**ADDIS ABABA UNIVERSITY**

**SCHOOL OF GRADUATE STUDIES**

**DEPARTMENT OF ZOOLOGICAL SCIENCES**

**(ECOLOGICAL AND SYSTEMATIC ZOOLOGY STREAM)**

# POPULATION STATUS, BEHAVIOURAL ECOLOGY OF PLAINS ZEBRA *(Equus quagga)* AND HUMAN-WILDLIFE CONFLICT IN NECHISAR NATIONAL PARK, ETHIOPIA

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**January 2021**

**Addis Ababa**

**Ethiopia**

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**A THESIS SUBMITTED TO**

**THE DEPARTMENT OF ZOOLOGICAL SCIENCES**

**PRESENTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN BIOLOGY (ECOLOGICAL AND SYSTEMATIC ZOOLOGY)**

**January 2021**

**Addis Ababa**

**Ethiopia**

**ADDIS ABABA UNIVERSITY**

**SCHOOL OF GRADUATE STUDIES**

This is to certify that the thesis prepared by Addishiwot Fekadu, entitled: Population status, behavioural ecology of Plains zebra *(Equus quagga*) and human-wildlife conflict in Nechisar National Park, and submitted in partial fulfillment of the requirements for the Degree of Doctor of Philosophy in Biology (Ecological and Systematic Zoology) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

Signed by the Examining Committee:

External Examiner ----------Signature----------Date----------

Internal Examiner ----------Signature----------Date----------

Advisor----------Signature----------Date----------

Chair----------Signature----------Date----------

## ABSTRACT

Population Status, Behavioural Ecology of Plains zebra (*Equus quagga*) and Human-Wild life Conflict in Nechisar National Park, Ethiopia.
Addishiwot Fekadu, Ph. D. Thesis, Addis Ababa University, January 2021

Plains zebra is the most abundant equid in the world. In Ethiopia, the total population size of this species was estimated to be around 2000 individuals. Nechisar National Park holds the largest populations of Plains zebra.The present investigation deals with population status, habitat preference, diurnal activity, feeding habit of Plains zebra (*Equus quagga*) and human-wild life conflict in Nechisar National Park. Data were collected for two consecutive years including both wet and dry seasons between December, 2017 and April, 2019. The entire study area was divided into five major habitat types. A total of 28 line-transects on five major habitats such as open grassland (7), wooded grassland (6), bushland (7), riverine vegetation (4) and lakeshores (4) were determined. Based on the observability of the animals 700 to 1000 m strip width was considered and fixed. Adjacent transects were at least 1.5-2.0 km apart. The average length of the line-transect was 9.84 km. Counting was carried out through direct observations with naked eye and/or by using binoculars. Diurnal activity pattern of plains zebra was also carried out through direct observations on major activity pattern using a 5 minutes focal animal sampling period. Feeding habit determination was carried out through direct focal animal observation. Semi-structured interviews and focus group discussions were also held with the local people. Data were analyzed using population density estimation parameters. A total of 716 individuals of Plains zebra were recorded from the study area. On average 272.25 (38.0%) and 443.75 (62.0%) were recorded during the dry and wet seasons, respectively. The distribution and abundance of the animals varied among habitats and between seasons. Plains zebra showed high preference for grassland followed by wooded grassland and bushland. The record showed maximum diurnal activity pattern for grazing (56.5%) and minimum for grooming (6.6%). From observations of foraging activities, six grass, four herbs and three shrubs species were identified as their common food items. During both seasons, Plains zebra preferred grasses species to others and didn't show significant difference ($F_{(5,10)}$=5.865, P>0.05). Herbs and shrubs were consumed more during the dry season than the wet season. They showed statistically significant variation in the consumption of Herbs ($F_{(3,6)}$=44.38, P<0.05) and Shrubs ($F_{(2,4)}$=19.42, P<0.05). On average, they proportionally consumed grass (70.0%), herb leaves (19.7%) and shrubs (10.3%). A total of seven species (five herbivores and two omnivores) were recoded as major hazards of crop damage, whereas seven species (six carnivores and one omnivore) were recoded as major predators. Crop damage, livestock loss and human impact such as overgrazing, illegal settlement, and resource exploitation were the major problems (60.2%) encountered between human and wildlife in the study area. Relatively, 51% of the respondents had a negative attitude towards conservation areas and wildlife. Responsible bodies and concerned stakeholders should integrate to resolve the challenges of conservation threats and protection of the wildlife in the study area.



**Keywords**: Abundance, plains zebra, conservation, livestock, Nechisar National Park and wildlife.

**ACKNOWLEDGEMENTS**

I would like to express my deepest gratitude to my advisor, Prof. Afework Bekele for his wholehearted encouragement and providing the opportunity to work with him. His assistance and unreserved help in all aspects of this research work is appreciated. I also appreciate his welcoming approach, valuable comments, suggestion and structuring of the draft manuscript. His willingness to share his knowledge and experiences is also greatly appreciated.

I would also like to express my appreciation and heartfelt thanks to my husband Dr. Demeke Datiko for his valuable support during the field work. His support starting from inception of the proposal idea to completion of the thesis is much appreciated.

I extend my special thanks to the Ethiopian Wildlife Conservation Authority for their provision of information and permission to conduct the research in the study area. I also wish to thank all the staff members of NNP, specifically, Mr. Abraham Marye, the Warden of the Park, and Mr. Tamirat Haile in supporting my work in the Park during data collection. I am especially thankful to all Park scouts involved during data collection in the Park as well as from the local community members. I sincerely acknowledge the local people of the Guji, Kore/Amaro and Zeysie ethnic groups for their cooperation, patience, hospitality and willingness to share their knowledge during discussion and respond to my interview voluntarily without which this work would not have been a reality.

I would like to express my sincere appreciation to Madda Walabu University for sponsoring my study. I also thank Addis Ababa University for providing financial assistance and the Department of Zoological Sciences for facilitating my work. I am also grateful to Dr. Tizazu Gebire for his great interest and willingness to help me in identifying the specimens. Finally, my gratitude goes to my children Eyasu and Dibora, my parents and friends who have in one way or the other encouraged and supported me throughout the study.

## DEDICATION

This work is dedicated to my husband and children, who encouraged and helped me from the beginning to the end of this research work

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# 1. INTRODUCTION

## 1.1. Background of the study

Mammals are the highest evolved group of the animal kingdom (Ghose and Manna, 2003). Among the mammals, plains zebra (*Equus quagga*), referred to as 'zebra', is the most abundant equid in the world (Hack, East and Rubenstein, 2002). They comprise large, single-hoofed ungulates that are built for speed and long-distance movements (Estes, 1997), range from South Africa north to southeastern Sudan, southern Ethiopia and southern Somalia (Hack, East and Rubenstein, 2002). The total global population of plains zebra in the wild is 663,212 (Hack *et al.*, 2002). Over 75% of the world's plains zebra are of the Grant's subspecies and, of these, nearly three-quarters live in just two countries Tanzania and Kenya (Duncan, 1992). There are Six subspecies of zebra, recognised based on morphological traits (Groves and Bell, 2004), yet there is very little genetic differentiation between subspecies (Lorenzen, Arctander and Siegismund, 2008). Different subspecies exhibit a decrease in stripe coverage from the north to the south of the range, coupled with an increase in body size. They can live up to 25 years in the wild and to 45 years in the captive. However, most wild mammals are at risk due to many factors in their natural habitats (Acevedo *et al*., 2005; Demeke Datiko and Lema Tiki, 2017). It is important for conservationists to have detailed information on impacts of expanding human population in areas of rich wildlife areas. Therefore, monitoring trends in animal population is a key aspect in the managements of wildlife (Acevedo *et al*., 2005).

Monitoring schemes must generate reliable estimates of abundance to allow assessment of population trends. Reliable estimates of abundance are also required to improve the understanding of ecological processes of expansion or inter-specific competition and also for the development of appropriate management strategies (Focardi *et al*., 2006). Most of the current biodiversity crisis arises as a result of increasing competition with humans for space and resources. Thus, protected areas become isolated islands of natural habitat that are invaded by human settlement. Conflicts between human and wildlife population emerge as a major conservation issue worldwide. One of the major causes for human

impacts on wildlife is increasing human population adjacent to the protected area. As human population increases, the demand for resources grows, and the frequency and intensity of conflict between wildlife and local people also becomes frequent around protected area (Tewodros Kumsa and Afework Bekele, 2008; Demeke Datiko and Lema Tiki, 2017). This can be manifested by increasing encroachment of wildlife habitats.

Most wild mammals in developing countries are at risk due to a variety of factors. For instance, the genus *Equus* comprises six species. Three of these species (*Equus burchelli burchelli, Equus burchelli hunippus* and *Equus przewalskii*) are extinct (IUCN, 1990). The three surviving species of zebras are the Mountain zebra (*Equus zebra*), Grevy's zebra (*Equus grevyi*) and Plains zebra (*Equus quagga*) (Estes, 1997). Plains zebra, once ranged throughout eastern and southern Africa (Estes, 1997; Stuart and Stuart, 2007). At present, their distribution range is across the Somali-Masai arid zone through the southern savannah and marginally in the southwest arid zone, from southeastern Sudan to South Africa and Angola with limited population in Ethiopia (Yisehak Doku *et al*., 2007).

Plains zebra are large sized, striped equid with average height of shoulder reaching from 100 to 145 cm, and their body mass is from 175 to 322 kg (Hoster, 2009). Extant species of Plains Zebra approximate a morpholine with *E. gravy,* particularly in body proportions and details of strip patterns. Compared with other species, *Equus quagga* has broad body strips (Baver *et al*., 1994) (Fig. 1). Plains zebras graze almost exclusively on grasslands and savanna woodlands (Bodenstein *et al*., 2000). The activity patterns can vary depending on seasons, the animal's sex, age or reproductive state (Blom, 2009). There are many factors (time of the day, season, resources, predation, etc.) that can influence the activity pattern of an animal (Fischhoff *et al*., 2007; Kamler *et al*., 2007). Zebras are most active in the early morning and late afternoon. Zebras are highly social and usually form small family groups. Groups are permanent, and their size tends to vary with habitat. Unlike many of the large ungulates of Africa, zebras prefer but do not require short grass to graze on. As a consequence, they range more widely than many other species, even into woodland. Nevertheless, for protection from predators's, Plains zebra retreat into open areas with good visibility at night time, and practice alternate standing

watch. Zebra populations have declined across most of their range in the last 50 years as a result of anthropogenic impact on the environment. Habitat loss and illegal hunting are the principal causes of concern (Fischoff *et al*., 2007). In East Africa, factors such as human settlements, livestock grazing and agricultural activities have restricted the distribution, leading to a decline in these populations (Yisehak Doku *et al*., 2006). The Plains zebra provides important functions for the ecosystem and for humans as in food chains, serving as prey for such predators like lions, hayenas and Nile crocodiles. Zebras have also often served as source of meat and hide, and at present Plains zebra is an important economic source of tourism.

In Ethiopia, major populations of Plains zebra occur in Omo, Mago and Nechisar National Parks, and in Yabelo Wildlife Sanctuary (Yisehak Doku *et al*., 2007; Reta Regassa and Solomon Yirga, 2013). Total population size of this species in the four protected areas was estimated to be around 2000 individuals (Duncan, 1992). As noted by Yisehak Doku *et al*. (2007), Nechisar National Park holds the largest populations of Plains zebra. However, the survival of these animals is affected by ever-increasing human and livestock population pressure, habitat fragmentation and related factors. As a result, long-term survival of many of the protected areas and the populations of the larger herbivore species is not safe (IUCN, 2000). Therefore, monitoring trends in animal population and related factors are key aspect of wildlife management (William, 2004). Particularly, trend data are central to setting species conservation priorities.

Human-wildlife conflict is one of the major problems in many parts of the world as stated by Hill *et al.* (2002), particularly human population growth, agricultural expansion, deforestation, hunting and the results of economic development have had profound cumulative impacts on the environment, natural habitats and wildlife populations all over the world (Bourn and Blench, 1999). The nature of conflict shows an increasing tendency between humans and wildlife over the use of natural resources mainly land, forests and water (Tewodros Kumsa and Afework Bekele, 2008; Demeke Datiko and Lema Tiki, 2017). The conflict is manifested as when people are killed or injured by wild animals, loss of livestock through predation, competition for pasture, wildlife invasion of crop farms and inadequate or lack of compensation for losses (Demeke Datiko and Afework Bekele,

2013a). Encroachment on wildlife areas such as forests and protected areas, blocking wildlife migration routes and poaching of wildlife for food, horns, skins and other valuable products are some of the problems observed in many countries throughout the world (Obunde *et al*., 2005). Moreover, there is an increasing risk of spread of disease from domestic animals to the wild animals.

As noted by Tewodros Kumsa and Afework Bekele (2008), human-wildlife conflict is more intense in developing countries where livestock holdings and agriculture are important parts of rural people's livelihoods and income. In these regions, competition between local communities and wild animals, for the use of natural resources, is particularly intense (Messmer, 2000). Growing densities in livestock populations can also create an overlap of diets and forage competition with wild herbivores. This results in overgrazing and decline or local extinction in wild herbivore populations (Mishra *et al*., 2003; Michalski *et al.*, 2006). Similarly, the problems of wildlife conservation in Nechisar National Park is very high. Particularly, habitats of large herbivores such as: Plains zebra, and grater kudu in the Nechisar National Park is degraded severely due to high livestock grazing in the plain area (Demeke Datiko and Afework Bekele, 2011). Moreover, many wild animal numbers are decreasing, and animals like Swayne's hartebeest locally extinct from the Park. As a result, monitoring the current population status of Plains zebra and related conservation gaps are indispensable.

### 1.2. Statement of the problem

Ethiopia is one of the richest countries in biodiversity. The altitudinal difference and geographical distribution of the country reflect the existence of a large number of mammalian species and other wildlife (Afework Bekele and Leris, 1997; Leykun Abune, 2000). This made the country to host high species diversity. However, of all other vertebrates, large sized mammals are vulnerable to a wide range of threats from human activities (Madhusudan and Mishra, 2003; Morrison *et al*., 2007). As a result, particularly large sized mammals including Plains zebra are susceptible for loss due to various reasons. The Park is acknowledged as one of the protected areas in Ethiopia that suffers

from a high anthropogenic resource extraction and loss of habitat. Overfishing in the lakes, wood gathering from the forests, cattle grazing in the grasslands and farming in the Sermelle River Valley are identified as the major problems of plains's zebra (Freeman, 2006; Yisehak Doku *et al*., 2007; Demeke Datiko and Afework Bekele, 2011).

Further more, the knowledge of distribution of animals in relation to their environment is essential to effective game management and range utilization control. Since habitat destruction due to overgrazing could reduce the fertility and growth rate of animals (Laws and Parker, 1968), the knowledge of distribution of animals in the habitat is of crucial importance in population control and habitat management. The major physical factors affecting the distribution of animals in any habitat are the availability of water, effect of fire, topography, temperature variability and relative humidity (Odum, 1971).

Many studies on plains zebras in the East and South African ecosystems were done during the 1960's and 1970's. As medium-sized herbivores, plains zebras are also considered to be an important component of African mammal communities, and a good knowledge of their ecology and demography is therefore essential for the conservation and management of these equid populations. The ecology and behaviour of zebras are well-known because of previous studies that mainly dealt with their particular social system, and also allowed comparisons between different populations and zebra species from East to South Africa (Klingel, 1967; Monfort and Monfort, 1978).

For instance, in the present proposed study area (Nechisar National Park), the population of endemic mammal Swayne's hartebeest decreased from 50 to 12 individuals within four years (Demeke Datiko and Afework Bekele, 2011). More over there is a limited information on the current population status of the Plains zebra except about 14 years ago and it was solely carried out in the Nechisar plain area of the Park, by Yisehak Doku *et al*. (2007), which is the present study area. Furthermore, the animals need large home range for their survival and restriction exposes them to death. The animals are also hunted and pouched illegally by local people and face increasing conflict with people for resource competition. Therefore, monitoring population status of animals, in the five major identified habitats of the Park and assessing their threat are very important for

proper conservation of the Plains zebra, and other wildlife in the Park. Moreover, the study will determine how zebra respond to changes in resource and habitat availability resulting from seasonal changes. As a result, the study examined movement of Plains zebra within the NNP and responded to resource availability. Therefore, the current proposed study was to investigate the population status, habitat preference, activity pattern, feeding habit of Plains zebra, and human-wildlife conflict in Nechisar National Park.

### 1.3. Significance of the study

Understanding population status, habitat preference, diurnal activity, feeding habit of the Plains zebra and conservation gaps/threat in Nechisar National Park should assist in proposing short-term and long-term management. It may be valuable for other wildlife management and conservation agencies on what should be done to halt the situation for the sustainable management and conservation of Plains zebra and other wildlife in the Park. The outcome of the study will play a profound role in contributing valuable information for policy makers in providing them with great insight on the problems associated with wildlife conservation for Ethiopian Wildlife Conservation Authority, Ethiopian Biodiversity Institute, and other concerned stakeholders.

### 1.4. Objectives

#### 1.4.1. General Objective

The general objective of this study was to investigate the population status, behavioural ecology of Plains zebra *(Equus quagga*), and human-wildlife conflict in Nechisar National Park, Ethiopia.

#### 1.4.2. Specific objectives

- ✓ To assess the population status of Plains zebra *(Equus quagga*) in the study area,
- ✓ To determine habitat preference in response to changes in resource availability between seasons in the Park;
- ✓ To examine diurnal activity pattern of Plains zebra;
- ✓ To determine the feeding habit/common food items of Plains zebra;
- ✓ To assess the conflict between human and wildlife in the Park.

## 2. LITERATURE REVIEW

### 2.1. Taxonomy and Physical Features

The genus *Equus* comprises six species and 22 subspecies. Three of these species (*Equus burchelli burchelli, Equus burchelli hunippus* and *Equus przewalskii*) are extinct (IUCN 1990). According to Groves and Bell (2004), the three extant species of zebras in Africa are Plains zebra (*Equus quagga*, Boddaert, 1785, or *Equus burchelli*, Gray 1824), Mountains zebra (*Equus zebra*, Linnaeus, 1758), and the Grevy's zebra (*Equus grevyi*, Oustalet, 1882). Groves and Bell (2004) described genetics-based taxonomy of the Plains zebra. However, this has not been fully resolved and there is a troubling lack of consensus among the much traditional taxonomy put forward for this species. The six subspecies of zebra are recognized based on morphological traits as: Grant's (*Equus burchellii boehmi*), Crawshay's (*Equss burchellii crawshayi*), Upper Zambezi (*Equus burchellii zambeziensis*), Chapman's (*Equss burchellii chapmanni*), Damara (*Equus burchellii antiquorum*), and the nominate Burchell's (*Equss burchellii. burchellii*) (Groves and Bell, 2004), based on coat patterns and coloration, body size, and the presence (or absence) of a mane, yet there is very little genetic differentiation between the subspecies (Lorenzen *et al*., 2008).

Plains zebra, has common names such as Burchell's zebra, common zebra and painted zebra (Yisehak Doku *et al.,* 2007). However, recently the trend to use the term Plains zebra. It is a large-sized and thick bodied with relatively short legs. The most conspicuous morphological differences include body size and the width, intensity, and coverage of dark stripes on the adult pelage. It is characterized by vertical stripes on the forepart of the body, which tend towards the horizontal on the hindquarters. Like all zebras, they are boldly striped as black and white (Rubenstein, 2010). The physical characteristics of their weight ranges from 220–322 kg for males while females weigh from 175–250 kg (Groves, 1974; Estes, 1999). Adults of both sexes of Plains zebras are similar in height and stand about 1 to 1.4 m high at the shoulder and approximately 2.3 m long. Ears are pointed, and relatively short and narrow, lack fringe of long hairs, legs are sturdy, hooves enclose and protect the toe. Pelages are dense, black and white hair (Groves and Bell, 2004) (Fig. 1).

Figure 1. Physical features of Adult Male Plains zebra (Addishiwot Fekadu, 2017)

**2.2. Distribution and Habitat Preference**

The species range is from the northern region of South Africa northwards to southern Sudan and Ethiopia, and westwards into northern Namibia and southern Angola (Hack *et al*. 2002). Historically, plains zebra exhibited a much broader range across the African continent, and fossil remains have been discovered in North Africa. During the past time, plains zebra could be found in nearly all the countries of eastern, southern, and southwestern Africa. The core of the historical range includes most African countries such as Kenya, Tanzania, and Sudan with peripheral populations in Somalia, Uganda, Burundi, Rwanda, Malawi, Mozambique, Zambia, Zimbabwe, northern and eastern Botswana, Swaziland, Lesotho and South Africa (Hack *et al*., 2002). More recently, plains zebra ranged throughout eastern and southern Africa, except of the forest belts of Uganda (Duncan 1992; Groves and Bell, 2004). In Ethiopia, major populations of Plains zebra occur in Omo, Mago and Nechisar National Parks (Yisehak Doku *et al.*, 2007), as well as in Yabello Wildlife Sanctuary (Reta Regassa and Solomon Yirga, 2013) (Fig. 2).

Plains zebra is a common, widespread and amongst the most abundant of all grazing mammals in Africa, with a total population size of 663,212 individuals estimated in 2002

(Hack *et al*., 2002). Recent information regarding global overall population numbers is limited. However, during the previous decades, this species has been extirpated from portions of its range (Hack *et al*., 2002).

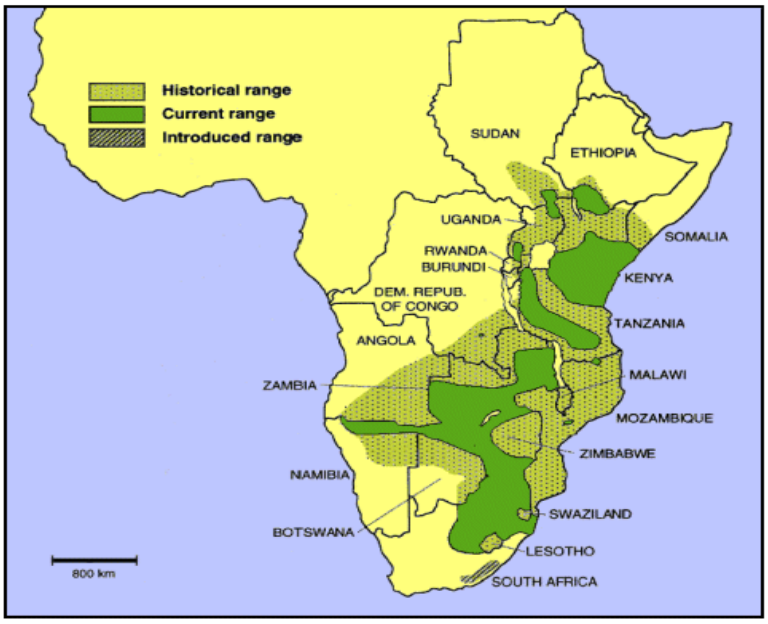


Figure 2. Historical and current ranges of plains Zebra

(https://www.google.com.com/url Equid specialist group 2008**)**

Analysis of how wildlife use habitats is among the most essential aspects of wildlife management (Henley 2001; Fishhoff *et al*., 2007b). Habitat selection is the process where animals occupy and utilize areas which provide the essential resources for survival. A preferred habitat type is one that is selected more than is expected from its availability (Bodenstein *et al*., 2000; Fishhoff *et al*., 2007b). The selection of habitat may be governed by various factors: the distribution and availability of water, the extent of interspecific competition, the distribution and availability of quality forage as well as the distribution and availability of forage quantity, predation and the distribution and availability of shelter (Ezenwa, 2004; Bonnet *et al*., 2010). Among these factors, food seems to be the most important in influencing habitat selection among large herbivores (Bodenstein *et al*., 2000).

Plains zebras thrive across a broad range of habitats in Africa (Hack *et al*., 2002; Stuart and Stuart 2007). From sea level to elevations of 4,300 m on Mount Kenya, plains zebras

utilize open grasslands, as well as savanna woodland (Duncan, 1992). In southern Ethiopia, Plains zebra reveal a distinct preference for open grassland habitats, and habitat preference showed seasonal variability (Reta Regassa and Solomon Yirga, 2013). Dietary flexibility and tolerance for highly fibrous grass material are factors that contribute to show broad geographic range (Schulz and Kaiser, 2013). The availability of water directly influences their movement and habitat selection (Duncan, 1992; Naidoo *et al*., 2012).

### 2.3. Reproduction

The mating system in Plains zebra is polygynous, with males mating with a number of females while defending the band (Rubenstein, 2010). Males that are reproductively unsuccessful, live as bachelors in loose aggregations (stallion groups), but they may switch between the two associations (Hack *et al*., 2002; Fischhoff *et al.,* 2007). They reach sexual maturity between 2-4 years. Males are able to compete for mares after they reach about 4 years of age. When attempting females for breeding, rival stallions compete fiercely by pushing, kicking and biting each other. Once a male establishes a harem, ownership of that harem is rarely disputed, unless unfit or sick. The gestation period of a zebra is about 12-13 months (365-390 days). Since a mare may come into estrus within days of giving birth, she can conceive almost yearly. The female gives birth to usually one foal and twins are rare. In general, zebra is less seasonal than other African mammalian species. Since the gestation period is about 12 months, mating activity occur throughout the year with a peak during the summer months (Grange and Duncan, 2006).

### 2.4. Diurnal Activity Pattern

In Plains zebra, diurnal activity patterns can vary, depending on seasons, sex type, age or reproductive state (Sandra, 2009; Gandiwa *et al*., 2016). There are many factors that can influence the activity pattern of an animal. Kamler *et al.* (2007) listed factors like temperature/climate, biological cycles, light and darkness, feeding sessions, phases of the moon, time of day/year, interactions and predation risks.

The time a zebra spends on feeding every day can depend on different factors such as the requirements of nutrients and energy and the availability of digestible food. Since zebras are hindgut fermenters, they have to graze frequently throughout the day and night (Bonnet *et al*., 2010). During the dry season, zebras drink at approximately once every day (Fischhoff *et al*., 2007b) which forces them to habitats not too far away from waterholes. During the wet season, zebras could stay without water for two or more days. Grass constitutes over 95% of the zebra's diet (Ogutu *et al*., 2008; Cain *et al*., 2012). To reduce the likelihood of being captured or encountered by predators, animals modify their behaviours as in habitat preferences and movement patterns (Fischhoff *et al*., 2007b). Individuals in a group can encourage other individuals to do specific behaviours.

The pattern of daily activity varies according to the nature of the habitat, food and weather conditions. In general, plains zebra spends most of the daylight grazing (Estes, 1997), in addition to dust bathing, robbing, and drinking and resting period. However, to consume adequate amount of herbage, they have to spend 60% of their time eating during day and night, under the best conditions, and over 80% under poor conditions. At night, they move very little unless disturbed by predators. From the group at least one animal per herd stands alert and guard while, others rest and sleep lying down (Estes, 1997).

Plains zebra are non-territorial and nomadic. They are migrators by nature, moving between food and water sources. Their home ranges are thus large, unstable and temporary. Plains zebra aggregate in a group of 100 individuals or more during the dry season. They split into smaller units of 10 -20 individuals during the wet season in Nechisar National Park (Yisehak Doku *et al*., 2007). Plains zebra live in long-lasting, stable social groups (bands) with a single breeding stallion and one to six adult mares and offspring of both sexes up to the age of 3 years (Hack *et al*., 2002; Pluháček *et al*., 2006; Rubenstein, 2010). The average size of bands correlates with the environmental conditions as well as the chance of predation (Skinner and Chimimba, 2005).

During the Pleistocene, equids were the most abundant, grazing animals of the grasslands and steppes of Africa, Asia, and the Americas. At present, there remain only seven species and many of these species are at risk. In Africa, most equids including the plains

zebra is dependent on conservation support. At present, like other mammals, equids are facing a great challenge due to both anthropogenic and natural factors (Reta Regassa and Solomon Yirga, 2013).

### 2.5. Feeding Habit

Forage available to herbivores can be categorized into three different groups; (1) plant forms (grasses, succulents, forbs, dwarf shrubs and shrubs), (2) plant parts (e.g. leaves and stems) and (3) plant species (Watson and Owen-Smith 2000). Diet selection is a complex behavioural act that is influenced by several factors. Physiological condition, degree of hunger, topography, competition from other animals and present and past grazing experience all influence which and how much of individual plant species are consumed (Fortin *et al*., 2003). Procedures used for estimating the botanical composition and diet quality of herbivore's diet include direct animal observation, stomach analysis, fistula sampling, and faecal analysis, however, direct animal observation requires minimal time and equipment inputs but the accuracy and precision are limited (Beauchamp, 2009).

Plains zebra are predominantly grazers but will occasionally browse and feed on herbs (Moelhman, 2003). In the Kruger National Park, Smuts (1975) from direct feeding observation, listed 50 species of grasses utilized, detailing the parts of the grasses eaten, whether inflorescence, leaf and stem. The Plains zebra is considered one of Africa’s most adaptable and successful grazers (Estes, 1991; Moelhman, 2003).

Zebras forage by selecting forage sites of higher biomass at the landscape scale but with an unselective strategy at the feeding patch (Brooks, 2005). Plains zebra are bulk forage feeders and, whilst their hindgut digestive system is efficient, they need to eat more than a similarly sized ruminant (Duncan, 1992). For their digestive system to work efficiently, they need to maintain a high intake and gut passage rate, which are influenced by the physical structure of the available sward and its effect on bite size and bite rate (Fleurance, 2010). Yet their potential daily food intake can exceed their digestive processing capacity (Owen-Smith, 2002). By selecting sites with improved forage quality

or quantity, herbivores are able to maximize their daily intake and/or minimize the time required to meet their energy requirements to allow additional time for non-foraging activities. Forage preferences also vary seasonally, with non-ruminants being more selective in the growing season when resource quality is highest, but less selective during more limiting seasons. To maximize forage intake, Plain zebra should adopt a selective foraging strategy at the habitat scale but an unselective strategy at the feeding site (Brooks, 2005).

Plains zebra associate with Grant's gazelle more frequently than with other wild herbivores (Duncan, 1992). Such interactions would probably explain that the two species are not ecological competitors as revealed from different feeding strategies. Plains zebra feed on taller grasses but Grant's gazelle feed on shorter grasses and dicotyledonous herbs, which are not consumed by Plains zebra. However, Yisehak Doku *et al.* (2007) and Demeke Datiko and Afework Bekele (2011) have pointed out that overgrazing severely deteriorated the Nechisar open grassy plain area and enhanced invasion of ticks during the dry season.

### 2.6. Population and Conservation status of Plains Zebra

Plains zebra is listed as near threatened in the IUCN red list and on Appendix I of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) CITES Appendix I (IUCN, 2008). As noted by Fanuel Kebede *et al.* (2012), the exponential growth of the human population is limiting the wildlife habitats all around the world. Humans affect the natural habitats by transforming them to agricultural farms and human settlements in addition to overgrazing and hunting (Yisehak Doku *et al*., 2007, Demeke Datiko and Afework Bekele, 2011). These changes can result in reducing the population of a species to the extent of extinction. Humans are also one of the main reasons of climate change (Ellis *et al*., 2010). These changes, together with the human interventions can result in fragmentation of the habitat of species. The combination of climate change and habitat fragmentation can lead to shifting of range, population

decline, less genetic diversity and local extinction in small patches (Opdam and Wascher, 2003).

Worldwide concern for natural and biological resources is higher than ever before. However, mainly, anthropogenic factors are identified as the main drivers (Demeke Datiko and Afework Bekele, 2011). At present, biodiversity particularly wild animals are under increasing pressure worldwide from increasing human population, global economic and social changes, and climate change. These pressures result from the interaction between the expanding influence of humanity and ecological processes that alter the delivery of ecosystem goods and services (Dudley *et al*., 2008). This resulted in human-wildlife conflict (HWC) in many parts of the world, particularly in developing countries. Human-wildlife conflict is defined as 'when the needs and behaviour of wildlife impacts negatively on the goals of humans, or when the goals of humans impact negatively on the needs of wildlife' (Hill and Wallace, 2012). Conflict occurs due to competition over resources such as grazing, loss of human-life, potential disease transmission between wildlife and domesticated livestock or humans or due to damage to crops, property, fish stocks and livestock (Enari and Suzuki, 2010; Hill and Wallace, 2012; Hoare, 2012; Schakner and Blumstein, 2013).

Human–wildlife conflict is intense in developing countries where livestock raring and agriculture are important parts of rural livelihoods (Tewodros Kumsa and Afework Bekele, 2008). Conflict occurs when the requirements of wildlife overlap with those of human populations, affecting residents and wild animals. It is more common in and around protected areas (Demeke Datiko and Afework Bekele, 2013b). These increase contact between people and wildlife, often generating intense conflict due to wild animals raiding crops and attacking and killing livestock (Marker *et al*., 2003; Ogada *et al*., 2003). Farmers are also sometimes the cause for crop loss because they continuously change the vegetation structure of the land closer to the Protected Areas. This changed vegetation probably becomes attractive to wild herbivores around Protected Area (Treves and Karanth, 2003). As a result, pest species are likely to flourish along the edges of natural habitat and agricultural lands (Bagchi and Mishra, 2006).

The transformation of global landscapes from predominantly wild habitat to modified over the last few centuries has created competition between humans and wildlife for space and resources. This has reached unprecedented levels because of rapidly growing human populations and expanding settlements (Ellis *et al*., 2010). As habitats are destroyed, isolated and fragmented, the extent of interface between humans and wildlife increases. It also leads to greater contact and conflict with humans as wild animals seek to fulfill their nutritional, ecological and behavioural needs (Anthony *et al*., 2010; Hazzah *et al*., 2013; Makindi *et al*., 2014). Developing countries such as Ethiopia are more vulnerable than developed nations since livestock and agriculture are an important part of rural livelihoods (Dickman, 2010; Mekbeb *et al*., 2010).

Ethiopia is a large and ecologically diverse country with unique environmental conditions. However, the natural vegetation of the country has been destroyed by humans and natural catastrophic and converted into agricultural and pastoral land. Moreover, its vegetation has been deforested for various purposes ((Demeke Datiko and Afework Bekele, 2011). As a result, wild animal resources of the country are now largely restricted to a few Protected Areas (Tewodros Kummsa and Afework Bekele, 2008). The forest area of the country has been under great threat due to over exploitation which forces wild animals to compete with humans for their resource resulting in conflict between them (Dejene Worku and Demeke Datiko, 2018).

Wildlife impact on human resources is a worldwide problem, particularly in rural areas (Ojo *et al*., 2010). It is intense in developing countries, particularly in Africa including Ethiopia, mainly in and around Protected Areas where humans and wildlife live in proximity. Wild animals such as elephants, baboons, monkeys, warthogs, and different antelopes cause major crop damage, and predators also attack domestic animals around Protected areas (Petersen, 2003). These animals can also cause significant damage to human lives and livestock. These losses can trigger conflict between rural people and wildlife (Begg *et al*., 2007; Bonham *et al.*, 2007). As noted by Newmark *et al*., 1994, most often, children are assigned to look after the farm area resulting in missing of schools, loss of sleep and even restriction to travel. As a result, rural Africans generally do not want to have wildlife nearby due to crop damage and loss of livestock as well as

lack of benefits from the sector (Newmark *et al*., 1994; Ojo *et al*., 2010**)**. As noted by Hill (2000), crop damage affects farmers directly through loss of their primary food and cash resources and indirectly through a variety of social costs such as costs for school and hospital. Farmers themselves are sometimes, the causes for crop loss because they continuously change the vegetation structure of the land closer to the Protected Areas (Demeke Datiko and Afework Bekele, 2013b).

As noted by, Woodroffe (2000) and Conover (2002), wild carnivores are one of the major challenges of wildlife conservation in most African countries. Carnivores can also benefit humans by the provision of ecosystem services such as the mitigation of diseases, carcass removal and for ecotourism activities. However, large carnivores range widely and their feeding habits pose a direct threat to livestock and people (Packer *et al*., 2011). In response to this threat, people commonly kill carnivores resulting in the local extirpation of many carnivore populations (Treves and Karanth, 2003).

Habitat loss across many parts of the world has led humans to live in greater proximity to wildlife, including carnivores. Those wild species have large home ranges and dietary requirements rersulting in conflict with humans (Inskip and Zimmermann, 2009). Interaction between people and wildlife has currently become fundamental aspects of wildlife management. It arises mainly because of the loss, degradation and fragmentation of habitats through human activities such as; logging, animal husbandry, agricultural expansion and developmental projects (Yosef Mamo and Afework Bekele, 2012). As habitat gets fragmented, the length of edge for the interface between humans and wildlife increases, while the animal populations become compressed in insular refuges. Consequently, it leads to greater contact and conflict with humans as wild animals seek to fulfill their nutritional, ecological and behavioural needs. Destruction of forests, occupation of original habitat of wildlife for investments increases the impact of human on wildlife (Mesele Yihune *et al*, 2009; Mekonen *et al.*, 2012). Human livelihoods can be severely affected by such depredation, generating negative attitudes toward wild animals (Hussain, 2003).

Attitude surveys make it possible to predict how people's attitudes will influence conservation policies and vice versa, allowing for more effective management and planning potential dangers posed by conflicts with large bodied wild animal species negatively influence attitudes of local people towards wildlife (Browne-Nuñez and Jonker, 2008). Personal beliefs and experiences, and different economic, legal, social and ecological concerns are additional factors that affect the attitudes of local people towards wildlife (Shibia, 2010; Andrade and Rhodes, 2012). Therefore, collecting baseline information is a vital step in managing human-wildlife conflict in Ethiopia.

## 3. MATERIALS AND METHODS

### 3.1. The study area

The study was carried out in Nehisar National Park (NNP) between December, 2017 and April, 2019. Nechisar National Park is located between $5^0$51' to $60^0$10'N latitudes and $37^0$32' to $37^0$48'E longitudes, the altitude of the area ranges from 1250-1360 m a.s.l. 540 km south of Addis Ababa and the study area covers 270 $km^2$ (Hillman, 1993). The area was designated as a National Park since 1972 and established in 1975 (Hillman, 1993). The Park was part of the Rift Valley floor between the two lakes, Lake Abaya and Chamo. The Park includes a portion of the two southern lakes of Ethiopia and the chain of hills separated by the two lakes called "God's bridge" by the local people (Fig. 3). The Park is bounded to the east by the Amaro Mountains, to the west the town of Arba Minch and to the north and south by lake Abaya and lake Chamo, respectively. In the far eastern part of the Park, hot springs bubble to the surface, while numerous natural springs known as Arba Minch (meaning ''forty springs'') are found in the western most extreme of the Park. Approximately, 15% of the Park consists of parts of Lake Abaya and Lake Chamo (Yisehak Doku *et al*., 2007). There are rivers draining into the lakes from the escarpments along the west and east. The two major rivers are Kulfo and Sermelle near the plains. The Park has also hot springs on its eastern border (Demeke Datiko and Afework Bekele, 2011).

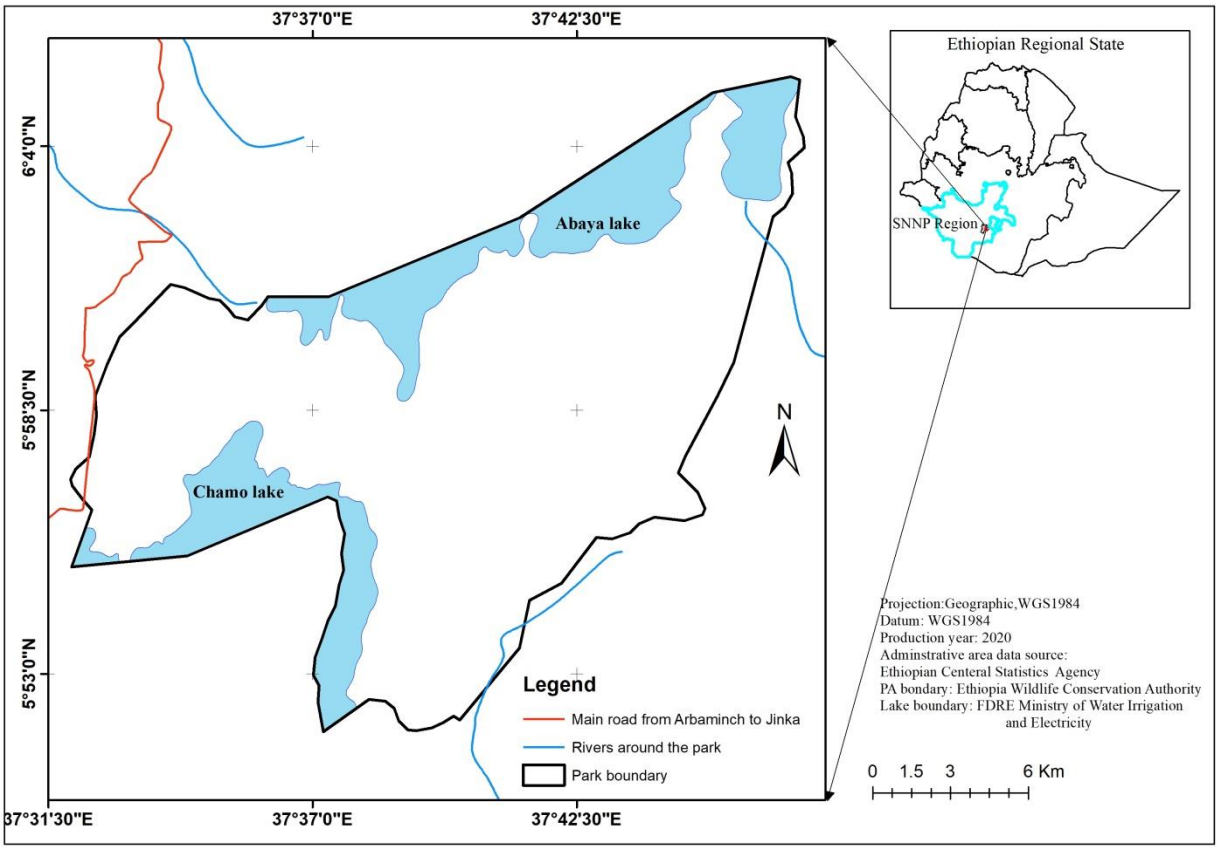


Figure 3. Map of the study area.

The Park consist of four major types of vegetation, the Somali-Masai *Acacia-Commiphora* deciduous bushland and thicket, the Somali-Masai edaphic grassland, the Somali-Masai riverine forest and herbaceous fresh water swamp and the aquatic vegetation (Evans *et al*., 1992; Hillman, 1993). Among these, the Somali-Masai edaphic grassland covers a large portion of the Nechisar plain and is highly dominated by common grass species (Duckworth, 1992). The dispersed Somali-Masai *Acacia-Commiphora* deciduous bush and thicket are characteristic vegetation of the Nechisar plain. A total of 208 species of floristic diversity belonging to 56 families and 124 genera were identified and documented from Nechisar National Park (Samson Shimelse *et al*., 2010).

The dominant grass species in the plain are *Chrysopogon aucheri, Cenchrus ciliaris* and *Ischaemum afrum, Bothryocchioa radicans, Cenchrus ciliaris, Chloris roxburghiana, Chrsopogon aucheri Chrsopogon* sp. *Heteropogon controtus, Ischaemum afrum, Lintonia nutans, Loundentia phragmitoides, Setaria sphacelate* and *Themeda traindra* (Samson

Shimelse *et al*., 2010). The shrub in the area consists of thick *Acaca melifera*, *D. cinera*, *A. oerfota, A. senegal* and *A. brevispica* (Svitalek, 2008). According to Svitalek (2008) and Samson Shimelse *et al*., 2010), *D. cinerea* and *A. melifera* are the species responsible for the ongoing bush encroachment seen in the Nechisar plain. Sermale River Valley is near the plains and dominated by *Acacia polychantha* under which are found *Maerua aethiopiea, Capparis tomentosa* and *Balanities aegyptiaca*. The habitat has been degraded by livestock grazing (Demeke Datiko and Afework Bekele, 2011).

The freshwater swamps at the mouth of Kulfo River and in Lake Chamo are dominated by *Typha angustifolia*, tall waterside grasses and the small leguminous trees, such as *Aeschynomene elaphroxylon* and *Sesbania sesban*. Taller trees found in the Park include *Dichrostachys cinerea*, *Acacia tortilis*, *Balanites aegyptiaca* and less commonly *Acacia nilotica*. The southern part of the Park is dominated by edaphic grassland and a calcareous black clay soil underneath with *Dobera glabra, Acacia tortilis* and the grass *Chrysopogon aucheri* forming much of the landscape (Samson Shimelse *et al*., 2010). Species typical of bushland habitats include *Phoeniculus somaliensis, Lanius dorsalis* and *Cisticola bodessa* and the open plains support three species that are very unknown elsewhere in Ethiopia: an isolated population of *Mirafra albicauda,* the endemic *Caprimulgus solala* and the rare *C. stellatus*. The southwestern corner of Lake Abaya supports one of only two Ethiopian populations of *Myrmecocichla albifrons*.

The Park contains more than 90 mammal species and 351 species of birds of which three species that are little known in Ethiopia are white-tailed lark, the endemic Nechisar nightjar and the rare star-spotted nightjar (Yisehak Doku *et al*., 2007; Demeke Datiko and Afework Bekele, (2011). In addition to Plains zebra (Plate 2), Nechisar National Park hosts the endemic Swayne's hartebeest (*Alceluphus buselaphus swaynei)* and other mammals such as Grant's zebra (*Equus quagga boehmi*), Grant's gazelle (*Gazella granti*), Guenther's Dik-Dik (*Rhynchotragus guentheri*), Greater kudu (*Tragelaphus strepsiceros*), lion (*Panthera leo*) and spotted hyaena (*Crocuta crocuta*). Recently, Swayne's hartebeest (*Alcelaphus buselaphus swaynei*) is locally extinct (NNP, 2012). The Park also serves as the destination of many Palearctic and intra-Africa migrants'

birds (Duckworth *et al.,* 1992). The medium and larger mammal species commonly found in and the vicinities of the NNP are shown in Appendix I.

A part of the northwest shoreline of Lake Chamo is known as Crocodile Market, where abundant and very large crocodiles (5 m long) are basking. Furthermore, the Park is home to the largest hippo population in Ethiopia, abundant fish including Nile perch, diverse insects of which 69% of the butterfly's species in Ethiopia are recorded in NNP and 20% of them are endemic (Yieshak Doku *et al*., 2007).

Human settlement is very high particularly from Guji Oromo people from east side of the Park. Most of the people are nomadic pastoralists holding thousands of cattle grazing on the plains. These have profoundly changed the landscape and greatly modified the habitats available to mammals (Yisehak Doku *et al*., 2006; Demeke Datiko and Afework Bekele, 2011). During the military regime, the settlers inside the park were forcefully evicted. As a result, competition between livestock and wildlife were minimized (Yisehak Doku *et al*., 2006). But, following the downfall of the Derg regime in the early 1990s, there was negative attitude towards conservation activities of the Park (Hillman, 1993; Yisehak Doku *et al*., 2006).

The climate of the study area (NNP) is characterized by a relatively warm climatic condition with low and unevenly distributed rainfall pattern. The rainfall and temperature data obtained from Arbaminch State Farm Meteorological Station. Data were obtained from the station which is about 11 km on the west side of the Park with relatively similar altitude and weather pattern.

The mean annual rainfall in the range measured over the last 15 years (2006-2020) was found to be 897 mm. The bimodal regime is characterized by two distinct rainfall peaks with dry season in between. Most of the rain is from March to May (long rain season) while the short rainy season is between September and November (EWCO, 1999; Yisehak Doku*et al*., 2007; Demeke Datiko and Afework Bekele, 2011). The driest season of the year in the area was from January to February and the other dry period is from June to August. The mean annual temperature ranges from 12.3 to 35.8$^0$C. (Fig. 4)

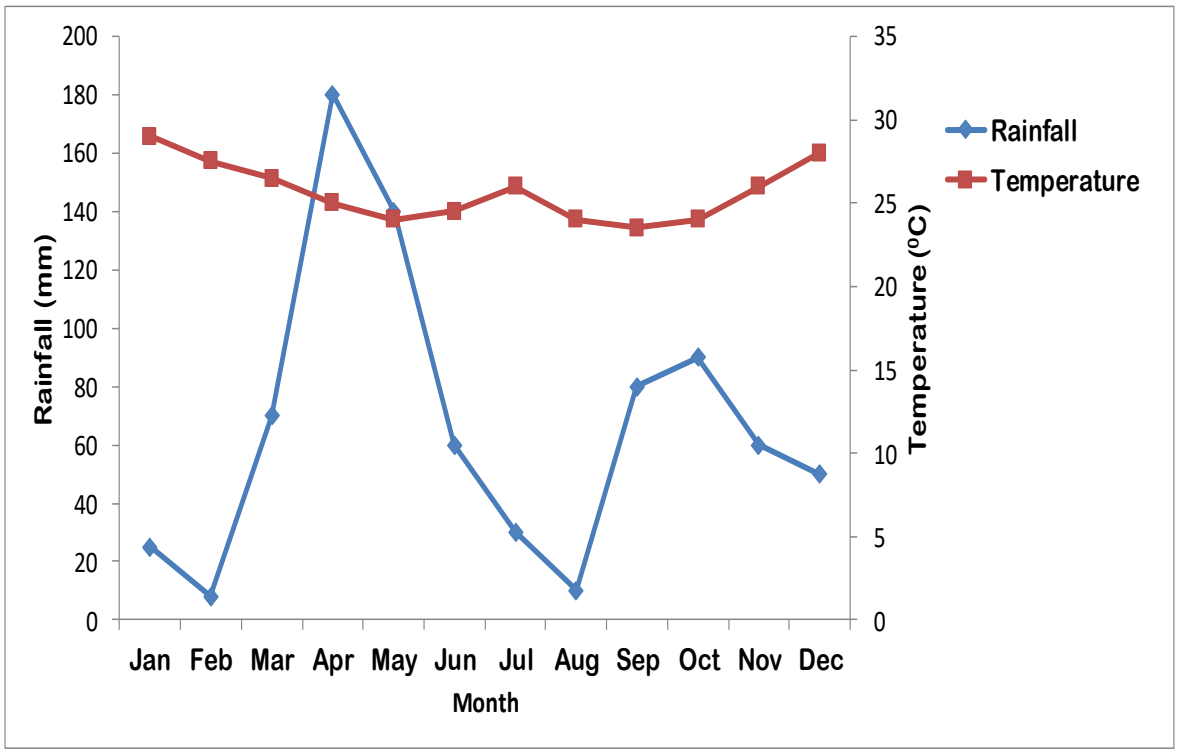


Figure 4. Average monthly (mm) and temperature ($^0$C) from 2006-2020

(source: National Meteorological Agency of Ethiopia, 2020).

### 3.2. Preliminary study and Sampling design

Before the actual data collection, reconnaissance survey was carried out to get information on accessibility, climate, vegetation cover/habitat type, topography, infrastructure, fauna, and distribution of Plains zebra, representative villages and sites/blocks. Therefore, research design was established based on these initial observations.

Following preliminary survey, the study area was classified into five major habitats or sample units/blocks; based on topography, vegetation cover/habitat type, the total distribution area of the Plains zebra, following the methods of Wilson *et al.* (1996). The major identified habitats were open grassland, wooded grassland, bushland, riverine vegetation and lakeshores. Based on the type and size of habitat types/sampling blocks were designed randomly or/and purposefully. Based on observability and size of the

habitat types, a total of 28 transects were identified: open grassland (7), wooded grassland/montane woodlands (6), bushland (7), riverine vegetation (4) and lakeshores (4). Line transect sampling methods were designed and employed for the estimation of the population density following the methods of Buckland *el al.* (1993) and Sutherland (1996). Line transects started from a random point, and then located using GPS in each habitat type. In addition, to determine the feeding habit and diurnal activity pattern, focal sampling methods were designed following the methods of Bodenstein *et al*. (2000)

Moreover, based on villages bounding the study area/National Park, eight representative villages were identified: five from Guji, two from Amaro/Koire and one from Zeysie ethnic groups. These villages have a distance of less than 0-5 km from the Park with high contact with the Park. To obtain actual information, semi-structured questionnairres were also designed and developed to assess conservation gaps of the wildlife in the study area (Appindex I).

### 3.3. Methods of Data Collection

#### 3.3.1. Animal survey

Data collection was carried out for two years encompassing wet and dry seasonsfrom December, 2017 to April, 2019. A line-transect census method was employed to assess the type of population size, habitat preference and social organization of the animals. Based on each habitat types and its area coverage, 28 transects were determined. Transects were placed according to a stratified random sampling, in which transect placement was proportional to the area of the habitat types. Based on the observability of the animals in each habitat type, 700 to 1000 m strip width was considered and fixed to assist the foot counts following standard methods of transect counting methods (Yisehak Doku *et al*., 2007; Yosef Mamo *et al*., 2015) and marked by GPS. Adjacent transects were at least 1.5-2.0 km apart. The average length of transacts was 9.84 km, covering a total area of 241.66 $km^2$ (Table 1).

Table 1. Habitats surveyed, number of line transects and average length of transects.

| Surveyed habitat type | No. of line transects | Estimated average strip width (m) | Estimated average length of transects (km) | Estimated area covered ($km^2$) |
|---|---|---|---|---|
| Grassland | 7 | 1000 (500) | 13.9 | 97.3 |
| Wooded grassland | 6 | 800 (400) | 9.6 | 46.08 |
| Bushland | 7 | 800 (400) | 9.4 | 52.64 |
| Riverine vegetation (Seremele) | 4 | 700 (350) | 7.8 | 21.84 |
| Lake shore (Abaya and Chamo) | 4 | 700 (350) | 8.5 | 23.8 |
| Total/average | 28 | 700-1000 | 9.84 | 241.66 |

To determine the population size, density, habitat preference, seasonal distribution and population structure of Plains zebra, a line-transect census method was employed along each transects and on major identified habitat types following the methods of Buckland *et al*. (1993). The actual data collection was carried out through direct observations with naked eye and/or by using binoculars (10x25 magnifications) in each habitat types along line transects (Appendix II). As indicated by Wilson *et al*. (1996), silent detection method was practiced to minimize disturbances. During the transect walking, the observers recorded start and end of GPS locations. Two to three trained people/scouts were involved in each transect count of animals during data collection. A survey was carried out during morning (6:00 - 11:00 a.m.) and afternoon (3:00-6:00 p.m.), when the animals were more active feeding and maximum observation of the animal was possible as noted by Yisehak Doku *et al.* (2007). In addition, population trend and status of Plains zebra was compared with the previous findings of different researchers in the study area.

The population structure (group sizes, age and sex composition) of Plains zebra was determined from data obtained from the observations following the methods of Moehlman (2002). Each of this individual in a group was identified and categorized into its respective age and sex categories during counting. The categories used were adult male, adult female, sub-adult, juvenile and foal (Appindex III). To categorize the animals into such groups, the methods of Kingdon (1997) and Yisehak Doku *et al.* (2007) were

followed. The sex and age category were carried out using body size such as the relative size, external genitalia and furry-hair as adopted by Befekadu Refera and Afework Bekele (2004). Repeated/double counting of the same herd or cluster was avoided using recognizable features such as cluster size, harem composition and distinct individuals with body deformities such as cut tail and ear (Wilson *et al*., 1996).

Plains zebra group and individual sightings as well as counting were carried out in each habitat type during population census data collection to obtain habitat preference and seasonal distribution. Therefore, habitat selection of Plains zebra was determined from the numbers sighted from each line transect of the five main habitat types as noted by Wilson *et al.* (1996).

As noted by Yisehak Doku *et al*. (2007), habitat utilization was determined by taking each group and individual sighting and comparing their frequencies with respect to the relative availability of vegetation/habitat types. The seasonal distribution pattern of Plains zebra population was determined from the seasonal observation made on each line transects of the habitats. As a result, a seasonal change of Plains zebra population was also monitored on seasonal basis in each habitat type.

### 3.3.2. Diurnal Activity Pattern

Diurnal activity pattern of Plains zebra was carried out during both wet and dry seasons. For diurnal behavioural study of the Plains zebra, scan/instantaneous sampling methods was used following Altmann (1974); Martin and Bateson (1993). Direct observations on each activity pattern of the animals were used using unaided eye and binoculars (10X25). The focal animals were selected by choosing the closest animal to the observer at the beginning of data collection (Appendix IV). Focal animals were observed for 5 minutes (Neuhaus and Ruckstuhl, 2002). As stated by Wilson *et al.* (1996) and Sutherland (1996), silent detection method was used for daily activity observation. Focal animals were classified as adult on the basis of relative size and pelage, while focal sex of the animal was assessed on the basis of genitalia (Smuts, 1975; Gautam, 2013). All identifiable daily activity rhythms and behavioural traits were recorded on data sheet. The major activities recorded were grazing, walking, resting, standing/idle, and grooming and others (playing, fighting, suckling and urinating which do not feature strongly in general activity

patterns). A total of 300 (150 individuals during each season) focal animals were observed with an average of 15 individuals per habitat type and per season. The activity of each individual/focal zebra under observation was recorded and ticked on the data sheet at 5 minutes interval, and when unique activity was observed, it was recorded on a separate notebook. The observation was carried out the whole day time from morning 06:00 to afternoon 06:00 hours during both wet and dry reasons for 24 days (15 days per each season).

### 3.3.3. Feeding habit/Common Food Items Determination

Forage determination and direct focal animal observation method using binoculars (10X25) was carried out following the methods of Altmann (1974) during both wet and dry seasons. A focal animal was a selected individual from a population where its specified actions are recorded during a predetermined sample period (Altmann, 1974). Focal animals were selected by choosing the closest animal to the observer not exceeding 100 m to avoid observer error (Ben-Shahar and Coe, 1992). Group sizes of more than 10 individuals were excluded due to difficulty to sustain visual contact with focal animals within a large group. A total of 180 (90 individuals during each season) focal animals were observed with an average of 9 individuals per habitat type. Focal animals were observed during a feeding session 5 minutes as used by Neuhaus and Ruckstuhl (2002). Observations was conducted between 06:00-10:00 and 15:00-19:00 hours when zebras were most active feeding. Focal animals were classified as adult on the basis of relative size and pelage, while focal animal sex was assessed on the basis of genitalia (Smuts, 1975).

To identify diet composition, species composition of consumed plants was determined from focal animal observation while at the feeding site and by locating where the focal animal was foraging. Signs such as exudation of sap, crushed tissue and fresh clippings were used to judge a plant species consumed (Watson and Owen-Smith, 2000; Owen-Smith, 2002). Plant parts that were plucked and masticated as the animal lifted its head was observed to aid in identification of the plant that was consumed. During observation, forage types consumed by the animals were categorized as three different groups; plant

forms/types such as grasses, herbs and shrubs identified at species levels (Appendix V). A specimen of each species consumed at each feeding site was collected for identification once the focal animal moved into safe distance to reduce disturbance. Plant samples were collected by cutting off a branch from woody plants or by uprooting a specimen. In addition, photographs of sampled plant species were taken to aid in the identification process. Sampled plant specimens/voucher specimens of major plants in the study area were collected, pressed, dried and identified at Arbaminch University Herbarium to species level with aid of identification keys.

### 3.3.4. Semi-structured Interview

In order to assess the impacts of anthropological activities on Plains zebra and other wildlife, a standard questionnairre was developed. The questionnairre was designed to understand the conservation gaps/threats of the National Park. Data collection were carried out by means of a semi-structured questionnairre modified from Maddox (2003). Eight representative villages in and around the Park were identified for interview with the local people. The questionnaire was administered to farmers within their area of farming and/or residence at a random manner based on first come first serve basis, alternating male and female respondents as much as possible as well as different age groups (Newmark *et al*., 1994; Hill, 2000). In every household, the head of the household was interviewed. However, when this was not possible, they allowed other representatives to provide the information on behalf of the household. The questions covered socioeconomic and demographic information, wildlife impact on humans (crop damage and domestic animals loss/predation) we have incorporated ten years of trend on the population change of crop raiding animals and their major impacts. Moeover, impact of humans on wildlife such as human settlement, agricultural expansion, livestock grazing, utilization of resources, attitudes of settlers/local people towards Plains zebra and other wildlife in the Park (Appendix VI).

Focus group discussions (8 to 12 individuals in each group) were held in already selected village to discuss the experience in the conservation gaps and attitude of local people towards animals and the Protected area. Kebele leaders and Park manager as well as

scouts took part in the discussion (Plate 3). Group discussion was used as a complement for the information gathered using questionnairy. In addition, direct observation of the National Park was used to collect relevant information. Information obtained from group discussion was summarized using text analysis method, and reported in narrative form. In addition, direct field observation was also conducted during the study period.

### 3.4. Data analyses

Data were analyzed to determine population density and habitat preferences of Plains zebra following Buckland *et al*. (1993) and Yisehak Doku *et al*. (2007). Population size was estimated by multiplying the population density with total area following the methods of Buckland *et al*. (1993) and Wilson *et al*. (1996). Based on the total area of the surveyed area, the population abundance of Plains zebra was calculated from their population density estimate. When an animal or a group was spotted, the following estimation was made: D = N/2WL, where D = estimated density of animals (or animal groups), N= number of animals seen/count, L = length of transect line(s) and W = mean perpendicular distance of animals seen (2WL= Area). The population size of Plains zebra was estimated by multiplying the population density (D) with total extent of habitat by the present study, following the methods of Buckland et al. (1993), Sutherland (1996) and Yisehak Doku *et al*. (2007):

N = D x A (2WL), where, N = total population size

D = Population density (individual per $km^2$)

A = Total extent of habitat by the present study (in $km^2$).

The average number of Plains zebra observed in the five habitat types was compared with vegetation cover and types in the study area. Habitat preference and abundance of the animals were also calculated by using the formula adopted from Pokhrel (1996) and Gautam (2013).

Habitat preference (HP) = (APE/ TAP) × 100, Where,

APE = animals present in each habitat type

TAP = Total animals present in all the habitat types

$$S.D = \frac{\sqrt{\Sigma|X-\mu|^2}}{\sqrt{N}}$$

S.D= Standard deviation

Σ=Sum, X=data point, π= mean, N= total no of data

One-way ANOVA test, followed by Tukey multiple comparison test used to compare the feeding preference between seasons. All the differences were considered statistically significant at $\alpha = 0.05$ (at 95%) confidence interval. In addition, SPPS computer software program version 16 was used to test for differences of population structure, daily activity patterns between seasons and among habitat types. The questionnaire survey data was also analyzed using descriptive statistics.

## 4. RESULTS

Data obtained during the present investigation are presented in three parts: The first section highlights the general descriptions of habitats surveyed; and the number of line transects surveyed during the data collection. The second section deals with the results obtained on population status/trend, density estimation and population structure, distribution and habitat preference, diurnal activity pattern and feeding habit. The third part deals with conservation challenges/gaps in and around the Park.

### 4.1. Population estimate, abundance and trends

The average number of individuals counted during wet and dry seasons is shown in Table 2. On average, 544.5 and 887.5 individuals were counted during the dry and wet seasons, respectively. On average 716 individuals of plains zebra were counted during the study period. Their abundance was 38.0% for dry season and 62.0% for wet season. There was significant difference obtained between seasons ($\chi^2 = 5.76$, df = 1, $P < 0.05$).

Table 2. Average number of individuals counted during wet and dry seasons

| Main Seasons | No. of indiv. counted | Abundance (%) |
|---|---|---|
| Dry Season | 544.5 | 38.0 |
| Wet Season | 887.5 | 62.0 |
| Total/average | 1,432/716 | 100 |

The population trends of Plains zebra in NNP during the past 54 years are given in Fig.5. The population size has been fluctuating since 1967. The highest was recorded in 1985 and very low in 1967. During the present study, the 716 individuals of plains zebra were counted. The population size among counted years was different and decreased during the present study.

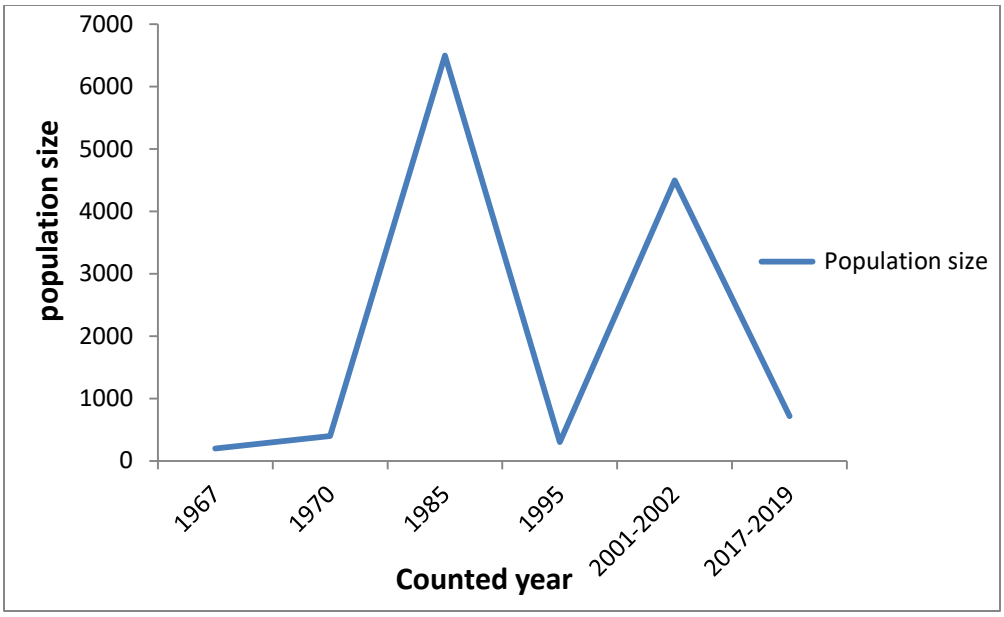


Figure 5. Population count and trend of the Plains zebra in NNP

### 4.2. Population Structure

The population structure of Plains zebra in NNP is given in Table 3. On average 716 individuals counted during four counting sessions, 309(43.2%) were adult males, 322.8 (45.1) adult females, 51.7(0.07%) sub-adults and 32.5(0.05%) were juveniles/foals. There was a statistically significant difference in population structure ($\chi^2$ = 371.5, df = 3, P < 0.05) among seasons.

Table 3. Population structure of Plains zebra in NNP. (No=number of individuals, AM=adult male, AF=adult female, SA=sub-adult, Juv/Fo=juvenile/foa).

| Month, year and season | Sex and Age groups | | | | |
|---|---|---|---|---|---|
| | No | AM | AF | SA | Juv/Fo |
| Dry | 545.5 | 230.5 | 244.0 | 14.5 | 55.5 |
| Wet | 887.5 | 387.5 | 401.5 | 89.0 | 9.5 |
| Total/Average | 716 | 309 | 322.8 | 51.7 | 32.5 |

The ratio of adult male to female was 1:1.06 and 1:1.04 during the dry and wet seasons, respectively. The average age ratio of adult to juvenile/foals was 1:0.12 and 1:0.01 during the dry and wet seasons, respectively. (Table 4)

Table 4. Average population structure of the Plains zebra in NNP

| Season | Sex and Age groups | | | | | Sex and Age ratio | |
|---|---|---|---|---|---|---|---|
| | No | AM | AF | SA | Juv/Fo | AM:AF | AD:Fo |
| Dry | 1089 | 461 | 488 | 29 | 111 | 1:1.06 | 1:0.12 |
| Wet | 1775 | 775 | 803 | 178 | 19 | 1:1.04 | 1:0.01 |
| Average/ratio | 716 | 309 | 322.8 | 51.7 | 32.5 | 1:1.05 | 1:0.05 |

The average group size during the dry and wet seasons is given in Table 5. During the dry season, the average group size was less than during the wet season. It is not statistically significant ($\chi^2$ = 1.37, df =1, P>0.05). On average, 85 herds of Plains zebra were observed in the study area. The average number of group during the dry season was 51 and the mean group size was 11.7 and S.D$\pm$0.95. During the wet season, 39.5 groups were recorded and the mean group size was 17.75 with S.D$\pm$0.85. The average group size was statistically significant ($\chi^2$ = 29.44, df =1, P<0.05) between seasons. The group range also varied among seasons. It ranged from 1-27 during the dry season and 1-58 during the wet season.

Table 5. Group size of Plains zebra during wet and dry seasons

| Season | Total number | Total group | Range of group size (Minimum-maximum) | Mean group size |
|---|---|---|---|---|
| Dry | 544.5 | 51.0 | 2-27 | 11.5 |
| Wet | 887.5 | 39.5 | 2-58 | 17.8 |
| Total /average | 1432/716 | 45.3 | 2-58 | 14.6 |

### 4.3. Density, seasonal distribution and habitat preference

The density of Plains zebra at different habitats of each season is given in Table 6. During the study period, the average population density of Plains zebra was 3.30/km$^2$ in the surveyed area. The population density was not statistically significant ($\chi^2$ =1.13, df =4, P>0.05) among habitats. The highest density (5.73/ km$^2$) was recorded from wooded grassland during the wet season, whereas the lowest was from grassland (1.27/km$^2$) during the dry season. The average density of Plains zebra during the dry and wet seasons varied from 2.84/km$^2$ to

3.78/km$^2$, respectively. However, the average population density was not statistically significant ($\chi^2$ =0.13, df =1, P>0.05) between seasons.

Table 6. Density of zebra at different habitats in NNP duing dry and wet seasons (GL: Grassland; WGL: Wooded grassland; BL: Bushland; RV: Riverine vegetation; LS: Lake shore)

| Season | Density (individuals/km$^2$) | | | | | |
|---|---|---|---|---|---|---|
| | GL | WGL | BL | RV | LS | Total/average |
| Dry | 1.35 | 2.89 | 1.77 | 3.64 | 4.54 | 2.85 |
| Wet | 3.07 | 5.73 | 3.08 | 3.66 | 3.49 | 3.78 |
| Average | 2.21 | 4.31 | 2.36 | 3.65 | 4.01 | 3.31 |

The average distribution of Plains zebra in each habitat type is given in Table 7. The highest number of Plains zebra was recorded from grassland (214.7) and the least from riverine vegetation (83.3). The average number of counts was statistically significant among habitat types ($\chi^2$ =2,311.16, df=4, P<0.05).

Table 7. The average distribution of Plains zebra from five major habitat types (GL: Grassland; WGL: Wooded grassland; BL: Bushland; RV: Riverine vegetation; LS: Lake shore).

| Age categories | Average number of indiv. counted in each habitat | | | | | |
|---|---|---|---|---|---|---|
| | GL | WGL | BL | RV | LS | Total |
| Adult | 191.5(766) | 174.3 (697) | 106.7 (427) | 73.7 (295) | 85.5 (34 | 631.7 (2527) |
| Subadult | 13.0 (52) | 14.5(58) | 11.5 (46) | 6.8(27) | 6.0 (24 | 51.8 (207) |
| Young/foal | 10.5 (41) | 9.7(39) | 6.0 (24) | 2.8 (11) | 3.8 (15 | 32.5 (130) |
| Total count | 214.7 (859) | 198.5 (794) | 124.3 (497) | 83.3(333) | 95.3(381 | 716 (2,864) |

Total count of Plains zebra between seasons in each habitat type and their abundance is presented in Table 8. The variation in total count is statistically significant ($\chi^2$ = 465.64, df =4, P<0.05) among different habitats. The highest abundance count was in grassland (35.04%) during the wet season and minimum (14.44%) during the dry season.

Table 8. Count of Plains zebra between seasons in each habitat type and their abundance (GL: Grassland, WGL: Wooded grassland, BL: bushland; RV: Riverine vegetation LS: LS: Lake shore; TC: total count).

| Habitat types | No. of transects | Season | Total count | Abundance (%) |
|---|---|---|---|---|
| GL (859) | 7 | Dry | 131 | 15.25 |
| | 7 | Wet | 298.5 | 34.75 |
| WGL (794) | 6 | Dry | 131 | 16.75 |
| | 6 | Wet | 264 | 33.25 |
| BL (497) | 7 | Dry | 93 | 18.72 |
| | 7 | Wet | 155.5 | 31.25 |
| RV (333) | 4 | Dry | 79.5 | 23.88 |
| | 4 | Wet | 87 | 26.13 |
| LS (381) | 4 | Dry | 108 | 28.4 |
| | 4 | Wet | 82.5 | 21.65 |

The number of individuals of Plains zebra counted in each habitat type during the wet and dry seasons is given in Table 9. The count showed high habitat preference for grassland followed by wooded grassland. The variation in total count is statistically significant ($\chi^2$ = 465.64, df =4, P<0.05) among habitat types. The distribution of the animals varied among seasons. In most habitat types, the total number of animals seen during the dry and wet seasons varied. Relatively higher number of individuals were observed from lake shore and riverine vegetation during the dry season than wet season.

Table 9. Number of Plains zebra counted during the dry and wet seasons in each habitat type (GL: Grassland; WGL: Wooded grassland; BL: Bushland; RV: Riverine vegetation; LS: Lake shore).

| Season | Habitat types | | | | | |
|---|---|---|---|---|---|---|
| | GL | WGL | BL | RV | LS | Total |
| Dry | 131.0 | 133 | 93.0 | 79.5 | 108 | 544.5 |
| Wet | 298.5 | 264 | 155.5 | 87 | 82.5 | 887.5 |
| Average | 214.75 | 198.5 | 124.25 | 83.25 | 95.25 | 716 |

### 4.4. Diurnal activity pattern

The proportion of time spent for different activities varied during both dry and wet seasons and the observation has taken for twelve hours (Table 10). The average proportion of quantified observations from diurnal activities were: grazing (56.5%), moving (13.5%), resting (14.0%), and grooming (6.6%), while the remaining (6.5%) was spent in other activities. During the dry season, grazing and moving activities were higher than during the wet season. However, resting and grooming activities were higher during the wet season. Average diurnal activity pattern of Plains zebra showed statistically significant variation during both seasons ($\chi^2 = 67.95$, d.f=4, $P<0.05$).

Table 10. Percentage of time spent by the plains zebra in different activities during the dry and wet seasons.

| Activity | Dry season | Wet season | Average | $\chi^2$ | Df | P-value (at 95%) |
|---|---|---|---|---|---|---|
| Grazing | 61.5 | 51.5 | 56.5 | 0.88 | 1 | P<0.05 |
| Moving | 19.7 | 14.3 | 13.5 | 5.69 | 1 | P<0.05 |
| Resting | 11.4 | 16.6 | 14.0 | 0.48 | 1 | P>0.05 |
| Grooming | 3.1 | 8.9 | 6.0 | 13.80 | 1 | P<0.05 |
| Others | 5.2 | 7.8 | 6.5 | 0.26 | 1 | P>0.05 |

The average daily time budget of Plains zebra during the dry and wet seasons is given in Figs. 6 and 7. During both seasons, grazing/feeding activity was the highest in the early morning (06:00 -10:00 h) and late afternoon (14:00-16:00 h). Grazing, took relatively more time during the dry season than the wet season. Movement was recorded high during the mid-day between (10:00-13:00 h) during both seasons. Relatively, the movement of animals was higher during the dry season than the wet season. Resting and grooming activities were high during mid-days (12:00-14:00 hr) and minimum during early morning (06:00 – 09:00 h) and late afternoon (15:00-17:00 hr) during both seasons. The average time devoted for main activities of Plains zebra during the periods of the day showed statistically significant

variation during the dry ($\chi^2$ = 91.23, d.f=4, P<0.05) and wet seasons ($\chi^2$ = 57.69, d.f=4, P<0.05) during the study period.

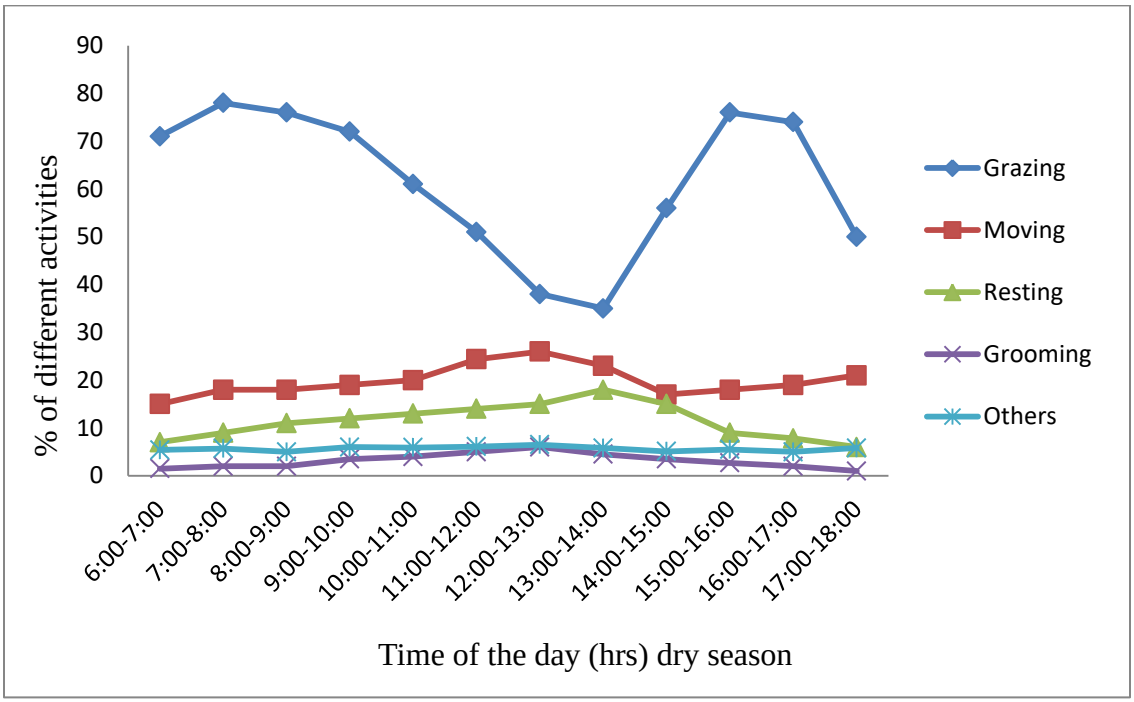


Figure 6. The average daily time budget of Plains zebra during the dry season.

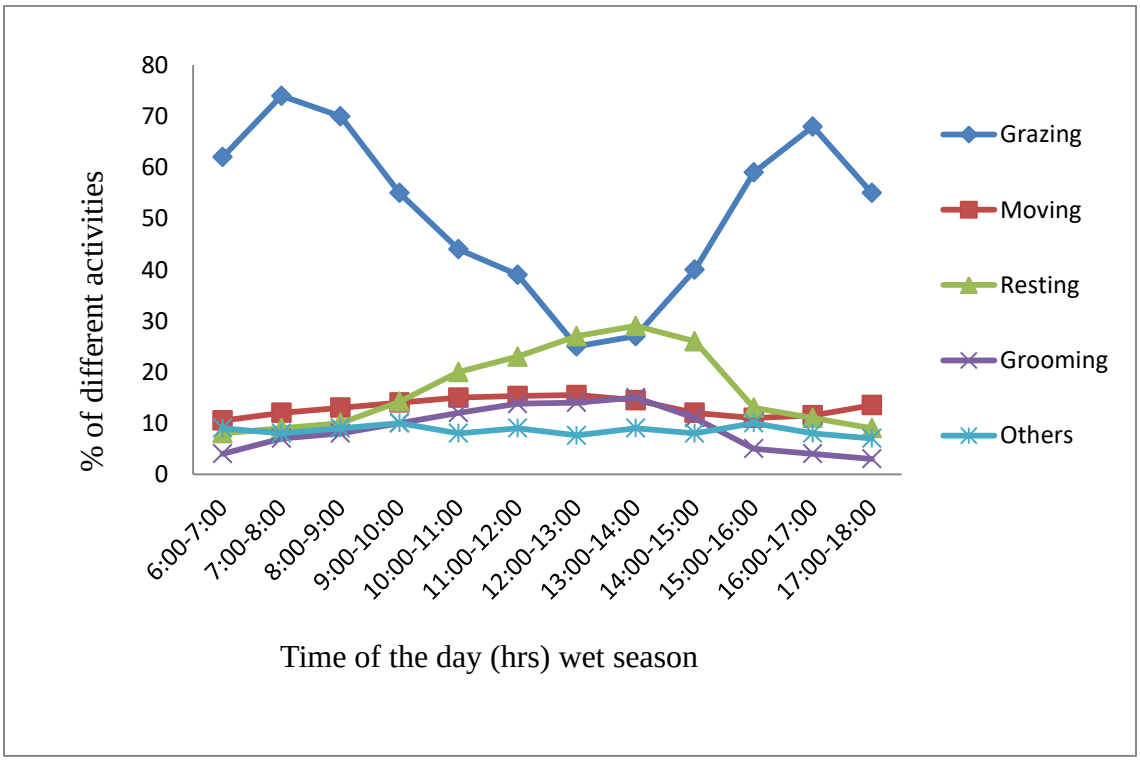


Figure 7. The average daily time budget of Plains zebra during the wet season.

### 4.5. Feeding Habit

Out of the 180 (90 dry season and 90 wet season) behavioural observations of foraging activities, six grass species, four herb species and three shrub species were identified as commonly used plant species by Plains zebra in the study area. We have employed similar number of observation for each habitat type (36) and between the seasons (90). Ssighting frequency for AM (72) and AF (76).

Table 11. Number of individuals in each habitat type, and sex and age categories of sighted Plain zebra.

(GL: Grassland; WGL: Wooded grassland; BL: Bushland; RV: Riverine vegetation; LS: Lake shore), AM=adult male, AF=adult female, SA=sub-adult, Juv/Fo=juvenile/foal.

| Season | Habitat types | | | | | | Sex and age | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | GL | WGL | BL | RV | LS | Total | AM | AF | SA | JU/FO |
| Dry | 18 | 18 | 18 | 18 | 18 | 90 | 36 | 38 | 12 | 4 |
| Wet | 18 | 18 | 18 | 18 | 18 | 90 | 36 | 38 | 12 | 4 |
| Total | 36 | 36 | 36 | 36 | 36 | 180 | 72 | 76 | 24 | 8 |

Lists of commonly sighted plant species and sighting frequency percentages are given in Table 12. The sighting frequency of percentage of plant species was highest for *Lintonia nutans* (28.8%) followed by *Themeda triandra* (25.8%). The variation in the total sighting frequency of plant species such as grass, herb and shrub species was statistically significant ($\chi^2$ =152.74, d.f=2, P<0.05).

Table 12. List of commonly sighted plant species, and sighting frequency and their percentage of consumption by Plains zebra.

| Commonly sighted plant species taken | Sighting frequency | Percentage |
|---|---|---|
| Grass species | | |
| *Lintonia nutans* | 47 | 28.8 |
| *Themeda triandra* | 42 | 25.8 |
| *Setaria sphacelata* | 21 | 12.9 |
| *Ischaemum afruml* | 19 | 11.7 |
| *Chrysopogon aucheri* | 18 | 11.0 |
| *Cenchrus ciliaris* | 16 | 9.8 |
| Total | 163 | 100 |
| Herb species | | |
| *Ageratum conyzoides* | 14 | 30.4 |
| *Cynodont plectostachyus* | 12 | 26.1 |
| *Dobera glabra* | 11 | 23.9 |
| *Justica flava* | 9 | 19.6 |
| Total | 46 | 100 |
| Shrub species | | |
| *Saccharum spontaneum* | 10 | 41.7 |
| *Dodonoea angustifolia* | 8 | 33.3 |
| *Euphorbia tirucalli* | 6 | 25.0 |
| Total | 24 | 100 |

Commonly sighted plant species and sighting frequency percentages during dry and wet seasons are given in Table 13. In total, 13 commonly used/consumed plant species were identified by Plains zebra in the study area. The total percentage frequency of plant species intake in the study area was statistically different ($\chi^2$ =61.71, d.f=2, P<0.05). It also showed statistically significant difference between seasons for herbs ($\chi^2$ =15.37, d.f=1, P <0.05), and shrubs ($\chi^2$ =17.31, d.f=1, P <0.05). For grasses, it showed no statistical difference ($\chi^2$ =1.16, d.f=1, P>0.05).

Table 13. Commonly sighted plant species and sighting frequency percentages during dry and wet seasons.

| Commonly sighted plant species taken (%) | Sighting frequency | Seasons (% of frequency) | |
|---|---|---|---|
| | | Dry | Wet |
| Grass species (Leaves) | | (69.96) | |
| *Lintonia nutans* | 47 | 20 (42.6) | 27 (57.4) |
| *Themeda triandra* | 42 | 19 (45.2) | 23(54.7) |
| *Setaria sphacelata* | 21 | 9 (42.9) | 12(53.1) |
| *Ischaemum afruml* | 19 | 7 (36.8) | 12(63.2) |
| *Chrysopogon aucheri* | 18 | 9(50.0) | 9(50.0) |
| *Cenchrus ciliaris* | 16 | 7(43.8) | 9(56.2) |
| Total | 163 | 71(43.6) | 92(56.4) |
| Herbs species (Leaves and Steam) (19.74) | | | |
| *Ageratum conyzoides* | 14 | 9 (64.3) | 5(35.7) |
| *Cynodont plectostachyus* | 12 | 8(66.7) | 4(33.3) |
| *Dobera glabra* | 11 | 8(72.8) | 3(27.2) |
| *Justica flava* | 9 | 7(77.8) | 2(22.2) |
| Total | 46 | 32(69.6) | 14 (30.4) |
| Shrub species (Leaves and Steam) (10.30) | | | |
| *Saccharum spontaneum* | 10 | 7(70.0) | 3(30.0) |
| *Dodonoea angustifolia* | 8 | 6(75.0) | 2(25.0) |
| *Euphorbia tirucalli* | 6 | 4(66.7) | 2(33.3) |
| Total | 24 | 17(70.8) | 7(29.2) |

During both seasons, Plains zebra preferred grasses species to others and didn't show significant difference ($F_{(5,10)}$=5.865, P>0.05). Herbs and shrubs were consumed more during the dry season than the wet season. They showed statistically significant variation in the consumption of Herbs ($F_{(3,6)}$=44.38, P<0.05) and Shrubs ($F_{(2,4)}$=19.42, P<0.05). (Table 14) Multiple pair-wise comparisons using the Tukey test indicated that Plains zebra prefered grass species during both seasons, since it is abundantly found in the habitat unless they would shift to herbs and shrubs.

Table 14. Comparison of the plant species between dry and wet seasons using ANOVA

| Plant species | F-value | P-value |
|---|---|---|
| Grass | 5.865 | 0.7600 |
| Herb | 44.38 | 0.0118 |
| Shrub | 19.42 | 0.0008 |

### 4.6. Conservation challenges

Representative villages and distance from the Park were given in Table 15. Of the representative villages, all of the five villages from Guji are living inside or close to the Park. Totally, 364 respondents participated for interview. Of these, 211 (58.5%) were males and 153 (41.5%) were females.

Table 15**.** Representative villages and distance from the Park (N=no. of individual households).

| villages | N | Distance from the Park (km) |
|---|---|---|
| Gode | 58 | <1 |
| Arda Gudina | 41 | <1 |
| Watchole | 47 | 2-3 |
| Mado | 39 | 2-3 |
| Doga | 45 | 2-3 |
| Yira | 50 | 3-5 |
| Abulo Alfacho | 44 | 3-5 |
| Shele | 40 | 1-5 |
| Total/Average | 364 | <5 |

The age of respondents ranged from 18 to 75 years. The majority (55.8%) of the respondents' age ranged from 31 to 60 years (Table 16). Among the respondents, 181 (50%) were illiterate.

Table 16**.** Age category and educational level of the local people (N=no. of individuals).

| Age category | N | Percentage | Educational level | N | Percentage |
|---|---|---|---|---|---|
| 18-30 | 87 | 23.9 | Illiterate | 181 | 49.7 |
| 31-45 | 104 | 28.6 | Primary education | 73 | 20.1 |
| 46-60 | 99 | 27.2 | Secondary education | 58 | 15.9 |
| 61-75 | 74 | 20.3 | Informal education | 52 | 14.3 |
| Total /average | 364 | 100 | Total /average | 364 | 100 |

Secondary educated respondents had more positive (66.9%) attitude towards the conservation of the Park. Illiterate respondents had negative (50.3%) attitude towards the conservation of the Park. Majority of respondents (51.3%) had a positive attitude towards the protected area. Statistically significant variation was observed in the attitude of the respondents towards the Park conservation ($\chi^2$ =28.67, d.f=2, P<0.05) during the study period. (Table 17)

Table 17**.** Attitude of the local people towards the National Park (N=no. of individuals).

| Educational level | N | Attitude towards the Park | | |
|---|---|---|---|---|
| | | Positive (%) | Negative (%) | No idea |
| Illiterate | 181 | 40.2 | 50.3 | 9.5 |
| Primary education | 73 | 52.5 | 39.1 | 8.4 |
| Secondary education | 58 | 66.9 | 25.7 | 7.4 |
| Informal education | 52 | 45.4 | 43.8 | 10.8 |
| Total /average | 364 | 51.3 | 39.7 | 9.0 |

Threats were identified as crop damage, livestock attack and human safety and even may cause diseases. All listed animals cause damage on their crops, but baboons and porcupines (85%) were the highest followed by Plains zebra (78.9%). (Table 18)

Table 18**.** Percentage of type of damage caused by wild animals in the study area (n=364).

| Pest animals | Threat % of the respondents | | | |
|---|---|---|---|---|
| | Crops damage | Livestock predation | Threat to humans | Cause disease |
| Anubis baboon | 89.7 | 15.6 | 14.2 | 8.4 |
| Porcupine | 85.8 | 0.0 | 16.3 | 0.0 |
| Plains zebra | 78.9 | 0.0 | 0.0 | 7.9 |
| Common warthog | 75.0 | 0.0 | 0.0 | 0.0 |
| Bush pig | 67.4 | 0.0 | 0.0 | 0.0 |
| Vervet monkey | 50.5 | 0.0 | 0.0 | 5.9 |
| Hippopotamus | 30.6 | 15.3 | 32.5 | 0.0 |
| Average | 68.3 | 4.4 | 9.0 | 3.2 |

A total of seven animal species (five herbivores and two omnivores) were recoded as major pest animals in the study area (Table 19). These were: Anubis baboon, porcupine, Plains zebra, common warthog, bush pig, vervet monkey and hippopotamus. Among the respondents, 89.2% noted these animals to cause problem on their crops as pests. There was a stastical significant difference in the extent of damage caused by different wild animals in the study area ($\chi^2$ =23.14, df=2, P<0.05). Among the animals, Anubis baboon (75.9%) was the most and hippopotamus (20.5%) was the least in causing crop damage in the study area.

Table 19. Pest animals that cause crop damage (N=364).

| Common name | Species | % of problem ranking | | |
|---|---|---|---|---|
| | | Major Problem | Minor Problem | No Problem |
| Anubis baboon | *Papio anubis* | 75.9 | 20.5 | 3.6 |
| Porcupine | *Hystrix cristata* | 64.6 | 27.9 | 7.5 |
| Plains zebra | *Equus quagga* | 50.3 | 38.4 | 11.3 |
| Common warthog | *Phacochoerus africanus* | 43.7 | 45.1 | 11.2 |
| Bush pig | *Potamocherus larvatus* | 39.8 | 46.4 | 13.8 |
| Vervet monkey | *Cercopithecus aethiops* | 33.1 | 54.5 | 12.4 |
| Hippopotamus | *Hippopotamus amphibious* | 20.5 | 64.2 | 15.3 |
| Total/average | 7 | 46.8 | 42.4 | 10.8 |

High intensity of crop damage by Anubis baboon (76.1%) followed by porcupine (48.4%) while a decrease in plains zebra (62.5%). The average reflection of the respondents, on their crop damage was statistically significant ($\chi^2$ =33.63, df=3, P<0.05).

Table 20. Trends of crop damage during the last 10 years (N=364).

| Species | Trends of damage (%) | | | |
|---|---|---|---|---|
| | Increased | Decreased | The same | Un knowen |
| Anubis baboon | 76.1 | 8.9 | 10.9 | 4.1 |
| Porcupine | 48.4 | 33.5 | 13 | 5.1 |
| Hippopotamus | 42.6 | 27.5 | 20.4 | 9.5 |
| Common warthog | 40.5 | 37.8 | 11.1 | 10.6 |
| Bush pig | 40.9 | 34.2 | 15.9 | 9 |
| Vervet monkey | 39.7 | 32.2 | 20.6 | 7.5 |
| Plains zebra | 18.3 | 62.5 | 12.8 | 6.4 |
| Average | 43.8 | 33.8 | 15.0 | 7.4 |

There was population change of crop raiding animals which implied by respondents, particularly high for Anubis baboon (60.8%). The average difference in the population change was statistically significant ($\chi^2$=23.7, df=3, P<0.05). Table 21

Table 21. Percentage of population change of crop raiding animals in the study area (N=364)

| Species | Population change (%) | | | |
|---|---|---|---|---|
| | Decreased | Increased | Stayed the same | Un know |
| Vervet monkey | 26.6 | 36.5 | 27.2 | 9.7 |
| Bush pig | 25.9 | 34.3 | 31.2 | 8.6 |
| Plains zebra | 25.6 | 33.5 | 32.4 | 8.5 |
| Common warthog | 21.7 | 47.5 | 24.4 | 6.4 |
| Hippopotamus | 20.4 | 42.3 | 27.8 | 9.5 |
| Porcupine | 17.3 | 42.8 | 29.7 | 10.2 |
| Anubis baboon | 15.9 | 60.8 | 17.2 | 6.1 |
| Average | 21.9 | 42.5 | 27.1 | 8.5 |

Table 22, shows distance from the Park and trends of crop damage. All of the respondents noted crop damage has increased during the last 10 years. Out of the 364 respondents, 67.2% responded the trend is increasing, whereas 22.9% responded a decreased trend. Views of respondents on trends of crop damage were statistically significant ($\chi^2$=54.08, df=2, P<0.05). More people from Guji (Gode, Arda Gudina, Watchole, Mado, Doga) faced more crop damage than the other three villages.

Table 22. Approximate distance from the Park, trend of crop damage in the last 5 years.

| Villages | N | Distance from the Park (km) | Trends of crop damage (%) | | |
|---|---|---|---|---|---|
| | | | Increased | Decreased | Unknown |
| Gode | 58 | <1 | 67.2 | 20.6 | 12.2 |
| Arda Gudina | 41 | <1 | 70.6 | 20.8 | 8.6 |
| Watchole | 47 | 2-3 | 69.2 | 23.5 | 7.3 |
| Mado | 39 | 2-3 | 73.1 | 16.8 | 10.1 |
| Doga | 45 | 2-3 | 71.4 | 19.3 | 9.3 |
| Yira | 50 | 3-5 | 62.1 | 26.4 | 11.5 |
| Abulo Alfacho | 44 | 3-5 | 65.9 | 25.1 | 9.0 |
| Shele | 40 | 1-5 | 58.3 | 30.6 | 11.1 |
| Average | 364 | <5 | 67.2 | 22.9 | 9.9 |

A total of seven species (six carnivores and one omnivore) were recoded as major predators of domestic animals such as cattle, sheep, goats, donkeys, and chicken around the Park. These predators were: Anubis baboon, Spotted hyaena, serval, lion, caracal, black backed jackal and Nile crocodile. Among these, Anubis baboon (65.1%) and spotted hyaena (61.2%) were considered as serious predators on domestic animals, whereas Nile crocodile (25.3%) and black backed jackal (35.9%) posed less problem. Among the respondents, the majority (84.5%) noted that these animals caused either major or minor problems on their livestock. This difference was statistically significant ($\chi^2$ =14.50, df=2, P<0.05) among percentage of problems ranked in the study area. (Table 23)

Table 23**.** Threats of carnivores in livestock predation (N=364).

| Common name | Species | % of threats | | |
|---|---|---|---|---|
| | | Major | Minor | No idea |
| Anubis baboon | *Papio anubis* | 65.1 | 21.6 | 13.3 |
| Spotted hyena | *Crocuta crocuta* | 61.2 | 29.1 | 9.7 |
| Serval | *Felis serval* | 42.6 | 38.4 | 19 |
| Lion | *Panthera leo* | 39.5 | 49.2 | 11.3 |
| Caracal | *Felis caracal* | 38.4 | 43.3 | 18.3 |
| Black backed Jackal | *Canis mesomelas* | 35.9 | 47.5 | 16.6 |
| Nile crocodile | *Crocodylus nilotics* | 25.3 | 54.6 | 20.1 |
| Average | 7 | 44.0 | 40.5 | 15.5 |

All identified predators caused threats on human life and crocodiles (55.3%) caused the highest threat. There was a statistically significant difference in the mean percentage of threat scores ($\chi^2$ =26.69, df =3, P<0.05). (Table 24)

Table 24. Reasons given by respondents for considering species as threats (n=364).

| Species | Percentage of respondents and the threat scale | | | | |
|---|---|---|---|---|---|
| | Threat to large livestock | Threats to small livestock | Threats to chicken | Threat to humans | Average |
| Lion | 60.3 | 74.6 | 0.0 | 18.7 | 38.4 |
| Nile crocodile | 65.4 | 69.1 | 0.0 | 55.3 | 47.5 |
| Spotted hyaena | 20.8 | 50.3 | 0.0 | 28.9 | 25 |
| Black Jackal | 5.5 | 70.8 | 19.5 | 15.2 | 27.8 |
| Caracal | 19.8 | 63.6 | 0.0 | 15.6 | 24.8 |
| Serval | 0.0 | 12.7 | 83.4 | 0.0 | 24 |
| Anubis baboon | 0.0 | 50.9 | 55.6 | 15.8 | 30.6 |
| Average | 24.5 | 56.0 | 22.6 | 21.4 | 100 |

Table 25. shows the time of attack and preferred size of domestic animals. The time of attack on domestic animals varies from species to species. Nile crocodile, black jackal and Anubis baboon attack the animals during the day time, whereas lion and spotted hyaena usually attack during the night. Except serval and lions, all predators prefer medium sized and young animals. Lions and Nile crocodiles attack large sized domestic animals

Table 25. Time of attack in domestic animals.

| Carnivores | Time of attack |
|---|---|
| Lion | Evening/night |
| Nile crocodile | Day |
| Spotted hyaena | Evening/night |
| Black backed Jackal | Day |
| Caracal | Night |
| Serval | Day/night |
| Anubis baboon | Day |

The respondents noted trends of damage by Anubis baboon (70.9%) followed by Nile crocodile (61.5%). The least was mentioned for caracal (25.1%). (Table 26)

Table 26**.** Trends of livestock damage during the last 10 years (N=364).

| | Trends of damage (%) | | | |
|---|---|---|---|---|
| Species | Increased (%) | Decreased (%) | The same (%) | Don't know (%) |
| Anubis baboon | 70.9 | 11.6 | 13.4 | 4.1 |
| Nile crocodile | 61.5 | 17.4 | 15.4 | 5.7 |
| Spotted hyaena | 45.8 | 21.6 | 23.7 | 8.9 |
| Serval | 40.5 | 24 | 26.3 | 9.2 |
| Black backed Jackal | 27.7 | 30.6 | 31 | 10.7 |
| Lion | 26.3 | 39.1 | 27.5 | 7.1 |
| Caracal | 25.1 | 32.3 | 29.2 | 13.4 |
| Average | 42.5 | 25.2 | 23.8 | 8.5 |

On average, 42.5% of the respondents claim that most of these animals have been posing damage while 25.2%% noted a decrease over the last 10 years. The average score towards the trends of damage was statistically significant ($\chi^2$ =24.58, df=3, P<0.05) in the last 10 years.

Attitude of respondents towards of population change of carnivores/animals for Anubis baboon was (70.9%) followed by Nile crocodile (61.7%). The average view of respondents was statistically significant ($\chi^2$=29.89, df=3, P<0.05). (Table 27)

Table 27. Attitude of respondents towards population change of Predators (N= 364).

| Species | Attitude of respondents (%) | | | |
|---|---|---|---|---|
| | Increase | Decrease | Stayed the same | Un know |
| Lion | 28.5 | 25.2 | 32.9 | 13.4 |
| Caracal | 25.8 | 33.6 | 27.5 | 13.1 |
| Black Jackal | 21.7 | 34.9 | 29.4 | 14 |
| Serval | 20.5 | 45.8 | 27.3 | 6.4 |
| Nile crocodile | 15.8 | 61.7 | 14.5 | 8 |
| Spotted hyena | 12.9 | 58.4 | 18.1 | 10.6 |
| Anubis baboon | 9.9 | 70.9 | 13.5 | 5.7 |
| Average | 19.3 | 47.2 | 23.3 | 10.2 |

Livestock grazing (76.6%), human settlement (67.5%), and agricultural expansion (62.8%) were the series problems of the Park and increasing the trend of utilizing resources from time to time in and around the National Park. Majority of the respondents (60.2%) noticed these factors have increased. These threats on natural resources and wildlife of the Park showed statistically significant ($\chi^2$ =68.90, df=6, P<0.05). (Table 28).

Table 28. Trends and major identified problems, on natural resources and wildlife of the Park in the last 10 years (n=364).

| Major factors | Trends | | | |
|---|---|---|---|---|
| | Increased | Decreased | The same | Un knowen |
| Grazing | 76.6 | 12.5 | 7.3 | 3.6 |
| Human settlement | 67.5 | 14.6 | 12.5 | 5.4 |
| Agricultural expansion | 62.8 | 13.7 | 16.4 | 7.1 |
| Dry season fire | 59.1 | 17.6 | 17.4 | 5.9 |
| Fuel wood consumption | 56.4 | 20.3 | 16.2 | 7.1 |
| Grass cutting/thatching house | 50.4 | 21.4 | 20.5 | 7.7 |
| Poaching/hunting | 48.7 | 23.4 | 19.6 | 8.3 |
| Average | 60.2 | 17.6 | 15.7 | 6.5 |

Local people put pressure on the Park by utilizing the resources of grasses and trees for different purposes (Plate 4). Most (76.6%) respondents noted to use the grasses primarily for grazing, 56.4% for fuel wood, and 50.4% is for thatching houses and various activities. Local people use trees from the Park for fire wood, house construction and fence construction. The average use of resource utilization from the Park was statistically significant ($\chi^2$ = 41.76, df=4, P<0.05). (Table 29).

Table 29**.** Use of resources from the Park (N=no. of households).

| Villages | N | Grazing (%) | Fuel wood collection (%) | Grass cutting (%) | Other Benefits (%) |
|---|---|---|---|---|---|
| Gode | 58 | 85.4 | 57.5 | 58.1 | 12.6 |
| Arda Gudina | 41 | 83.9 | 55.4 | 57.7 | 14.5 |
| Watchole | 47 | 86.1 | 58.7 | 55.5 | 16.9 |
| Mado | 39 | 80.6 | 53.3 | 47.2 | 13.2 |
| Doga | 45 | 79.5 | 56.9 | 49.8 | 15.7 |
| Yira | 50 | 65.7 | 54.2 | 45.3 | 12.8 |
| Abulo Alfacho | 44 | 68.3 | 52.8 | 46.4 | 14.5 |
| Shele | 40 | 63.6 | 62.4 | 43.1 | 10.4 |
| Average | 364 | 76.6 | 56.4 | 50.4 | 13.8 |

Most (82.8%) of the respondents use the Park for livestock grazing during the dry season while only17.2% use outside the Park (Plate 5). The average livestock grazing inside and outside the Park during the dry season was statistically significant ($\chi^2$ = 43.03, df=1, P<0.05). Whereas, during the wet season, 52.4% were used outside and 47.6% used inside the Park. The average livestock grazing inside and outside the park during the wet season was statistically insignificant ($\chi^2$ = 0.12, df=1, P>0.05. Table 30

Table 30. Seasonal status of livestock grazing during the last 10 years (N=364).

| Villages | N | Status of livestock grazing (%) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Dry Season | | Wet Season | | Mean | |
| | | Inside NP | Outside NP | Inside NP | Outside NP | Inside NP | Outside NP |
| Gode | 58 | 91.5 | 8.5 | 52.4 | 47.6 | 72.0 | 28 |
| Arda Gudina | 41 | 93.9 | 6.1 | 56.8 | 43.2 | 75.4 | 24.6 |
| Watchole | 47 | 89.6 | 10.4 | 55.5 | 44.5 | 72.6 | 27.4 |
| Mado | 39 | 90.4 | 9.6 | 53.7 | 46.3 | 72.1 | 27.9 |
| Doga | 45 | 92.8 | 7.2 | 58.1 | 41.9 | 75.5 | 24.5 |
| Yira | 50 | 74.7 | 25.3 | 49.4 | 50.6 | 62.1 | 37.9 |
| Abulo Alfacho | 44 | 63.2 | 36.8 | 47.3 | 42.7 | 55.3 | 44.7 |
| Shele | 40 | 66.3 | 33.7 | 45.9 | 44.1 | 56.1 | 43.9 |
| Average | 364 | 82.8 | 17.2 | 52.4 | 47.6 | 67.6 | 32.4 |

Table 31, shows attitudes of local people towards conservation area and benefits obtained from the Park. Of the respondents, 51.3% supported the existing Park/wildlife conservation systems, while 39.7% had a negative attitude towards the protected area. There was a statistically significant difference on the attitude towards the conservation area ($\chi^2$ =28.67, df=2, P<0.05). Among the respondents, 80.8% believed that they did not receive any benefit from the existence of the Park. However, few of the respondents (19.2%) noted that they have received benefits from the protected area. There was a statistically significant difference on benefit obtained from the Park by the local people ($\chi^2$ =37.95, df=2, P<0.05).

Table 31. Attitudes of local people towards the conservation area and benefits obtained from the Park (N=No. of sampled households).

| Villages | | Attitude (%) | | | Benefit from the Park (%) | |
|---|---|---|---|---|---|---|
| | N | Positi | Negative | No idea | Some benfit (eployment) | No benefit |
| Gode | 58 | 49.9 | 39.7 | 9.7 | 20.4 | 79.6 |
| Arda Gudina | 41 | 53.2 | 38.1 | 8.8 | 18.7 | 81.3 |
| Watchole | 47 | 50.9 | 43.9 | 7.6 | 21.1 | 78.9 |
| Mado | 39 | 52.3 | 37.4 | 9.5 | 16.9 | 83.1 |
| Doga | 45 | 48.6 | 42.1 | 9.2 | 20.9 | 79.1 |
| Yira | 50 | 52.4 | 37.6 | 7.3 | 17.6 | 82.4 |
| Abulo Alfacho | 44 | 53.4 | 38.5 | 9.7 | 21.5 | 78.5 |
| Shele | 40 | 49.7 | 40.3 | 10.2 | 16.7 | 83.3 |
| Total/average | 364 | 51.3 | 39.7 | 9.0 | 19.2 | 80.8 |

The major problems identified during FGD were crop damage and livestock depredation. Moreover, livestock grazing, illegal settlement expansion (Plate 6), illegal hunting, fire during the dry season (Plate 7), illegal fishing, frequent drought, weak law enforcement, resource utilizationwere also big problems of conservation of wildlife inside the Park. Livestock grazing was high from Guji ethnic group that dwell inside the Park. Discussions held with local communities showed that they had negative attitude towards the existence of problem causing animals. However, the majority had a positive attitude towards other wildlife. Very few discussants recognized the value of the Park for the contribution to the regional economy through tourism and climate stability in the future.

Some discussants were dissatisfied with the existence of the National Park due to the restriction of livestock grazing inside the Park. As a result, they considered the Park as a limiting factor in improving their livelihood as most have high number of livestock. They also felt that Park staff members do not like communities around the Park boundaries. As far as issues of re-translocation are concerned, most of the local people responded that, they have stayed there for more than 50 years and they do not want to go to other areas.

Government intervention is essential as a way to find a solution for wildlife and communities.

# 5. DISCUSSION

## 5.1. Population Status, Distribution and Habitat Preference

In order to manage the population of Planis zebra and other wildlife in Protected Areas, timely understanding of their population status and ecology is very important. The population estimate of Plains zebra showed a reduced number during the dry season. This might be due to the shortage of resources (food, water and shelter) forcing the animals to move outside the Park area. The high number of Plains zebra during the wet season is due to the availability of enough resources in their vicinity leading to minimizing movement outside the Park. Similar studies by Barraquad and Benhanmou (2008) and Bonnet *et al*. (2010) also supported the view in that large herbivores undergo less movement due to availability of forage/green fresh grasses during the wet season. However, during the dry season, the availability of forage grasses, particularly in the open plain (common place of zeberas') is totally degraded due to overgrazing by livestock forcing the animals to move outside the Park (Plate 9). This might lead Plains zebra to move to the surrounding wooded grassland, and bushland to look for food source and rest under shades of trees. In addition, they might move outside the Park to minimize observability of the animals.

The population trend of Plains zebra has decreased dramatically in the study area. Different researchers noted the fluctuation of Plains zebra population size due to various factors such as revenge by the local community during the fall of Derg military regime, which caused killing of many wild animals in the Park in 1992. However, Yisehak Doku *et al*. (2007) noted after 1995 due to the application of strict wildlife management regulation and regular patrolling, the wildlife population recovered. The study by Yisehak Doku *et al*. (2007) revealed 4500 individuals from the present study area. However, during the present study period, the estimated population size was only 716. This high decrease in the population might be related to the high drought of 2019 which killed many plains zebra with intense competition with livestock grazing (Plate. 9) in the plain/grassland area. This resulted in the shortage of food and increase in crop damage resulting in killing/conflict with local community. Similarly, Craigie *et al*. (2010)

revealed shortage of forage and wildlife conflict are the main factors affecting the survival of large herbivores in most Protected Areas in Africa.

The present study also noted that Plains zebra associate with a few ungulates such as Grant's gazelle, Greater kudu and livestock in the Park. However, in the study area the dominant competitor of Plains zebra is cattle, causing catastrophic effect to the grassland of the Plain area. The previous studies by Demeke Datiko and Afework Bekele (2011) have also pointed out that overgrazing severely deteriorated the Nechisar open grassy plain area. Moreover, during the present study observation, the open grassy plain area was mostly affected by illegal livestock grazing. As a result, the grassland area which was the main habitat of Plains zebra has been replaced by invasive bush species. This is a big challenge for large herbivore conservation in the Park.

As noted by Wilson *et al*. (1996), knowledge of population structure such as sex ratio and age distribution of individual mammals is vital for evaluating the viability of a species. The female biased sex ratio may indicate a good chance for the population to recover. The smaller number of male individuals might be due to their more anti-predator behaviour. Similarly, Yisehak Doku *et al*. (2007) also noted that the dominant adult Plains zebra usually stands staring at the predator and actively defending the harem and missing mares or young. However, the number of young/foal observed was low. The low proportion of young animals indicate that the population is not a healthy one. The low number of foal/young might be related to high predation of young by potential predators in the area. Reta Regassa and Solomon Yirga (2013) also observed similar findings from Yabelow Wildlife Sanctuary. The present study also revealed that the main predators of Plains zebra particularly of the foal/young were spotted hyaenas and lions. This was observed from killed and consumed carcass during the study period (Plate 10). In addition to these predators, ticks were the main problem of plains zebra as noted by Yisehak Doku *et al.* (2007) and confirmed during the present study.

During the present study period younger was counted during late dry season compared to others (Plate 11). Reta Regassa and Solomon Yirga (2013) also revealed similar findings from Yabelow Wildlife Sanctuary as a breeding peak from December to January. Yosef

Mamo *et al*. (2010) also revealed early wet season or late dry season to be the birth period for large herbivores. This highest number of young counts during the late dry season or early wet season might ensure maximum opportunity for the survival of young due to high availability of resources (forage, water and cover).

During the study period, the structure of Plains zebra group sizes varied from season to season. During the wet season, there were more individuals in a group than the dry season. However, the number of groups were high during the dry season count. Yisehak Doku *et al*. (2007); Reta Regassa and Solomon Yirga (2013) and also noted that Plains zebra form large groups when there is abundance of high-quality forage, but might be forced into smaller groups when food supply is less abundant and dispersed in distribution. Therefore, the possible reason for the increase in group size during the wet season compared to the dry season might be due to the availability of resources minimizing competition between them. Similar observations were also made for large herbivore by Evangelista *et al*. (2008) and Yosef Mamo *et al*. (2015) in Bale Mountains National Park. Whereas, the shortage of resource during the dry season might force the animals to disperse to minimize competition and search for forage.

Group formation of animals has both advantages and disadvantages. It may reduce predation risk as well as increase the chance of getting mate. However, it may also increase the chance of competition for resources. Estes (1997) also noted that Plains zebra herd members cooperate to protect themselves and reduce predation risk. Moreover, Yisehak Doku *et al*. (2007) noted that Plains zebra groups often detect an approaching animal/predator sooner than solitary individuals. This advantage may be practiced in larger group members giving alarm signals when a predator is sighted. This might help each individual in a group to spend less time in vigilance behaviour and can allocate more time to other activities such as feeding. The earlier detection of predators might increase the likelihood of escape by individual animals.

Prolonged study and inclusion of both wet and dry seasons was important in order to observe the influence of different seasons on the vegetation cover and their density as well as the distribution of animals. The seasonal distribution of Plains zebra significantly

varied in different habitat types during the study period. The highest density of animals was observed in wooded grassland during the wet season, and the lowest density in the grassland during the dry season. This is related to the absence of forage in the grassland areas during the dry season. During the dry season, overgrazing reduces the grass quality in the grassland area. As noted by Thaker *et al*. (2010) and Yosef Mamo *et al*. (2015), the density of animals is determined by the availability of resources in a given habitat. Moreover, as noted by Yisehak Doku *et al*. (2007), ticks invade the open grassy plains during the dry season which was not suitable for the animals (Plate 12) which may lead them to die. Except, riverine vegetation and lake shore habitats, the density of plains zebra was high during the wet season and low during the dry season in the Park. This might be due to shortage of forage during the dry season forcing the animals to scatter in varied habitats outside the Park. Whereas, the relatively high density of dry season around the riverine vegetation and around lakeshore might be related to daily demand of water and the existence of green forage in these habitats. This goes in line with the findings of Yieshak Doku *et al*. (2007) in the study area. During the study period most populations of plains zebra concentrated towards scattered trees and bushes during the dry season. Therefore, the bushes and trees might be an important refugion during dry season. However, plains zebra prefers less dense trees and bushes during the wet season.

Habitat preference of animals for a given habitat type is largely determined by the available vegetation within the area to obtain food, water, minerals, shelter from climatic extremes and cover from predators. The study revealed wooded grassland was more frequently visited followed by grassland and bushland by plains zebra. This type of habitat selection may be influenced by vegetation type, presence of water, predator avoidance and availability of food as well as cover. However, the study of Yisehak Doku *et al*. (2007) and Reta Regassa and Solomon Yirga *et al*. (2013) revealed that these animals preferred grassland habitat than others in NNP and Yabello Wildlife Sanctuary, respectively. However, in the Nechisar plain, it might be due to intensive overgrazing that caused the grassland area to be barren particularly during the dry season. Similarly, Reta Regassa and Solomon Yirga *et al*. (2013) noted that Plains zebra preferred woodland to others during the dry season. During the wet season, Plains zebra preferred grassland habitat to others as noted by the study of Yisehak Doku *et al*. (2007) and Reta Regassa

and Solomon Yirga *et al*. (2013). During the dry season Plains zebra visit more lakeshore and riverine vegetation habitats because of the heat shifting their habitat in order to protect from the sun. This was due to water demand as well as the presence of green vegetation/grasses for their forage around aquatic habitat. Similar findings were revealed by the study of Ogutu *et al*. (2008) in Mara-Serengeti in Kenya which shows the preference of habitat to be associated with what the habitat provides in terms of food and protection from predators. Therefore, variations in number of individuals in different habitats might be due to habitat quality, influence of human activities and livestock distribution as well as availability of resources in the area. Similar studies by Yosef Mamo *et al*. (2012) and Dejene Worku and Demeke Datiko (2017) that revealed resource distribution affecting habitat preferences of large herbivores in the Bale Mountains National Park.

### 5.2. Diurnal Activity Pattern and Feeding Habit

Time spent for each diurnal activity in Plains zebra varied. As noted by Reta Regassa and Solomon Yirga (2014), activity pattern of animals depends on the time allocation to behaviours governing the energy acquisition rate and the animal's probability of avoiding predators. This might be due to varied requirements of the animals during the day time. Feeding constituted the major component of all activities in natural population of animals (Reta Regassa and Solomon Yirga (2014). Plains zebra also spent most of their time grazing (56.5%). During the dry season, more time was consumed for grazing than the wet season. Bodenstein *et al*. (2000) also noted that in periods when food is scarce, the flexibility to regulate the time budget can be a help to maintain intake requirements. Similar observations were reported by Reta Regassa and Solomon Yirga (2014) for Plains zebra and Illis (2006) for other herbivores. Relatively, more time was taken for grazing activity during the dry season than the wet season. This might be related to increased food availability during the wet season minimizing the time for foraging. Similar observation was seen by study of Sandra (2009) and Reta Regassa and Solomon Yirga (2014) in their studies. Among other activities, resting and grooming were high during mid-days.

Seasonal diurnal activity pattern of Plains zebra varied during the study period**.** Fortin (2003) and Gandiwa *et al*. (2016) also noted that the basic activities in most ungulates

change seasonally. Seasonal daily activity patterns of animals are determined by environmental factors such as light and temperature as well as availability of resources. Similar findings were observed by the studies of Patterson *et al*. (1999), and Gandiwe *et al*. (2016). Moreover, habitat preference of plains zebra varied during diurnally. However, during the wet season, the diurnal activity was mostly in the grassland area. However, lakeshore and riverine vegetation habitats were visited during the mid-day compared to others. Reta Regassa and Solomon Yirga (2014) also noted that Plains zebra frequently visited water sites and non-selective roughage grazers. Similarly, the present study also revealed the daily dependence of plains zebra on water during the study period.

Herbivore diet is influenced by several factors such as anatomical and physiological characteristics of animals, and type of the plant species as well as their nutrient constituents (Henly *et al*., 2011). During the study period, Plains zebra mainly graze but occasionally browse on herb leaves and shrubs particularly during the dry season. Rubenstein (2010) noted that most of the food of the zebra was grass, and herb and shrub are consumed particularly during the shortage of grasses in their area. Similarly, during the study period, grasses constuted the highest. Moreover, the data showed that plains zebra feed upon most common grasses available in the Park, specifically species of *Lintonia nutans* and *Themeda triandra*. The study of Yisehak Doku (2003) also revealed the consumption of most of these grasses during both wet and dry seasons in the study area. However, during the wet season, consumed more grass material than the dry season. Herbs and shrubs were consumed more during the dry season that the wet season. This might be related to the availability of grasses during the wet season than dry season. As a result, during the dry season, the animals are forced to consume herbs and shrubs. Moreover, studies by Yisehak Doku (2003) and Reta Regassa and Solomon Yirga (2014) showed that grass comprises most of the diet of the Plains zebra during both seasons. This shows that the open grasslans plain of NNP habitat is degraded to support this animal for their forage. Bodenstein *et a*l. (2000) noted that Plains zebra are mainly grazers but occasionally browse on leaves and shrubs when resource is scarce.

## 5.3. Conservation Challenges

Collecting baseline information on human-wildlife conflict is a vital step in managing a protected area. This helps to understand the timing, status and location of the challenges as well as the perceptions of local people in order to take proper action (Maddox, 2008; Demeke Datiko and Afework Bekele, 2013b). Relatively educated respondents supported protected areas more than those with no formal education. This shows that support for conservation was positively correlated with the level of education of the respondents. Gadd (2005) also observed a similar situation in a study of people's attitudes towards the wildlife in Kenya and Reta Regassa and Solomon Yirga (2013), in Yabelow Wildlife Sanctuary in Ethiopia.

Crop damage was one of the most identified sources of conflict during the study period. The study revealed, seven species were recoded as pests of cereal crops, fruits and vegetables of farmlands around the Park. The damage is increasing from time to time due to the occupancy of most villages inside the Park. As noted by Chhangani *et al*. (2002), and Dejene Worku and Demeke Datiko (2017), a wide variety of herbivore pests come into conflict with humans around protected areas. The findings of Demeke Datiko and Afework Bekele (2013b) also showed similar problems around Chebera Churchura National Park. Except hippopotamus, all problematic animals are a serious crop raider around all surveyed villages. Shele and Abulo Alfacho are the only villages facing crop damage by hippopotamus. This is due to the location of the villages near to Lake Chamo where hippos inhabit. Moreover, the movement of hippo is determined by the topographic features in the area to reach other villages. Baboons are the most destructive crop raiding animals. Similarly, Demeke Datiko and Afwork Bekele (2013b) in Chebera Churchura National Park revealed baboons to consume whatever crop available in their farm. They also have the ability to intimidate people who keep the crops.

The present study also showed close proximity between farms and the Park to result in high levels of conflicts. Michalski *et al*. (2006) also noted that farmers residing close to the protected areas were severely attacked by pest animals. Most of the present studied villages are located inside the Park. As a result, those who live inside the Park face

frequent crop damage by pest animals. The high preference of crops by crop raider might be due to better palatability and nutritive value of the crops. However, local people used various methods such as physical barriers, guarding, using domestic dogs and fear-provoking stimuli around the farmland area to minimize the damage. This crop damage might have resulted in negative attitude towards pest animals and other wildlife in the Park.

The study also revealed, seven species as major predators of domestic animals such as cattle, sheep, goats, donkeys and chicken around the Park. As noted by Peterson *et al.* (2010) the reduction of the natural prey may be one of the major causes of predators shifting their diet to livestock that are easier to capture. The attack of crocodile on livestock and human at the shore was very high.The respondents noted that these animals caused loss of domestic animals and affect household food security. As a result, the local people have negative attitude towards the animals as well as the presence of the Park. Similarly, the studies of Woodroffe *et al*. (2005); Kolowski and Holekamp (2006) show that tolerance of local communities on predators depends on the extent of predation on their livestock.

The respondents indicated that the effect of carnivores on predation of their livestock has been increasing during the last 10 years. As a result, most respondents have a desire to reduce these predators. Similarly, the study of Marker *et al*. (2003) revealed that where there is loss of domestic animals, local farmers dislike the existence of pest animals around them. However, even if carnivores cause a problem on livestock and human welfare, they also perform a vital role in balancing the ecosystem and controlling pest wildlife on crops. Moreover, the study revealed that as distance from the Park boundary increases, predation on livestock decreases. Therefore, villages (Guji peoples') inside the Park were highly affected by predation of livestock. Similar findings were observed across other African countries such as in Kenya and Tanzania (Patterson *et al*. 2006; Holmern *et al*., 2007). The exact reasons why carnivores prey on domestic animals are not well understood by the current investigation. However, it might be related to decrease in the number of preys in the Park as well as domestic animals are easy to catch by predators and predation was high for small sized animals.

Like most African countries, humans also put pressure on NNP by various ways such as illegal expansion of settlements, agricultural expansion, livestock grazing and utilizing the resources to generate income, as well as setting fire to the grassland area in search of fresh grass. Similar studies by Demeke Datiko and Lema Tiki (2017) and Dejene Worku and Demeke Datiko (2018) revealed the problems in Chebera Churchura National Park. Particularly, livestock raring and agricultural expansion activities can have a negative impact such as deforestation and loss of habitat for wildlife. During the study period, the Park has been under increasing pressure from a rapidly growing pastoralist population and their livestock. High levels of livestock grazing in NNP may affect the quality of the habitat suitable for the wildlife community. At present, the previous "Nechisar" (white grass) which was called after the name of the Park was totally destroyed and replaced by invasive bush species. This might be related to frequent livestock grazing which utilize grasses before they produce flower and seeds. Similarly, studies of Yisehak Doku *et al*. (2007) and Demeke Datiko and Afework Bekele (2011) also noted these problems as the main challenges of the Park. Similarly, Yosef Mamo et al. (2012) observed livestock grazing to highly affecting the wildlife habitat in the Bale Mountains National Park.

During the study period, livestock is the most commonly observed domestic animal in the National Park. The respondents noted that the number of livestock grazing has been increasing in the Park, and it is one of the important factors affecting the vegetation area. This might encourage invasive bush species to spread in the Park. During the study period, large number of livestock compete directly for food with Plains zebras in the Park and other wildlife. This affects the distribution of Plains zebra and other wild herbivores in the Park. Similar situation was observed in Yabelow Wildlife Sanctuary (Reta Regassa and Solomon Yirga, 2013).

The other conservation threat that developed negative attitudes towards the park was the absence of direct benefit sharing for local communities. Similar studies by Newmark *et al*. (1994) showed attitudes of local people were influenced by the services and benefits that they receive from the Protected Area. Moreover, the negative attitude of the Guji

Oromo people towards the Park may have come from fear of displacement from their indigenous habitat for the interest of wildlife conservation. The communities that live in Nechisar plains already use all products of natural resources from the Park and they live inside the Park with their livestock. Few of the respondents claim that they have the right to utilize natural resources in their localities as long as they are pastoralists and lived around there for more than 50 years. As a result, they strongly oppose their displacement and exclusion from the resources. In addition, the Park staff also claim that the number of scouts is few and their monthly salary is not enough to support their families.

According to the respondents, most of the local people use the resources of the Park. This dependence of local people on the resources (wood, grasses, spices/medicinal plants) of the Park might affect wildlife management practices. Similar finding by Dejene Work and Demeke Datiko (2018) from Hanto Control Hunting Area revealed illegal utilization of resources are the main protected area challenge in Ethiopia. This resource consumption directly influences the population status of Plains zebra and other wild animals by reducing the grazing land and reducing vegetation cover of the Park. In addition, the local people besides imposing pressure on the Park, degrade the vegetation of the Park through uncontrolled wildfire during the dry season. Fire is set intentionally by the pastoral community in the Park to improve the forage resource for their livestock. However, frequent fire particularly during the long dry season affects the vegetation of the open grassland, leading to invasive species. Similar studies by Hassen *et al*. (2008) and Demeke Datiko and Afework Bekele (2011) revealed frequent fire affecting the ecosystem of a given area and reducing native species as well as encouraging growth invaders.

Moreover, during the study period, the respondents noted that hunting of wild herbivores such as Grater Kudu, waterbuck, lesser kudu is common practice in the Park for various purposes such as bush meat and for their skins as well as to minimize thir crop damage. Similarly, killing of Plains zebra was noted by respondents for various reasons. Ethnic groups around the Park (Guji, and Kore/Amaro) kill them while they damage their crops. This was also confirmed by the study of Yisehak Doku *et al*. (2007). However, the Konso ethnic people that come from south of the Park, poach the animals for meat and skin

during the dry season when the animals disperseduring the dry season. In addition, respondents noted that some people like the Gumayde Menz people use their skin to decorate and make house furniture. This was also confirmed by the study of Yisehak Doku *et al*. (2007).

Moreover, some years ago there was agreement between both the South Nations Nationalities of People's and Oromia Region to translocate their people from inside the Park by providing them incentives. As a result, Kore/Amaro people from SNNP were translocated, however, from Oromia the action was not taken. This decision disappointed the Kore/Amaro tribe due to action was taken on them only. They then started to resettle back. Therefore, the challenges of Nechisar National Park is increasing from time to time and at present the conservation practices are at a critical stage.

# 6. CONCLUSION AND RECOMMENDATIONS

## 6.1. Conclusion

A healthy population of wildlife is a function of high-quality habitats. The present investigation provided valuable information on population status, behavioural ecology of plains zebra and human-wildlife conflict in Nechisar National Park. The current population size of Plains zebra has decreased. Particularly, it has been decreasing since the last 15 years. Vegetation cover, availability of food, human factors and other environmental factors (water, temperature) were the main factors for the distribution, habitat preference and abundance of Plain zebra. The diurnal activity pattern of Plains zebra also varied with season. This shows that season is one of the main determinant factors for variation in the animal daily activity. Since, the area harbours this impressive animal and many other large mammal species, birds and other wild animals. Therefore, it can serve as important centre for conservation of the country's wildlife and tourist attraction area in the future. Besides its wild animal potential, the Park has impressive landscape and crater lakes which is a potential to tourism development.

At present, the major threats of the Park are crop damage and livestock loss. Human-wildlife conflict is the main problem in the Park. Human impact on the Park is also an increasing concern in the study area. Humans cause pressure in utilizing the resources of the Park which is a potential threat to the survival of Plains zebra and other wildlife species. In NNP, this threat is caused by numerous factors such as rapid illegal human settlement, agricultural expansion, livestock grazing and illegal resource exploitation. These are causing land cover changes within the Park and negative impacts on the natural habitats of the wildlife. Moreover, overgrazing and illegal resource utilization lead to encroachment of bushes particularly on the open grassland. In addition, frequent fire, limited number of scouts, poor facility in the Park and negative attitude of the local people towards the wildlife are the major challenges. Some respondents also oppose wildlife conservation in the area, which will have negative impact on their livelihoods and restriction of resource utilization by the Park office. It will help to pinpoint where the worst conflict occurs and direct deterrent efforts to where they are most needed. If this current trend of livestock grazing, agricultural expansion and illegal human settlement

continues, the existence of the Park will be indoubt in the future. The collected data will provide valuable information on the current population status and structure, habitat preference, diurnal activity pattern, feeding habit of Plains zebra as well as the human-wildlife conflict in the study area. In addition, the information obtained in this study also will give direction for responsible bodies about the Park. Now a days there are different concerned bodies are showen up and stand for the well being of the Park.

### 6.2. Recommendations

The following recommendations should be considered to overcome the problem and enhance sustainable conservation in and around the Park.

- ✓ law enforcement and awareness creation should be carried out in order to minimize the number of livestock.
- ✓ Overgrazing of livestock leads to bush encroachment, contributing to the reduction of important wildlife habitats. Therefore, monitoring the habitat and controlling the invasion of the open grassland plains by invasive bush encroachment should be minimized through controlled burning and selective cultivating of the invasive bushes within the Park
- ✓ Nechisar National Park has a great potential for the country's wildlife conservation and ecotourism/tourism development. Therefore, it is necessary to take timely and appropriate conservation measures (community-based conservation activities) to minimize the problems.
- ✓ As the Park possesses a great potential to conserve the wildlife of the country, additional budgets should be allocated from regional and federal government to support the overall conservation activities.
- ✓ Emphasis should focus on providing appropriate conservation education which is important for the local communities/children at different levels of schools (primary, secondary and high schools).
- ✓ Income generating projects should be emphasized which meet economic development/livelihood changes to the local people.
- ✓ Farmers should cooperatively keep their farm against crop raiders and guard their livestock by building enclosures to prevent them from predators at night.
- ✓ Energy efficient technologies (stoves) should be accessed by the government to the community to reduce deforestation.
- ✓ Continuous monitoring and evaluation of wildlife population and conservation threats are essential for better conservation and long-term management of the Park.
- ✓ There is a need to develop schemes where local people perceive tangible economic benefits to tolerate wildlife on the surroundings. It is also important to monitor conflict situations over time

- ✓ Therefore, all concerned institutions at the local, regional and federal levels should participate in conservation programmes to alleviate the conservation gaps of the Park.

# 7. REFERENCES


Acevedo, P., Escudero, M.A., Munoz, R. and Gortazar, C. (2005). Factors affecting wild boar abundance across an environmental gradient in Spain. *Acta. Theriol*. **51**: 327-336.

Afework Bekele and Leirs, H. (1997). Population ecology of rodents of maize fields and grasslands in central Ethiopia. *Belg. J. Zool*. **127**: 39-48.

Altmann, J. (1974). Observational study of behavior: sampling methods. *Behav*iour **43**: 227- 269.

Amano, T., Ushiyama, K., Fujita, G. and Higuchi, H. (2007). Predicting grazing damage by white fronted geese under different regimes of agricultural management and the physiological consequences for the geese. *J. Appl. Ecol.* **44**: 506-515.

Andrade, G.S.M. and Rhodes, J.R. (2012). Protected areas and local communities: an inevitable partnership toward successful conservation strategies. *Ecol. Soci.* **17**: 14–21.

Anthony, B.P., Scott, P. and Antypas, A. (2010). Sitting on the fence, policies and practices in managing human-wildlife conflict in Limpopo Province, South Africa. *Conserv. Soci.* **8:** 225-240.

Asa, C.S. (2002). Equid reproductive biology. **In**: *IUCN/SSC Equid Action Plan*, pp. 113–17,(Moehlman, P.D., eds). Gland.

Asmamawu, D. and Verma, A. (2013). Ecotourism as a tool for environmental conservation and its implication to community livelihoods, the case of the Bale Mountains National Park, Ethiopia. *J. Environ. Sci.Wat. Res. **2***: 250-259.

Bagchi, S. and Mishra, C. (2006). Living with large carnivores: predation on livestock by the snow leopard (*Uncia uncia*). *J. Zool.***268**: 217-224.

Barraquand, F. and Benhamou, S. (2008). Animal movements in heterogeneous landscapes: identifying profitable places and homogeneous movement bouts. *Ecology* **89:**3336-3348.

Bauer, I. E., McMorrow, J. and Yalden, D.W. (1994). The historic ranges of three equid species in North-East Africa quantitative comparison of environmental tolerances. *J. Biogeogr*. **21:** 169-182.

Beauchamp, G. (2009). How does food density influence vigilance in birds and mammals? *Anim. Behav.***78**:223-231.

Befekadu Refera and Afework Bekele (2004). Population Status and Structure of Mountain Nyala in the Bale Mountains National Park, Ethiopia. *Afr. J. Ecol*. **42**: 1-7.

Begg, C., Begg, K. and Muemedi, O. (2007). Preliminary data on human-carnivore conflict in Niassa National Reserve, Mozambique, pp22

Ben-Shahar, R. and Coe, M.J. (1992). The relationships between soil factors, grass nutrients and the foraging behaviour of wildebeest and zebra. *Oecologia* **90**: 422–428.

Blom, S. (2009). Diurnal behaviour of mother-young pairs of Plains zebras (*Equus burchelli*) in Maasai Mara National Reserve, Kenya. Student Report 281: Swedish University of Agricultural Sciences.

Blower, J. (1967). Report on visit to the Nechisar plains and Lake Chama. EWCO Report-I, Addis Ababa

Bodenstein,V., Meissner, H.H. and Van H.W. (2000). Food selection by Burchell's zebra and blue wildebeest in the Tmbavati area of the northern Province Lowveld. *Southern Africa. J. wildl. Res.* **30**: 63-73.

Boer, W.F. and Baquete, D.S. (1998). Natural resource use, crop damage and attitudes of rural people in the vicinity of the Maputo Elephant Reserve, Mozambique. *Environ. Conserv.* **25**: 208-218.

Bolton, M. (1970). Report on Nechisar National Park. Report-4. EWCO, Addis Ababa. 13 pp.

Bonham, R., Wield, R. and Turner, A. (2007). Human-wildlife conflict. *E. Afr. Soc. Rev.* **23**:1–3.

Bonnet, O., Fritz, H., Gignoux, J. and Meuret, M. (2010). Challenges of foraging on a high-quality but unpredictable food source: the dynamics of grass production and consumption in savanna grazing lawns. *J. Ecol.* **98:** 908-916.

Bourn, D. and Blench, R. (1999). *Can livestock and wildlife co-exist? An interdisciplinary approach: Livestock, Wildlife and People in Semiarid Rangeland of Eastern Africa*: Overseas Development Institute, London.

Brooks, C. J. (2005). The foraging behaviour of Burchell's zebra (*Equus burchelli antiquorum*). Dissertation, University of Bristol, Bristol.

Brooks, C.J. and Harris, S. (2008). Directed movement and orientation across a large natural landscape by zebras, *Equus burchelli* antiquorum. *Anim. Behav*.**76:** 277-285.

Browne, N.C. and Jonker, S.A.(2008). Attitudes toward wildlife and conservation across Africa: a review of survey research. *Hum. Dimen. Wil.* **13**: 47–70.

Buckland, S., Anderson, D., Burnham, K., and Laake, J. (1993). Distance sampling: estimating abundance of biological populations. Chapman and Hall, London.

Cain, J.W., Owen-Smith, N. and Macandza, V.A. (2012). The costs of drinking: comparative water dependency of sable antelope and zebra. *J. Zool*. **286**: 58-67.

Cameron, E.Z. and Linklater, W.L. (2000). Individual mares bias investment in sons and daugh-ters in relation to their condition. *Anim. Behav*. **60**: 359–367.

Cameron, E.Z. and Linklater, W.L. (2007). Extreme sex ratio variation in relation to change in condition around conception. *Biol. Lett.* **3**: 395–397.

Chhangani, A. K., Mohnot, S. M. and Pandey, R. P. (2002). Consumption of different plant parts by wild Hanuman langurs and their known medicinal practice by local people in Aravallis of Rajasthan, India. *J. Econo. Tax. Bot.* ***26*****:** 419–439.

Conover, M. (2002). *Resolving Human-wildlife Conflicts: the Science of Wildlife Damage Management*. Lewis Publishers, New York. 418 pp.

Craigie, I.D., Baillie, J.E.M., Balmford, A., Carbone, C., Collen, B., Green, R.E. and Hutton, J.M. (2010). Large mammal population declines in Africa's protected areas. *Biol. Conserv*. **143:** 2221-2228.

Darimont, C.T., Paquet, P.C., Treves, A., Artelle, K.A. and Chapron, G. (2018). Political populations of large carnivores. *Conserv. Biol*. **32**: 747–9

De Beenhouwer, M. (2011). *Effects of habitat fragmentation and coffee cultivation on the of epiphytic orchids in Ethiopian Afromontane forests*. Msc. Thesis. Katholieke Universities Leuven, Faculty of Science, Department of Biology, Plant Systematics and Ecology Section.

Decker, D.J., Lauber, T.B. and Siemer, W.F. (1992). *Human-Wildlife* C*onflict Management*. Cornell University, Ithaca, New York.

Dejene worku and Demeke Datiko (2017). Abundance, distribution and population structure of Mountain nyala (*Tragelaphus buxtoni*) in Hanto controlled hunting area, southeastern Ethiopia. *J. Bio. End. Speci.* **5**:1-7.

Dejene worku and Demeke Datiko (2018). Trophy Hunting and Humans of Hanto Controlled Hunting Area, Southeastern Ethiopia. *Int. J. Cur. Res.*: **10**: 73991-74000

Demeke Datiko and Afework Bekele (2011). Population status and human impact on the endangered Swayne's hartebeest (*Alcelaphus buselaphus swaynei*) in Nechisar Plains, Nechisar National Park, Ethiopia. *Afr. J. Ecol.* **49**: 311-319.

Demeke Datiko and Afework Bekele (2013a). Conservation challenge: human-carnivore conflict in Chebera Churchura National Park, Ethiopia. *Gre. J. Biol. Sci.* **3**: 108-115.

Demeke Datiko and Afework Bekele (2013b). Human-herbivore conflict in Chebera Churchura National Park, Ethiopia. *Pak. J. Biol. Sci.* **16**: 1758-1764.

Demeke Datiko and Lemma Tiki (2017). Challenges of human settlement on wildlife in Bale Mountains National Park, Southeast Ethiopia. *Int. J. Biodive. Conserv.* **9**: 107-114.

Dereje Yazezew, Yosef Mamo and Afework Bekele (2011). Population ecology of Menelik's bushbuck (*Traglaphus scriptus meneliki*) from Denkoro Forest Proposed National Park: Northern Ethiopia. *Int. J. Ecol. Environ. Sci.* **37**:1-13.

Desalegn Wana . (2004). Strategies for Sustainable Management of Biodiversity in the Nechsar National Park, Southern Ethiopia. A Research Report Submitted to OSSREA: Addis Ababa.

Dickens, M.J., Delhanty, D.J. and Romero, L.M. (2010). Stress: an inevitable component of animal translocation. *Biol. Conserv.* **143**: 1329-1341.

Dickman, A.J. (2010). Complexities of conflict: the importance of considering social factors for effectively resolving human–wildlife conflict. *Anim. Conserv.* **13**: 458-466.

Distefano, E. (2005). *Human-wildlife conflict worldwide: collection of case studies, analysis of management strategies and good practices*. Food and Agriculture Organization of the United Nations, Rome.

Dressel, S., Ericsson, G. and Sandström, C. (2018). Mapping socialecological systems to understand the challenges underlying wildlife management Environ. *Sci. Pol*. **84**: 105–12.

Duckworth, W.E., Safford, R.J., Telfer, M.G., Timins, R.J. and Chemere Zewide (1992). Reports on Cambridge-Ethiopia Ground-water forest expedition. *Afr. J. Ecol*. **30**: 90-97.

Dudley, N., Mansourian, S., Stolton, S. and Suksuwan, S. (2008). *Safety Net: Protected areas and poverty reduction*, WWF International, Gland.

Duncan, P. (1992). *Zebras, Asses, and Horses, an Action Plan for the Conservation of Wild Equids. IUCN/SSC Equid Specialist Group*. IUCN, Gland.

Ebensperger, L.A., Hurtado, M.J., Ramos, J. R. (2006). Vigilance and collective detection of predators in degus (*Octodon degus*). *Ethology,* **112**:879-887.

Ellis, E.C., Klein, G. K., Siebert, S., Lightman, D. and Ramankutty, N. (2010). Anthropogenic transformation of the biomes, pp.1700- 2000. *Glob. Ecol. Biogeogr*. **19**:589-606.

Else, J.G. (1991). Nonhuman primates as pests. In**:** *Primate responses to environmental change*. (Box, H. O.ed.), pp. 115–165. Chapman and Hall, London.

Enari, H. and Suzuki, T. (2010). Risk of agricultural and property damage associated with the recovery of Japanese monkey populations. *Landsc. Urb. Pla.* **97(2):** 83-91.

Eniang, E., Ijeomah, H. M., Okeyoyin, G. and Uwatt, A. E. (2011). Assessment of human wildlife conflicts in Filinga Range of Gashaka Gumti National Park. *Nigeria* **7**: 15-35.

Estes, R. D. (1999). *The Safari Companion: a Guide to Watching African Mammals*. Halfway House: Russel Friedman Books.

Estes, R.D. (1997). *Behavioural Guide to African Mammals - Including Hoofed Mammals, Carnivores, Primates*. Russell Friedman Books CC, Pretoria. *scie* **34**: 416-490.

Evangelista, P., Norman, J., Berhanu, L., Kumar, S. and Alley, N. (2008). Predicting habitat suitability for the endemic Mountain Nyala (*Tragelaphus buxtoni*) in Ethiopia. *J. Wil. Res.* **35**: 409-416.

Evans, M., Safford, R.J. and Chemere Zewdie (1992). *A survey of Nechi Sar National Park, Etiopia*: Report of the Cambride Ethiopia Ground-Water Forest Expedition,

1990, Report Number 50. International Council for Bird Preservation, Cambridge. pp.42.

EWCO (1999). *General description of the Nechi Sar National Park, produced information bulletin*, Addis Ababa.

Ezenwa, V. O. (2004). Selective defecation and selective foraging: antiparasite behavior in wild ungulates? *Ethology* **110**:851–862.

Fanuel Kebede, Afework Bekele, Moehlman, P.D. and Evangelista, P.H. (2012). Endangered Grevy's zebra in the Alledeghi Wildlife Reserve, Ethiopia: species distribution modeling for the determination of optimum habitat. *End. Speci. Res.***17**: 237–244.

Fischhoff, I.R., Sundaresan, S.R., Cordingley, J., Larkin, H., Sellier, M. and Rubenstein, D.I. (2007a). Habitat use and movements of Plains zebra (*Equus burchelli*) in response to predation danger from lions. *Behav.Ecol*.**18**:725–729.

Fischhoff, I.R., Sundaresan, S.R., Cordingley, J., Larkin, H., Sellier, M. and Rubenstein, D.I. (2007a). Social relationships and reproductive state influence leadership roles in movements of plains zebra, *Equus burchelli*. *Anim. Behav.***73**: 825-831.

Fleurance, G., Duncan, P., Fritz, H., Gordon, I.J. and Grenier, L.M.F. (2010). Influence of sward structure on daily intake and foraging behaviour by horses. *Animal* **4:**480-485.

Focardi, S., Isotti, R. and Tinelli, A. (2002). Line transect estimates ofungulate populations in a Mediterranean forest. *J.Wil.Man*. **66**:48–58.

Focardi, S., Aragno, P., Montanaro, P. and Riga, F. (2006). Inter-specific competition from fallow deer *Dama dama* reduces habitat quality for the Italian roe deer *Capreolus capreolus italicus. Ecography* **29**: 407–417.

Fortin, D. (2003). Searching behavior and use of sampling information by free-ranging bison (*Bos bison*). *Behav. Ecol.Socio*. **54:**194-203.

Fortin, D., Fryxell, J.M., O'Brodovich, L. and Frandsen, D. (2003). Foraging ecology of bison at the landscape and plant community levels: the applicability of energy maximization principles. *Oecologia* **134:**219-227.

Freeman, D. (2006). Natural Resource Management in and Around Nechsar National Park: A Situational Analysis. Final report, Addia Ababa.

Fryxell, J.M., Hazell, M., Borger, L., Dalziel, B.D., Haydon, D.T., Morales, J.M., McIntosh, T. and Rosatte, R.C. (2008). Multiple movement modes by large herbivores at multiple spatiotemporal scales. *Pro Nat. Acad. Sci. Uni.Sta. Ameri*. **105:**19114-19119.

Gandiwa, E., Heitkönig, I.M., Eilers, P.H. and Prins, H.H. (2016). Rainfall variability and its impact on large mammal populations in a complex of semi-arid African savanna protected areas. *Trop*. *Ecol*. **57**:163–180.

Gautam, D.N. (2013). Assessment of wild ungulates in the karnali flood plain of bardia National Park, Nepal. *Int. J. Conserv. Sci.* **4**: 87-94.

Georgiadis, N., Hack, M. and Turpin, K. (2003). The influence of rainfall on zebra population dynamics: implications for management. *J. Appl. Ecol*. **40**:125–136.

Ghose, K.C. and Manna, B. (2003). *Fundamentals of Zoology*. New Central Book Agency LTD, New Delhi.

Grange, S., Barnier, F., Duncan, P., Gaillard, J.M., Valeix, M., Ncube, H., Périquet, S., and Fritz, H. (2015). Demography of plains zebras (*Equus quagga*) under heavy predation. *Popul*. *Ecol*. **57**:201–214.

Grange, S., Duncan, P., Gaillard, J.M., Sinclair, A.R., Gogan, P.J., Packer, C., Hofer, H., and East, M. (2004). What limits the Serengeti zebra population? *Oecologia***140**:523–532.

Grange, S. and Duncan, P. (2006). Bottom-up and top-down processes in African ungulate communities: resources and predation acting on the relative abundance of zebra and grazing bovids. *Ecography* **29:**899-907.

Groves, C. (1974*). Horses, Asses and Zebras in the Wild*. Ralph Curtis Books, Hollywood, Florida.

Groves, C.P. and Bell, C.H. (2004). New investigations on the taxonomy of the zebras genus *Equus*, subgenus *Hippotigris*. *Mamm*. *Biol*. **69**:182–196.

Guinness, S.M. and Taylor, D. (2014). Farmers' perceptions and actions to decrease crop raiding by forest-dwelling primates around Rwandan forest fragment. *Human Dimens. Wildl.* **19**:179–190.

Hack, M.A., East, R. and Rubenstein, D.I. (2002). Status and action plan for the plains zebra (Equus burchelli). Equids: Zebras, Asses and Horses. Status survey and conservation action plan. IUCN/SSC 123 Equid specialist group, Gland.

Harris, G., Thirgood, S., Hopcraft, J.G.C., Cromsigt, J.P. and Berger, J. (2009). Global decline in aggregated migrations of large terrestrial mammals. *Endang. Specie. Res.* **7:** 55-76.

Hassan, S.N., Rusch, G.M., Hytteborn, H., Skarpe, C. and Kikula, I. (2008). Effects of fire on sward structure and grazing in western Serengeti, Tanzania. *Afr. J. Ecol*. **46:**174-185.

Hazzah, L., Dolrenry, S., Kaplan, D. and Frank, L. (2013). The influence of park access during drought on attitudes toward wildlife and lion killing behaviour in Maasailand, Kenya. *Environ. Conserv.***142**: 1–11.

Henley, S. R., Smith, D. G. and Raats, J. G. (2001). Evaluation of three techniques for determining diet composition. *J. Rang. Manag*. **54**:582–588.

Hill, C. (2000). Conflict of interest between people and baboons: Crop raiding in Uganda. *Int. J. Primat*. **21**: 299-315.

Hill, C., Osborn, F. and Plumpter, A.J. (2002). *Human-Wildlife Conflict: Identifying the* P*roblem and Possible Solutions*. Albertine Rift Technical Report Series Vol. I. Wildlife Conservation Society, Kampala.

Hill, C.M. and Wallace, G.E. (2012). Crop protection and conflict mitigation: reducing the costs of living alongside non-human primates. *Biod. Conserv.***21**: 2569-2587.

Hillman, J.C. (1993). *Ethiopia: Compendium of Wildlife Conservation Information. Vol. I. Wildlife Conservation Area.* New York Zoological Society and Ethiopian Wildlife Conservation Organization, Addis Ababa.

Hoare, R. (2012). Lessons from 15 years of human-elephant conflict mitigation: management considerations involving biological, physical and governance issues in Africa. *Pachyderm* **51**: 59-74.

Hostens, E. (2009). Modelling the Migration of Grevy's Zebra in Function of Habitat Type Using Remote Sensing. MSc Thesis, Ghent University.

Hussain, S.A. (2000) Protecting the snow leopard and enhancing farmers' livelihoods. *Mount. Res. Develop.* **20**: 226-231.

Illius, A.W. (2006). Linking functional responses and foraging behaviour to population dynamics. **In**: *large herbivore ecology, ecosystem dynamics and conservation*, pp. 71-96, (Danell, K., Duncan, P., Bergstrom, R. and Pastor,J., eds). Cambridge University Press, Cambridge.

Inskip, C. and Zimmerman, A. (2009). Human-felid conflict: a review of patterns and priorities worldwide. *Oryx* **43**: 18-34.

IUCN. (1990). *IUCN Red Data List of Threatened Animals*. International Union for Conservation of Nature and Natural Resources, Gland.

Kolowski, J.M. and Holekamp, K.E. (2006). Spatial, temporal, and physical characteristics of livestock depredations by large carnivores along a Kenyan reserve border. *Biol. Conserv*.**128**: 529-541.

Kamler, J. F., Jedrzejewska, B. and Jedrzejewska, W. (2007). Activity patterns of red deer in Bialowieza National Par. *J. Mamm.* **88**: 508-514.

Kingdon, J. (1997). *Kingdon Field Guide to African Mammals*. Academic Press, London.

Kingel, H. and Kingel, U. (1996). Tooth development and age determination in the plain Zebra (*Equus quagga boehim mastichie*). *Zool. Gard.* **33**: 34-54.

Kirubel Tesfaye (1985). *Nechisar National Park Preliminary Report With Particular Reference to the Distribution of Large Herbivores and Major Threats to the Park Resources.* Ethiopian Wildlife Conservation Organization, Addis Ababa.

Klingel, H. (1969). Reproduction in the plains zebra, *Equus Burchelli* Boehmi: Behaviour and ecological factors. *J. Reprod. Fert.* **6**: 339-345.

Laws, R. M. and Parker, I. S. (1968). Recent studies on elephant populations in East Africa. *Symp. Zool. Soc. Lond*. **21**: 319-359.

Leykun Abunie (2000). The challenges of conserving Ethiopian wildlife: overview. *Walia* **21**:56-62.

Linklater, W.L and Cameron, E.Z. (2009). Social dispersal but with philopatry reveals incest avoidance in a polygynous ungulate. *Anim. Behav.***77**:1085–1093.

Linklater, W.L., Cameron, E.Z., Stafford, K.J. and Veltman, C.J. (2000). Social and spatial structure and range use by Kaimanawa wild horses (*Equus caballus*: Equidae). *J. Ecol.* **24**:139–152.

Lorenzen, E.D., Arctander, P., and Siegismund, H.R. (2008). High variation and very low differentiation in wide ranging plains zebra (*Equus quagga*): insights from mt. DNA and microsatellites. *Molecu. Ecol*. **17**:2812–2824.

Madden, F. (2004). Creating coexistence between humans and wildlife: global perspectives on local efforts to address human-wildlife conflict. *Hum. Dimen.Wildl.* **9**:247-257.

Maddox, T. (2003). *The Ecology of Cheetahs and Other Large Carnivores in Pastoralist-Dominated Buffer Zone*, Ph. D. Thesis, University College and Institute of Zoology, London.

Madhusudan, M.D. and Mishra, C. (2003). Why big, fierce animals are threatened: conserving large mammals in densely populated landscapes. **In**: *Battles over Nature: Science and the Politics of Conservation.* Saberwal, V. and Rangarajan, M. Permanent Black, New Delhi.

Makindi, S.M., Mutinda, M.N., Olekaikai, N.K.W., Olelebo, W.L. and Aboud, A.A. (2014). Human-wildlife conflicts: causes and mitigation measures in Tsavo Conservation Area, Kenya. *Inter. J.Sci. Res.* **3**: 1025–1031.

Marker, L.L., Dickman, A.J., Macdonald, D.W. and Mills, M.G.L. (2003). Aspects of the management of cheetahs, *Acinonyx jubatus jubatus*, trapped on Namibian farmlands. *Biol. Conserv.***114**: 401-412.

Martin, P. and Bateson, P. (1993). *Measuring Behavior: An introductory guide.* Cambridge University Press, Cambridge.

Mesele Yihune, Afework Bekeleand Zelealem Tefera (2009).Human-Wildlife Conflict In and around the Simien Mountains National Park, Ethiopia *Sinet: Ethiop. J. Sci*. **32**:57–64.

Messmer, T.A. (2000). The emergence of human-wildlife conflict management: turning challenges into opportunities. *Inter. Biodet. Biodegr*. **49**: 97-102.

Michalski, F., Boulhosa, R., Faria, A. and Peres, A. (2006). Human - wildlife conflicts in a fragmented Amazonian forest landscape: Determinants of large felid depredation on livestock. *Anim. Conserv.* **9**: 179-188.

Mills, M.G.L. and Shenk,T.M. (1992). Predator-prey relationships: the impact of lion predation on wildebeest and zebra populations. *J. Anim. Ecol.* **61**: 693–702.

Mishra, C. (1997). Livestock depredation by large carnivores in the Indian trans-Himalaya: conflict perceptions and conservation prospects. *Environ. Conserv.* **24**: 338-343.

Mishra, C., Allen, P., McCarthy, T., Madhusudan, M., Bayarjarkal, A. and Prins, H. (2003). The role of incentive programs in conserving the Snow Leopard. *Conserv. Biol.* **17**: 1512-1520.

Moehlman, P. D. (2002). *Equids: Zebras, Asses and Horses. Status Survey and Conservation Action Plan, The international Union for theConservation of Nature and Natural resources,* Gland.

Moehlman, P. D., (2003). *Grizmek's Animal Life Encyclopedia*. Mammals IV. Detroit, the Gale Group, Inc.

Monfort, A. and Monfort, N. (1978). Structure et répartition des populations de zèbres (*Equus burchelli*) duParc de l'Akagera (Rwanda). *Mammal.* **42**: 315–322.

Morrison, J.C., Sechrest, W., Dinerstein.E., Wilcove, D.S. and Lamoreux, J.F. (2007). Persistence of large mammal faunas as indicators of global human impacts. *J. Mammal.* **88**: 1363–1380.

Naidoo, R., Du Preez, P., Stuart-Hill, G., Jago, M. and Wegmann, M. (2012). Home on the Range: Factors Explaining Partial Migration of African Buffalo in a Tropical Environment. PLoS One, **7,** e36527.

Naughton, T. L., Grossberg, R. and Treves, A. (2003). Paying for tolerance: rural citizens' attitudes toward wolf depredation and compensation. *Conserv. Biol.* **17**:1500-1511.

Naughton, T. L.A and Treves, A. (2005). Socio-ecological factors shaping local support for wildlife: crop-raiding by elephants and other wildlife in Africa. **In**: *People and wildlife: conflict or coexistence,* pp. 252–27, (Woodroffe, R., Thirgood, S. and Rabinowitz, A., eds). Cambridge University Press. Cambridge.

Nechisar National Park (NNP) (2012*). Annual Report,* Arbaminch.

Neuhaus, P. and Ruckstuhl, K. (2002). The link between sexual dimorphism, activity budgets, and group cohesion: The case of the plains zebra (Equus burchelli). *Canad. J. Zool.* **80**:1437-1441.

Newmark, W., Manyanza, D., Gamassa, D. and Sariko, H. (1994). The conflict between wildlife and local people living adjacent to protected areas in Tanzania: human density as a predictor. *Conserv. Biol.* **8**: 249-255.

Newmark, W.D., Leonard, N.L., Sariko, H.I. and Gemassa, D.M. (1993). Conservation attitude of local people living adjacent to five protected areas in Tanzania. *Conserv. Biol.* **63**:177-183.

Odum, H. T. (1971*). Enviroment, Power, and Society*. Wiley-Interscience, Newyork.

Obunde, P.O., John, M., Omiti, R. and Nsirengo, A. (2005). Policy dimension in human-wildlife conflicts in Kenya: Evidence from Laikipia and Nyandarva districts. *Insti. Poli. Analys. Res.***11**: 1-4

Ogada, M.O., Woodroffe, R. and Oguge, N.O. (2003). Limiting depredation by African carnivores: the role of livestock husbandry. *Conserv. Biol.* **17**: 1521-1530.

Ogutu, J.O., Piepho, H.P., Dublin, H.T., Bhola, N. and Reid, R.S. (2008). Rainfall influences on ungulate population abundance in the Mara-Serengeti ecosystem. *J. Anim. Ecol.***77:** 814-829.

Ojo, O. S., Akinyemi, O., Sodimu, A.I., Ojelade B. S. and Jayeoba, W.A. (2010). Human- wildlife conflict: Issues, effects and conservation. (Acceced 2019, http//environmentlankCom/blog/2010/ human%E2%80%93-wildlifeconflict-issues-effects-and-conservation).

Oli, M.K., Taylor, I.R. and Rogers, M.E. (1994). Snow leopard *panther unica* predation of livestock: an assessment of local perception in the Annapuma conservation area. *Nepa. Biol. Conserv*. **68**: 63-68.

Opdam, P. and Wascher, D. (2003). Climate change meets habitat fragmentation: Linking landscape and biogeographical scale levels in research and conservation. *Biol. Conserv*. **11**: 285-297

Owen-Smith, N. (2002). *Adaptive Herbivore Ecology*. Cambridge University Press, Cambridge.

Owen-Smith, N. (2008). Changing vulnerability to predation related to season and sex in an African ungulate assemblage. *Oikos* **117**: 602-610.

Owen-Smith, N., Fryxell, J.M. and Merrill, E.H. (2010). Foraging theory upscaled: the behavioural ecology of herbivore movement. *Philo. Transacti. Roy.Soci*. **365**: 2267-2278.

Packer, C., Brink, H., Kissui, B., Maliti, H., Kushnir, H. and Caro, T.M. (2011). Effects of trophy hunting on the population dynamics of an African lion population in a protected area. *Biol. Conserv.* **25**: 142-153

Parrini, F. and Owen-Smith, N. (2010). The importance of post-fire regrowth for sable antelope in a Southern African savanna. *Afr.J. Ecol.* **48:**526-534.

Patterson, B. R. and Bondrup-Nielsens, S. and Messier, F. (1999). Activity patterns and daily movements of the eastern Coyote, *Canis latrans*, in Nova Scotia. *Canad. Field Natu.* **113:** 251-257.

Petersen, J. (2003). *Human - Wildlife conflicts in Ethiopia.* Berryman Institute, Utah State University. NADCA Salt Lake City.

Peterson, M.N., Birckhead, J.L., Leong, K., Peterson, M.J. and Peterson, T.R. (2010). Rearticulating the myth of human–wildlife conflict. *Conserv. Letter* **3**: 74–82.

Pluhacek, J. and Bartos, L. (2006). High-ranking mares of captive plains zebras *Equus burchelli* have greater reproductive success than low-ranking mares. *Appl. Anim. Behav. Sci.* **99**: 315-329.

Pokharel, C. (1996). Food habit and habitat utilization of swamp deer (*Cervus duvauceli duvauceli*), M.Sc. Thesis Royal Bardia National Park, Nepal, Tribhuvan University, Nepal.

Pokharel, C.P. (1996). Food habit and habitat utilization of Swamp Deer (*Cervus duvauceli duvauceli*) in RBNP, Nepal. M.Sc. Dissertation, Tribhuvan University, Nepal.

Redfern, J.V., Grant, R., Biggs, H. and Getz, W.M. (2003). Surface-water constraints on herbivore foraging in the Kruger National Park, South Africa. *Ecology* **84:** 2092-2107.

Reta Regassa and Solomon Yirga (2013). Distribution, abundance and population status of Burchell's zebra (*Equus quagga*) in Yabello Wildlife Sanctuary, Southern Ethiopia. *J. Ecol. Natu. Environ*. **5**: 40-49.

Reta Regassa and Solomon Yirga (2014). Diurnal activity pattern of Burchell's zebra (*Equus gugga*, Gravy) in Yabellow Wildlife Sanctuary, southern Ethiopia. *Int. J. Biodiv. Conserve*. **6**:616-623.

Rubenstein, D.I. (2010). Ecology, social behaviour and conservation in zebras. *Advan. Behav*. **42**:231-258.

Samson Shimelse, Tamrat Bekele and Alemayehu Mengistu (2010). Floristic Diversity and Structure of Nechisar National Park, Ethiopia. *J. Drylan*. **3**: 165-180.

Sandra, B. (2009). *Diurnal Behavior of Mother- Young Pairs of Plains Zebra (Equus burchelli) in Maasai Mara National Reserve, Kenya.* Study report Number 281.

Swedish University of Agricultural Sciences Department of Animal Environment and Health Ethology and Animal Welfare programme, Sweden.

Schakner, Z.A. and Blumstein, D.T. (2013). Behavioral biology of marine mammal deterrents: a review and prospectus. *Biol. Conserv.***167**:380-389.

Shi, J., Beauchamp, G. and Dunbar, R.I.M. (2010). Group-size effect on vigilance and foraging in a predator-free population of feral goats (*Capra hircus*) on the Isle of Rum, NW Scotland. *Ethology* **116**: 329-337.

Shibia, M.G. (2010). Determinants of attitudes and perceptions on resource use and management of Marsabit National Reserve, Kenya. *J. Hum. Ecol.* **30**: 55–62.

Smuts, G.L. (1975). Pre- and post-natal growth phenomena of Burchell's zebra from the Kruger National Park. *Koedoe* **18**: 69-102.

Stuart, C. and Stuart, T. (1997). Field Guide to the Larger Mammals of Africa. Struik Publisher's Pvt. Ltd., Cape Town.

Sutherland, W. J. (1996). *Ecological Census Techniques; a handbook.* Cambridge University Press. Cambridge.

Svitalek, B.J. (2008). *Use of GIS technologies in biodiversity conservation: case study of vegetation and soil mapping in Nechi Sar National Park*, Ethiopia. M.Sc. thesis, Czech University of Life Science, Prague.

Tarrant, J., Kruger, D. and du Preez, L.H. (2016). Do public attitudes affect conservation effort? Using a questionnaire-based survey to assess perceptions, beliefs and superstitions associated with frogs in South Africa. *Afr. Zool.* **51**: 13–20.

Tewodros Kumsa and Afework Bekele (2008). Population status and structure of endangered Swayne's hartebeest (*Alcelaphus buselaphus swaynei*) in Senkele Swayne's Hartebeest Sunctuary: Ethiopia. *Act. Zool. Sin.* **54**: 569-575.

Thaker, M., Vanak, A.T., Owen, C.R., Ogden, M.B. and Slotow, R. (2010). *Group dynamics of zebra and wildebeest in a woodland savanna: effects of predation risk and habitat density.* School of Biological and Conservation Sciences, University of KwaZulu-Natal, Durban, South Africa.

Treves, A. and Karanth, K.U. (2003). Human-carnivore conflict and perspectives on carnivore management worldwide. *Conserv. Biol.* **17**: 1491–99

Treves, A., Wallace, R. B., Naughton, T. L. and Morales, A.(2006). Comanaging human–wildlife conflicts: a review. *Hum. Dimens. Wildl*. **11**: 383–96

Treves, A. (2006). Co-managing human-wildlife conflicts: a review. *Hum. Dimens. Wildl.* **11**: 383-396.

Van Eeden, D.G. (2006). *Habitat Preference and Status of Burchell's Zebra in Tembe Eelephant Park, South Africa.* University of Pretoria Press, Pretoria.

Warren, Y. (2003). *Olive Baboons* (Papio anubis): Behaviour, Ecology and Human Conflict in Gashaka Gumti National Park, Nigeria. *Ph.D. Thesis, University of Surrey*.

Watson, L.H. and Owen-Smith, N. (2000) Diet composition and habitat selection of eland in semi-arid shrubland. *Afr. J. Ecol*. **38**: 130–137.

William, S.D. and Low, B. (2004). *Grevy's Zebra Conservation: Proceedings of a Workshop.* Mpala Research Centre, Kenya.

Wilson, D.E., Cole, F.R., Nichols, J.D., Rudran, R. and Foster, M. (1996). *Measuring and monitoring biological diversity: Standard methods for mammals*. Smithsonian Institution Press, Washington, D.C.

Woodroffe, R. (2000). Predators and people: Using human densities to interpret declines of large carnivores. *Anim.Conserv.* **3**: 165–173.

Woodroffe, R. and Ginsberg, J.R. (1998). Edge effects and the extinction of populations inside protected areas. *Science* **280**: 2126–2128.

Woodroffe, R., Thirgood, S. and Rabinowitz, A. (2005). *People and Wildlife, Conflict or Co-existence?* Cambridge University Press, Cambridge.

World Parks Congress (2003). Vth IUCN World Parks Congress. Durban, South Africa,

MeseleYihune, Afewerk Bekele and Zelalem Tefera (2009). Human Gelada baboon conflict in and around the Semien Mountains National Park, Ethiopia. *Afr. J. Ecol*. **47**: 276-282.

Yisehak Doku (2003). *Populations Status and Human Impact on Burchell's Zebra* (*Equus burchelli*, Gray 1824) in Nechisar Plains, Nechisar National Park, Ethiopia. M.Sc. Thesis, Addis Ababa University, Addis Ababa.

Yisehak Doku, Afework Bekele and Balakrisnan, M. (2006). Human impact on the Plains Zebera (*Equus quagga*) population in Nechisar Plains, Necisar National Park, Ethiopia. *Int. J. Ecol. and Environ. Sci.* **32**: 137-142.

Yisehak Doku, Afework Bekele and Balakrishnan, M. (2007). Population status of plains Zebra (*Equus quagga*) in Nechi Sar National Park, Ethiopia. *Trop. Ecol.* **48:** 79-86.

Yosef Mamo (2015). Demography and population dynamics of mountain nyala (*Tragelaphus buxtoni)* before its population crash in 1991 in the Bale Mountains National Park, Ethiopia. *Inter. J. Develop. Rese.* **5**: 3085-3094

Yosef Mamo and Afework Bekele (2011). Human and livestock encroachments into the habitat of Mountain Nyala (*Tragelaphus buxtoni*) in the Bale Mountains National Park: Ethiopia. *Trop. Ecol.* **52**: 265-273

Yosef Mamo, Addisu Aseffa and Girma Mengesha (2015). Social organization in the mountain nyala (*Tragelaphus buxtoni*) population in Bale Mountain National Park, Ethiopia. *Inter. J. Biodiv. Conserv.* **7**: 103-111.

Yosef Mamo, Afework Bekele and Girma Mengesha (2012). Habitat use of mountain nyala (*Tragelaphus buxtoni,* Lyddeker,1911) in the Bale Mountain National Park. Ethiopia, *Inter. J. Biodiv. Conserv. **4**: 642-651*

Yosef Mamo, Michelle, A. and Afework Bekele (2010). Demography and dynamics of mountain nyala (*Tragelaphus buxtoni)* in the Bale Mountains National Park: Ethiopia. *Curre. Zool.* **56**: 660-669.

**APPENDICES**

**Appendix I**. Household questionnaire for local people around NNP.

1. Name of the respondent ----------

a. Sex

| Male | Female |
|---|---|
| | |

b. Age category

| 18-30 | 31-45 | 46-60 | >61 |
|---|---|---|---|
| | | | |

c. Family size----------

d. Occupation----------

e. Number of people per village----------

2. Residence

a. Village/Kebele----------

b. District----------

c. Distance from the Park----------

d. Dominant and common plants that occur in the area----------

e. For how long have you been a resident of this area? ----------

Where were you living before moving to this place (if moved in recently)?____

f. GPS location----------

3. Education Level a. Illiterate b. Elementary c. High school d. Others

4. Household economy

a. Pastoralist b. Farmer c. Both

5. What type of crop do you grow?

a ....., c....., e----------

b....., d....., f----------

6. Do you own livestock? Yes/No, if yes

a. No. of cattle---------  d. No. of donkeys------

b. No. of sheep--------  e. Chicken ----------

c. No. of goats---------  f. Others: specify ----------

7. Where do they graze?

a. In the study area  b. Outside the Park, c. Both

8. If in the study area, for how long they graze?

a. 1-2 months  b. 2-4 months  c. 5-7 months  d. above 7 months

9. Are you dependent on the National Park for livelihood activities? Yes/No, if yes, how?

10. Where do you collect fire wood and use other resources (wood, grass)?

a. From the Park  b. Outside the Park

**Impact of Wild animals on human resources**

**A. Crop damage by pest animals**

11. What kind of problems do you face because of these animals?

| Animal type | Crop damage | Predation | Threats on humans | Disease |
|---|---|---|---|---|
| Anubis baboon | | | | |
| Plains zebra | | | | |
| Bush pig | | | | |
| Common warthog | | | | |
| Hippopotamus | | | | |
| Porcupine | | | | |
| Vervet monkey | | | | |

12. How is the extent of damage by wildlife?

a. Very high b. high c. less d. No

13. Type of damaged crop(s) by animal type

| Animal type | List of damaged crop(s) types |
|---|---|
| Anubis baboon | |
| Plains zebra | |
| Bush pig | |
| Common warthog | |
| Hippopotamus | |
| Porcupine | |
| Vervet monkey | |

14. Can you sort these pictures into animals that are cause major damage, minor damage or no damage around this household, and explain why?

| Animals | Damage | | |
|---|---|---|---|
| | Major | Minor | No |
| Anubis baboon | | | |
| Plains zebra | | | |
| Bush pig | | | |
| Common warthog | | | |
| Hippopotamus | | | |
| Porcupine | | | |
| Vervet monkey | | | |
| Others | | | |

15. What do you think about the population status of hazardous herbivores since the last 5 years?

| Animal type | Increased | Decreased | The same | Don't known |
|---|---|---|---|---|
| Anubis baboon | | | | |
| Plains zebra | | | | |
| Bush pig | | | | |
| Common warthog | | | | |
| Hippopotamus | | | | |
| Porcupine | | | | |
| Vervet monkey | | | | |
| Other: specify | | | | |

16. What do you think about these animals?

| Animals | Attitude | | |
|---|---|---|---|
| | No problem | Like | Dislike |
| Anubis baboon | | | |
| Plains zebra | | | |
| Bush pig | | | |
| Common warthog | | | |
| Hippopotamus | | | |
| Porcupine | | | |
| Vervet monkey | | | |
| Others | | | |

17. What do you feel about the population change of these animals in the Park?

| Animals | Desired population change | | | |
|---|---|---|---|---|
| | Increase | Decrease | Stay the Same | Don't know |
| Anubis baboon | | | | |
| Plains zebra | | | | |
| Bush pig | | | | |
| Common warthog | | | | |
| Hippopotamus | | | | |
| Porcupine | | | | |
| Vervet monkey | | | | |

18. Which animals are the most hazardous in terms of crop damage?

a. ---------- b. ----------c. ---------- d. ---------- e----------f. ----------

19. What is the tendency of the crop damage from time to time?

a. Increasing b. Decreasing c. Unknown

20. Do you get help from other sources to solve your problem? Yes..... No.....

If yes, from where do you get the help?

21. Describe the different techniques you use to control (minimize) the damage caused by pest animals on crops. i....., ii....., iii.....

22. How do you minimize the damage?

a. Physical barriers (fence, walls)

b. Guarding (watching eyes, dogs)

c. Fear-provoking stimuli (visual: scarecrows, lighting fires)

d. Auditory: exploders and distress calls

e. Chemical repellents

23. What do you do when you find out that the crop is damaged by large herbivore pests?

a. Report to the Park offices c. Use poison to kill predators

b. Use traps d. Kill (shoot, axle, gun)

e. Others: please specify---------

**B. Carnivore and livestock predation**

24. Do you have problems with these predators? Yes/No, If yes, what is problem?

25. What kind of problems do you face because of these animals?

| Species | Threat | | | | |
|---|---|---|---|---|---|
| | large livestock | Small livestock | Chickens | humans | Diseases |
| Anubis baboon | | | | | |
| Black Jackal | | | | | |
| Caracal | | | | | |
| Lion | | | | | |
| Nile crocodile | | | | | |
| Serval | | | | | |
| Spotted Hyena | | | | | |
| Average | | | | | |

26. Can you sort these pictures into animals that are a major threat, minor threat or no threat surrounding this household, and explain why?

| Animal type | Threats | | |
|---|---|---|---|
| | Major | Minor | No |
| Anubis baboon | | | |
| Black Jackal | | | |
| Caracal | | | |
| Lion | | | |
| Nile crocodile | | | |
| Serval | | | |

| | | | |
|---|---|---|---|
| Spotted Hyena | | | |
| Others | | | |

27. What do you think about the population status of problematic carnivores since the last 5 years?

| Animal type | Increased | Decreased | The same | not known |
|---|---|---|---|---|
| Anubis baboon | | | | |
| Black Jackal | | | | |
| Caracal | | | | |
| Lion | | | | |
| Nile crocodile | | | | |
| Serval | | | | |
| Spotted Hyena | | | | |

28. What do you feel about the population change of these animals in the Park?

| Animals | Desired population change | | | |
|---|---|---|---|---|
| | Increase | Decrease | Stay the Same | Don't know |
| Anubis baboon | | | | |
| Black Jackal | | | | |
| Caracal | | | | |
| Lion | | | | |

| | | | | |
|---|---|---|---|---|
| Nile crocodile | | | | |
| Serval | | | | |
| Spotted Hyena | | | | |
| Others | | | | |

29. Attitude of people towards each animal

| Animals | Attitude | | |
|---|---|---|---|
| | No problem | Like | Dislike |
| Anubis baboon | | | |
| Black Jackal | | | |
| Caracal | | | |
| Lion | | | |
| Nile crocodile | | | |
| Serval | | | |
| Spotted Hyena | | | |
| Others | | | |

30. Do you have problems with predators? Yes/No

a. If yes, what is the problem?----------.

b. Has a carnivore ever attacked your livestock? Yes/No

c. If yes, please indicate the predator species and number of livestock you have lost in the last three years during wet and/or dry season?

| Livestock type | Predators | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | baboon | Nile crocodile | Hyena | serval | Jackal | Lion | Caracal | |
| Sheep | | | | | | | | |
| Goat | | | | | | | | |
| Cattle | | | | | | | | |
| Chicken | | | | | | | | |
| Donkeys | | | | | | | | |
| Dogs | | | | | | | | |
| Others | | | | | | | | |

31. Which animals are the most problematic in terms of livestock predation?

a. ---------- b. ----------c. ---------- d. ---------- e----------f. ----------

32. Where and when are livestock frequently attacked by carnivores in this area?

| Predator | Location of attack | | Season | | Time of attack | | | |
|---|---|---|---|---|---|---|---|---|
| | Home | forest | Wet | Dry | Mo | Md | Ev | Nt |
| Anubis baboon | | | | | | | | |
| Black Jackal | | | | | | | | |
| Caracal | | | | | | | | |
| Lion | | | | | | | | |
| Nile crocodile | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Serval | | | | | | | | |
| Spotted Hyena | | | | | | | | |
| Other: specify | | | | | | | | |

Mo = morning, Md = midday, Ev = evening, Nt = night

33. What is the preferred size of livestock by predators?

| Carnivore animal | List preferred prey size |
|---|---|
| Anubis baboon | |
| Black Jackal | |
| Caracal | |
| Lion | |
| Nile crocodile | |
| Serval | |
| Spotted Hyena | |

34. Please provide an estimate of predators removed over the past 3 years and methods used

**Total** **Method/s used**

a. Lion ---------- ----------

b. Leopard ---------- ----------

c. Hyena ---------- ----------

d. Jackal ---------- ----------

e. Wild dog ---------- ----------

f. Caracal ---------- ----------

g. Anubis baboon ---------- ----------

f. Other: specify ---------- ----------

35. Have you ever asked for help on how to prevent livestock losses to predators? Yes/No, if yes, state where assistance was sought, if no, state reasons.

36. Have you been compensated for any of your livestock killed by carnivores? Yes/NoPlease explain:_____

37. Where do losses occur?

a. Livestock kraal---------- c. Field----------

b. Near water--------- d. Others: please specify---------

38. What do you do when you find out that you have lost livestock to a predator?

a. Report to the Park offices c. Use poison to kill predators

b. Use traps d. Kill (shoot, axe, gun)

e. Others: please specify---------

39. Do you keep a guard dog with the livestock/cattle when herding at this household? Yes/No. If yes, how many? ___

40. Why do you keep these dogs? _____

41. How do you minimize the loss?

a. Physical barriers b. Guarding c. Fear-provoking stimulie. chemical repellents

**C. Attitudes and knowledge of local people to wards wildlife/Park**

42. Do you think that the presence of National Park benefited the community? Yes/No, if yes, in what way?----------

43. Are there any resources that you have been prevented from the National Park? Yes/No, if yes, do you know the reason? If yes, mention----------

44. Do you think conserving wildlife is important? Yes/No

45. Do you want to involve yourself in managing the protected areas? Yes/No, if no, why?

46. What do you think about the presence of the Park around you?

a. Like b. Dislike c. No idea

47. Who do you believe the cause of the problem? a. wildlife b. People.

Reason out----------

48. Do you get any benefit from the Park? Yes/No, if yes, would you mention them……?

49. Do you agree to move out, if the government arranges to you other settlement place? Yes/No, if no, why?

50. Do you think that the National Park staffs are doing good work? Yes/No

51. What do you think the effects on your economy if there is no conservation area here?

a. Positive effect, how? b. Negative effect, how? c. Neutral effect

52. Do you think that livestock and wildlife can live together? Yes/No, if yes, how?

53. Do you think the presence of people and livestock nearby the Park affect the National Park? Yes/No, if yes, in what way?

54. Do you know mammals that occur in the Park? Yes/No, if yes, are they hunted by local people?

55. If yes, to what extent? a. Very high b. High c. Very low

56. What do you view about problems of wildlife in the future?

a. Increasing b. Decreasing c. The same e. Unknown

**Appendix II**. Line transect data sheet of plains zebra population census

Name of the data Collector ----------Survey site ----------Date,----------

Line transect direction------- Line transect no.---------- Line transect length (km),

Altitude---------- Temperature---------- Season---------- Weather condition ___ _

Start time---------- End time---------- Location----------

| No. of observ | Sight distance adjacent to line transect (M) | Sex and age categories | | | | Total | Habitat type | Other mammals species observed | Remark |
|---|---|---|---|---|---|---|---|---|---|
| | | AM | AF | SA | Juv/Fo | | | | |
| | | | | | | | | | |
| Total | | | | | | | | | |

AM: Adult male, AF: Adult female, SA: Sub adult Jo/Fo: juvenile/Foal, M=meter

**Appendix III**. Sex characteristics and age estimate used for field identification.

| Categories | Sex and age characteristics |
|---|---|
| Adult males | Full-grown animals. Estimated age was more than 30 months. Interfemoral's hairless, stripe narrow and black. Testes are often visible. Abdominal curvature is less pronounced than in females. Circumference of nose is greater than in females. |
| Adult females | Full- grown animals. Their age was estimated more than 30 months. Interfemoral's hairless, stripe black and broad. Abdominal curvature is more convex than in males'; circumference of nose is smaller than in males. |
| Sub-Adults | Animals not full have grown, but larger than juveniles. Sexually immature. Fuzzy brown "foal hair" is absent. Their age was estimated from 18-30 months. |
| Juveniles/Foals | -A weaned young mammal that still associated with its mother, may nurse infrequently. They are usually smaller than a subadult and larger than foals. Less conspicuous fuzzy brown "foal hair". Their age was estimated from 1-18 months. -A newborn offspring. Fuzzy "brown hair" more conspicuous. Frequently nursing and associated with its mother. Their age was estimated as less than one month. |

**Appendix IV**. Daily activity pattern recording sheet of plains zebra

Name of the data Collector ---------- Date ----------

Survey site---------- Season---------- Altitude----------

Temperature----------

Weather condition---------- Habitat type---------- Vegetation type ----------

| Time | No. observation | Main activities | | | | | |
|---|---|---|---|---|---|---|---|
| | | Grazing | Moving | Resting | Grooming | Others | remarks |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

- Grazing: browsing
- Moving: running/walking
- Resting: standing/sleeping
- Grooming
- Others : fighting, mating, sniffing etc

**Appendix V**. Commonly sighted plant species taken, frequency and season.

| Sr. No | Commonly sighted plant species taken | Plant parts | Sighting frequency | Seasons | Habitat type | Remarks |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
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**Appendix VI**. Some plates taken during data collection period

Plate 1. Some topographic and habitats features of NNP (Addishiwot Fekadu, 2017**)**

Plate 2. Zebra in Nechiar plains (Photo: Demeke Datiko, 2017)

Plate 3. Some of focus group discussion with local people in different villages (Photo: Addishiwot Fekadu, 2018)

Plate 4. Illegal grass cutting and fire wood collection from the Park (Photo: Addishiwot Fekadu, 2018)

Plate 5. Livestock grazing in the NNP (Photo: Addishiwot Fekadu, 2018).

Plate 6. Settlement expansion in the Park by Guji Ethnic groups (Photo: Addishiwot Fekadu, 2019).

Plate 7. Fire in the Park (fresh grass) (Photo: Addishiwot Fekadu, 2019).

Plate 8. Death of zebras due to drought in 2017 (Photo: Addishiwot Fekadu, 2017).

Plate 9. Overgrazed Nechisar plains during dry season in NNP (Photo: Addishiwot Fekadu, 2017).

Plate 10. Death of young/foal due to unknown reasons (Photo: Addishiwot Fekadu, 2017)

Plate 11. High number of young individuals during late dry season (Photo: Addishiwot Fekadu, 2018).

Plate 12. Ticks on the grass (problem to Zebra, young) (Photo: Addishiwot Fekadu,2018).

Plate 13. Invasive bush and weed encroachment in Nehisar open grassland plains (Photo: Demeke Datiko, 2017).

**Appendix VII**. List of medium and large sized mammals observed during the study period.

| Common name | Scientific name |
|---|---|
| Aardvark | *Orycteropus afer* |
| Plains zbra | *Equus Burchelli* |
| Grants Gazelle | *Gazella granti* |
| African civet | *Civettictis civetta* |
| Colobus monkey/guereza | *Colobus gureza* |
| Vervet monkey | *Cercopithecus aethiops* |
| Common bushbuck | *Tragelaphus scriptus* |
| Caracal | *Felis caracal* |
| Common duiker | *Sylvicapra oreotragus* |
| Common warthog | *Phacochoerus africanus* |
| Greater kudu | *Tragelaphus strepsiceros* |
| Lesser kudu | *Tragelaphus imberbis* |
| Golden jackal | *Canis aureus* |
| Duiker | *Sylvicapra grimmia* |
| Ground squirrel | *Xerus rufilus* |
| Nile crocodile | *Crocodilus niloticas* |
| Hippopotamus | *Hippopotamus amphibius* |

| | |
|---|---|
| Honey badger | *Mellovora capensis* |
| Leopard | *Panthera pardus* |
| Lion | *Panthera leo* |
| Porcupine | *Hystrix cristata* |
| Anubis baboon | *Papio anubis* |
| Serval | *Felis serval* |
| Spotted hyaena | *Crocuta crocuta* |
| Waterbuck | *Kobus ellipsipprymus* |
| Wild dog | *Lycaon pictus* |
| Bushpig | *Potamocherus larvatus* |