It also informs whether the population is increasing, decreasing or remaining constant. The sex ratio of Chital in Babai valley of BNP was 1:2.5 showing 48 bucks to 100 does (48:100). The male to female ratio was 1:2.5 showing a ratio of 47.88 bucks to 100 does. The ratio of male to female was less than the ratio which was estimated by Nichols (1960). He reported that the sex ratio of adult male to female was 77:100 in Hawaii. The sex ratio of the species in study area was also lower than the estimated by Tamang et al. (1976) at Chitwan National Park, Nepal (59:100), by Parajuli (2007) in Bardia National Park, Nepal (49:100) and by Schaller (1967) in Corbett National park (70:100). This ratio was higher than the estimated by Dinerstein (1980) in Karnali Bardia, Nepal and by Johnsingh (1983) in Bandipur, India, which was 0.5:1 and 0.6:1. The sex ratio in Babai Valley of Bardia National Park was almost near the Bardia National Park and comparatively lower than Chitwan National Park, it may be due to improper management of park habitat and unavailability of water inside it. Selective predation has a possible effect on the adult sex ratio. Presence of regular large carnivore like Tiger, Leopard and Wild dog were another factor for lower sex. The disproportion of adults may be due either to an unequal sex ratio at birth or higher male fawn mortality or both.

In the present study average herd size was found to be 9.33. It is less than the estimated by Sapkota (1999) in Parsa National Park, by Sharma (2013) in Ghailaghari Buffer Zone Community Forest and by Parajuli (2007) in Bardia National Park which was 20, 14.8 and 16.67 individual in one herd. It may be due to the availability of less open habitats, presence of predators and wild dogs. The herd size was also slightly less than other study which was estimated by Ganguly et al. (2011) in Zoological garden of India, Ramesh et al. (2011) in Western Ghat, India and Srinivasulu (2001) in Eastern Ghat India, which was 10.36, 13.1 ± 0.50 and 12 respectively. According to Dinerstein (1980), Chital group size in Karnali-Bardia (Nepal) varied from one to 91 individuals with a mean group size of 10.7. Barrette (1991) reported 2 to 125 individuals in Wilpattu (Sri Lanka) with a mean group size of 12 which was also higher than the present study. Mishra (1982) reported that mean group size of Chital was 7.5 in Chitwan National Park where as in Sariska, Chital group size was 7.8 ± 8.3 (Sankar 1994). Barrette (1991) reported that Chital group was 6 in Wilpattu which was lower than the present study.

As a result, from one-way ANOVA the study of population composition of Chital showed that there was higher contribution of female individuals for the formation of the larger groups, and these larger groups possess the greater number of sub-adult and young individuals, which was also recorded in CNP by Bhattarai and Kindlmann (2018). There were no solitary male and young found in this study. It may be due to the young always remains with mother. Bhattarai and Kindlmann (2018) also recorded that no solitary sub-adults and young in Chitwan National Park.

5.3 Distribution of Chital

In this study area population of Chital were observed in different habitats. Chital prefers secondary Sal forest, riverine forest and grassland with good understory of grasses, forbs and tender shoots, over mature inferior forests (Thapa 2003). It may be due to different availability of resources in different habitats may be the reason in inhabits in all habitats. The ungulates are not distributed equally in all areas. The difference in occurrence of the ungulates means that ungulate prefers different areas of the forest and floodplain differently, which indicate the difference in their preference for different habitats. This means that they do not utilize all the habitats equally and each habitat is not equally favourable of the ungulates. To minimize the risk of predators prefers open habitats like grassland than closed habitats may be another reason to prefer different habitats. Chital mostly preferred grassland habitat and least preferred habitat was riverine forest habitat. Similar result was found in Parsa National Park, Nepal by (Sapkota 1999). Grassland was preferentially utilized by female at night during hot season in Lowland of Nepal (Moe & Wegge 1994).

The grassland habitat was mostly used by Chital, it may be due to the availability of grass species such as *Imperata cylindrica*, *Saccharum spontaneum*, *Cynodon dactylon*, as well as *Digitaria* species. Riverine forest was least preferred. It may be due to unavailability of grass species for grazing. But dissimilar result was found in different area. Moe and Wegge (1994) reported that riverine forest was mostly preferred habitat in hot-dry season and sal forest was preferred in monsoon season in Lowland of Nepal. Sal forest was highly preferred habitat in Suklaphanta National park, Nepal (Pokhrel 2005). Mixed forest habitat with high density of grass was mostly preferred habitat in Kuno Wildlife Sanctuary (Kushwah et al. 2012) and hardwood forest was mostly preferred and flood plain was least preferred habitat Karnali flood plain on Bardia National Park, Nepal (Gautam 2013).

The result from the study of eight different locations of about 20 km² area of Eastern Park showed clumped or uneven type of distribution, which is the most common pattern of distribution among the larger mammals. In this study area Chital was distributed in clumped pattern according to the variance to mean ratio. Biological populations in natural habitat generally exhibit clumped type distribution pattern (Odum 1996). Such pattern of distribution was also recorded in South Western part of Bardia National Park (Parajuli 2007). Similar trends were also reported by Adhikari and Khadka (2009). The uneven distribution of Chital in the study area may be due to less competition in larger sampling area, different habitats and availability of resources like food, water and cover.

5.4 Factors affecting distribution of Chital

Water sources and canopy cover had influence the Chital distribution. Tree canopy cover, ground cover and distance to road were positively correlated with the distribution of Chital which is similar to another study in Tanahun (Adhikari et al. 2019). Distribution of Chital were found in different habitats, which is quite similar to other studies (Adhikari et al. 2019). Their distribution towards different habitats may be because of availability of more food, water and canopy cover. Similarly, distance to water sources, presence of people showed negative correlation with Chital distribution which was almost similar to another study in Chitwan National Park (Bhattarai & Kindlmann 2018). This might be due to the smore occurrence of large mammals nearby water resources and human activities in the study area that affects the Chital because of disturbances and habitat destruction. Similarly, Chital distribution close to water resources, hence, as distance to water sources increased within the study area, Chital observation was less. Maximum number of Chital were observed in grassland i.e. open habitat in our study which is similar to another study in CNP (Bhattarai & Kindlmann 2018). In this study, large and very large group of Chital were recorded in the grassland while other small groups were found in closed habitats, which was mainly due to presence of predator and human disturbance which is similar to another study in CNP (Bhattarai & Kindlmann 2018). Abson and Termansen (2010) reported that the major factors which affected the chital distribution were land use for agriculture, deforestation, poaching and hunting, grazing competition with livestock, road and train network. In our study, the distribution of Chital were affected by road which is similar to another study in Mukandra Hills Tiger Reserve (Abson & Termansen 2010). This might be due to human disturbance in road. In this study there is no village inside the intensive study area, competition for food between domestic livestock and wild ungulates

was not observed during the present study. The abundance of major prey species of common Leopard and Bengal tiger except primates, was highly negatively associated with disturbances (Bhattarai & Kindlmann 2012). Adhikari et al. (2019) found that the distribution of large mammals were greatly affected by habitat and disturbance factors which is similar to our study. Similarly, water resources played great role in distribution of wildlife, as there were more occurrence of large mammals nearby water resources which is similar to our study. Research on factors influencing the distribution of large mammals within a protected central African forest indicated that human activities significantly influence the distribution of large mammals, even within the protected areas (Blom et al. 2005).

6. CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Bardia National Park is the prime habitat of Chital. A total number of 252 individuals of Chital were observed from eight different locations including major habitat about 20 km² area of the Northern east of BNP. Among different study blocks, maximum presence of Chital were recorded in the F block 68 individuals (26.99%), and minimum population was found in H block 11 individuals (4.37%). However, Chi-square test revealed that there is significant difference in population status of Chital among different study blocks. The density of Chital was 43.39 individuals/km². The male to female sex ratio was 1:3 showing the ratio of 48 bucks to 100 does with more females than the males in all blocks and time. The sex ratio of Chital was the highest in grassland and lowest in riverine forest. Similarly, the sex ratio of Chital were similar in both sal forest and mixed-hardwood forest. The average mixed herd size was computed as 9.33 individuals, being 40 individuals were highest mixed herd in the Park. Among them highest population distribution of Chital were recorded as 100 individuals (39.68%) in grassland and that of least in riverine forest 37 individuals (14.68%). Distribution pattern of Chital was clumped with significant difference in distribution of population within the different study blocks of the Park. Tree canopy, ground cover, distance to road showed positive relation while distance to water resources and presence of people showed negative relationship with observed Chital. Habitat loss, poaching, forest fire and feral dog were identified as a serious threat to species survival.

The results indicate that population distribution of Chital are observed in different habitats. Chital are not distributed equally in all areas. It may be due to different availability of resources in different habitats may be the reason in inhabits in all habitats. Present study observed low population distribution of Chital in riverine forest in comparison to other habitat types and limited plots were surveyed in this habitat. So, in depths study in riverine forest is necessary. Chital monitoring in intensive areas of BNP can provide valuable information in conservation as well as in ecosystem management effort of the BNP. Chital mostly preferred grassland habitat compared to others. In grassland, the availability of grass species such as *Imperata cylindrica*, *Saccharum spontaneum*, *Cynodon dactylon*, as well as *Digitaria* species. Age and sex composition of Chital implied that there was bias towards the female and these possess fewer number of young individuals. The results also indicate

that the population of female Chital are greater than male Chital. Selective predation has a possible effect on the adult sex ratio.

This study found that distribution of Chital are influenced by habitats, cover and human disturbance. In the disturbed areas, Chital resorted into small groups in the forest areas, which might be a reason of escaping and hiding from human disturbances. Chital forms large groups in the open areas and small groups in forest, which were less disturbed by humans.

Based on questionnaire survey, this study found that there are various conservation threats to the survival of Chital. The major threats is habitat loss and forest fire. Chital in the study area can be conserved by launching livelihood developmental programme for villagers, conservation awareness programme and strict implementation of Park rules and regulations. Grassland management, control of poaching, and provision of artificial waterholes in the northern edge of sal forests and grasslands may continue flourishing of Chital as one of the beautiful wild animal of BNP. Regular monitoring of the population of Chital is important to achieve more information for Chital and facilitate expedient planning.

6.2 Recommendations

1. From this study, Babai Valley Bardia National Park lying inside the protected area was found to be one of the most important areas for Chital. Further studies related to the conservation of this species in this area are recommended to future researchers and conservationists.
2. The feral dogs should be eliminated from inside and outside of the protected areas.
3. Provision and management of artificial waterholes should be created in water scarce areas.
4. The rules and regulations for the wildlife conservation should be implemented effectively and efficiently together with the joint effort of park authorities, army and local people.
5. Regular monitoring, yearly census and research of Chital in BNP should be done to acquire information about their status.
6. This study could not cover the whole Chepang Post Babai Valley due to dense vegetation cover and limited period of time. So, detailed study of Chital on the seasonal monitoring should be conducted covering all the potential sites in Bardia National Park.

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APPENDICES

Appendix I- Questionnaire Survey Data Sheet

Form no:-

Date:-

District Nagar.....Village Ward no.....

1. Name of respondent.....

Age Sex..... Education.....

2. Have you seen Chital? a) Yes b) No

3. What is your attitude toward Chital? a) Positive b) Negative c)

Neutral

4. Have you ever seen soil licking of Chital?

Please specify the place.....

5. In which time do you see the animals grazing in the large numbers in Phantas?

a) Early in the morning b) late morning c) Afternoon d)

Evening

6. Where to conserve Chital?

a) National Parks/Reserve c) Zoo d) No idea

7. In your opinion what is the general herd size?

a) 1-5 b) 5-10 c) 10-15 d) 15- 20 e) > 20

8. What is your opinion about number of chital?

a) Number increase b) Number decrease c) Not quite known

9. Are Chital chased or killed by people?

.....

10. What may be the major threats to Chital in this area?

.....

11. What can be done to conserve Chital?

.....

APPENDIX II- GPS points of Field

| Transect | Habitat | Starting point of transect(degree minute second) | | Ending point of transect(degree minute second) | |
|----------|-----------------------|--|---------------|--|---------------|
| | | North | East | North | East |
| 1 | Riverine Forest | 28°21' 17.4 " | 81°42' 21.2 " | 28°21' 11.2 " | 81°42' 19.3 " |
| 2 | Riverine Forest | 28°21' 18.5 " | 81°42' 15.0 " | 28°21' 12.6 " | 81°42' 12.0 " |
| 3 | Riverine Forest | 28°21' 21.3 " | 81°42' 10.8 " | 28°21' 15.3 " | 81°42' 8.5 " |
| 4 | Riverine Forest | 28°21' 23.9 " | 81°42' 2.5 " | 28°21' 16.9 " | 81°42' 1.2 " |
| 5 | Sal Forest | 28°21' 28.8 " | 81°41' 51.7 " | 28°21' 23.2 " | 81°41' 50.2 " |
| 6 | Sal Forest | 28°21' 31.7 " | 81°41' 47.4 " | 28°21' 26.8 " | 81°41' 44.5 " |
| 7 | Sal Forest | 28°21' 30.7 " | 81°41' 38.6 " | 28°21' 35.7 " | 81°41' 40.9 " |
| 8 | Sal Forest | 28°21' 31.7 " | 81°41' 33.8 " | 28°21' 36.7 " | 81°41' 34.5 " |
| 9 | Grassland | 28°21' 30.9 " | 81°42' 2.8 " | 28°21' 25.7 " | 81°41' 00.8 " |
| 10 | Grassland | 28°21' 32.9 " | 81°41' 55.9 " | 28°21' 27.2 " | 81°41' 54.1 " |
| 11 | Grassland | 28°21' 35.1 " | 81°41' 50.0 " | 28°21' 29.5 " | 81°41' 48.0 " |
| 12 | Grassland | 28°21' 37.5 " | 81°41' 44.2 " | 28°21' 32.4 " | 81°41' 42.1 " |
| 13 | Grassland | 28°21' 41.9 " | 81°41' 47.7 " | 28°21' 50.3 " | 81°41' 48.3 " |
| 14 | Grassland | 28°21' 44.0 " | 81°41' 37.2 " | 28°21' 51.4 " | 81°41' 38.7 " |
| 15 | Grassland | 28°21' 45.7 " | 81°41' 27.9 " | 28°21' 54.0 " | 81°41' 28.9 " |
| 16 | Grassland | 28°21' 45.4 " | 81°41' 18.4 " | 28°21' 52.7 " | 81°41' 19.7 " |
| 17 | Grassland | 28°21' 44.0 " | 81°41' 8.7 " | 28°21' 52.3 " | 81°41' 6.7 " |
| 18 | Mixed-Hardwood forest | 28°21' 38.4 " | 81°40' 50.4 " | 28°21' 32.8 " | 81°40' 49.0 " |
| 19 | Mixed-Hardwood forest | 28°21' 37.5 " | 81°40' 50.0 " | 28°21' 32.3 " | 81°40' 55.3 " |
| 20 | Mixed-Hardwood forest | 28°21' 37.8 " | 81°41' 1.3 " | 28°21' 32.0 " | 81°41' 1.8 " |
| 21 | Mixed-Hardwood forest | 28°21' 40.1 " | 81°41' 7.4 " | 28°21' 34.1 " | 81°41' 7.9 " |
| 22 | Mixed-Hardwood forest | 28°21' 44.5 " | 81°41' 17.8 " | 28°21' 37.0 " | 81°41' 17.9 " |
| 23 | Mixed-Hardwood forest | 28°21' 43.1 " | 81°41' 27.9 " | 28°21' 36.4 " | 81°41' 26.1 " |

APPENDIX III- Species of different habitats

| Habitat Type | Dominant species | Other associates |
|-----------------------|---|---|
| Riverine forest | <i>Dalbergia sissoo, Trewia nudiflora, Mallotus philippensis</i> | <i>Ehretia laevis, Ficus glomerata, Syzigium cumini, Bombax ceiba</i> |
| Sal forest | <i>Shorea robusta</i> | <i>Terminalia tomentosa, Buchanania latifolia</i> |
| Mixed-hardwood forest | <i>Lagerstroemia parviflora, Caseria tomentosa, Murraya keonigii,</i> | <i>Bombax ceiba, Adina cardifolia, Mitragyna parviflora, Zyzipus mauritiana, Solanum verbascifolium</i> |

APPENDIX V- Photo Plates



Photo 1 A matured male Chital



Photo 2 Yearling female in alert posture



Photo 3 A matured female Chital



Photo 4 Female-fawn herd in alert posture



Photo 5 Herds of Chital at grassland in cool-dry season



Photo 6 Langur-Chital association in study area



Photo 7 Herds of Chital in grassland



Photo 8 Observation of Chital



Photo 9 Antler of Chital



Photo 10 Questionnaire survey with villager



Photo 11 Artificial waterhole construction inside the Park



Photo 12 Skull of Chital