

1 INTRODUCTION

1.1 Background

The Tiger is one of masterpieces of nature and belongs to genus *Panthera*, order carnivore and family felidae defined by their ability to roar, which other member of felidae cannot do (McDougal 1977). The Tiger is the largest predator in Asia (Weber and Rabinowitz 1996) and are considered as top carnivore of forest and grassland ecosystem (Grey 2009). Tigers are terrestrial and occupy relatively larger habitats, the size of which usually depends on the density of their prey species (Bhattarai 2009). Since the early 1970s Tigers have been used as an umbrella species for wild life conservation in South Asia and it is widely considered to be one of the most charismatic species on earth (Grey 2009). As a result, thousands square kilometer of natural habitat has been proclaimed as protected areas for Tiger conservation (Karanth 2003).

The Tiger is considered as a cultural icon over much of its range and yet, fragmentation of population and most importantly, the depletion of its prey base (Bagchi et al. 2003). There were eight sub-species of the Tiger, Bengal Tiger (*P.tigris tigris*), Caspin Tiger (*P.tigris virgata*), Amur Tiger (*P.tigris altica*), Javan Tiger (*P.tigris sondica*), South China Tiger (*P.tigris amoyensis*), Bali Tiger (*P.tigris balica*), Sumatran Tiger (*P.tigris sumatre*) and Indo- Chinese (*P.tigris corbetti*) (Khan 2004). Among known eight species of Tiger three species, Bali Tiger Javan Tiger and Caspian Tiger have become extinct since 1950s (KMTNC 1998, Khan 2004). Of the total five surviving Tiger species, the Bengal Tiger (*P. tigris tigris*) is found in Asian countries (Thanet 2010). The habitats of Tigers are tropical dry forests and mangroves, tropical moist evergreen forests, sub-tropical and temperate upland forest, Subtropical moist deciduous forest, Alluvial Grassland, temperate broadleaf mixed Conifer forest and Boreal Taiga (WWF 1998). In Nepal, Tigers inhabit dense mixed forest, riverine sal dominated forest, grassland and Savannas of Tarai forest (Bogati 2001).

Information on the status of Tiger and its distribution is integral to developing conservation strategies and programs to safeguard Tiger populations in the landscape level of Nepal. Although we lack baselines to adequately assess Tiger's role in structuring the communities in which they occur (Seidensticker and McDougal 1993), it is widely accepted that these

predators play a relatively major role in shaping prey communities in the stable environment of tropical forests (Karantha and Sunquist 1995). The search for food occupies a large part of the private life of the Tiger (Shrestha 1997). The Tiger becomes a man eater only after they are wounded by hunters or disabled by age or some other natural causes (Chalise 2008).

1.2 Morphology

The Tiger has dark reddish-ochre to pale yellow body colour with vertically-arranged black stripes, more pronounced towards the rump and thighs; under parts whitish and Head-body length 140-280 cm and the tail length 60-110 cm; height at the shoulder 95-110 cm. Male weighs 180-280 kg and female 115-185 kg (Khan 2004). The background colour of the Tiger's pelage varies from a dark reddish-ochre to a pale yellow and the stripe patterns differ between individual Tigers and from one side of the body to the other in the same individual (Chalise 2008).

1.3 Biology

Tigers normally mate year-round, but most frequently from the end of November to early April and the oestrous cycle is 15-61 days and duration is 5 -7 days (Sunquist and Sunquist 2002). The male becomes sexually matured at 3-4 years, whereas the female becomes sexually matured at about 3 years. The female to male ratio of adult Tigers may be as much as 2:1 to 4:1 depending upon habitat and food situation and tigresses have a high reproductive potential, and normally give birth to a new litter every two years (Smith and McDougal 1991, Khan 2004).

1.4 Origin

The origin of Tiger is a subject of much controversy. Many scientists have given different arguments for origin and evolution of Tiger. Huxley (1960); cited in Kotpal 1998, statements based on the occipital condyles in the skull of both Amphibian and Mammalian species. Huxley's theory was not acceptable a long time because condyles are derived from exoccipitals in amphibians and basioccipital in mammals. The Synapsida acquired several mammalian characteristics. They lived throughout the Permian and Triassic periods, dating back 280 million years or more (Kotpal 1998). Around the 60 – 65 million years ago,

Shrew like early mammals was evolved. Khan (2004) stated that the early carnivores, known as miacids, lived at the time between 60 and 55 million years ago. All modern members of the Order Carnivora (about 236 species) are the descendants of the miacids. About 55 million years ago these early arboreal carnivores splitted into two branches the cats (Feloidea) and the dogs (Canoidea). The cat-branch dominated in the Old World and the dog-branch in the New World. The first true cat was *Pseudaelurus*, which evolved by 20 million years ago. They were medium-sized ambushers of small vertebrates. Among all the families of the carnivores only the members of the family Felidae (i.e. true cats) are specialized hunters and they are purely carnivorous. They are characterized by having high-domed skulls and short snouts, which provide anchorage for muscles that power a lethal bite.

Hemmer (1976) mentioned that the genus *Panthera* was generally evolved within the last five million years or so. The oldest known fossil remains of the Tiger were discovered in the New Siberian Islands and the exact place of its origin is still shrouded in mystery (Shrestha 2004). Shrestha (2004) stated that the Tigers appear to have entered in Nepal and India from the hill range of Assam. He further speculated that the absence of Tiger from Ceylon suggested the important fact that the south ward migration of the Tiger was very late, probably after the separation of Ceylon from India.

1.5 Nomenclature

Linnaeus (1758) gave the classification of felid and coined the generic name of Felis. The family name Felidae was put by Fisher in 1817. Later on, Jardine (1834) made a significant contribution to the taxonomic relationships between the species in the family Felidae. The classification of the family Felidae, as well as the genus *Panthera*, by Wozencraft (1993) is the most recent evaluation, which has been adopted by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the World Conservation Monitoring Centre (WCMC), and the IUCN/SSC Cat Specialist Group. Wozencraft (1993) kept four species under the genus *Panthera*. These are *P. tigris* (Tiger), *P. leo* (lion), *P. pardus* (leopard) and *P. onca* (jaguar). The species *Panthera tigris* has again been divided into eight distinctive sub-species, which apparently vary in body size, characteristics of the skull, and colour and markings of the pelage (Nowell and Jackson 1996).

1.6 Systematic Position

Kingdom: Animalia

Phylum: Chordata

Class: Mammalia

Order: Carnivora

Family: Felidae

Sub family: Pantherinae

Genus: *Panthera*

Species: *tigris*

Subspecies: *tigris*

(Sources: www.iucnredlist.org)

1.7 Distribution of Tiger

In the past, Tigers were found throughout Asia, from the Caucasus Mountain and the Caspian Sea to Siberia and the Indonesian islands of Java, Bali and Sumatra. Fossil remains indicate Tigers were also present in Borneo and Palawan in the Philippines during the late Pleistocene and Holocene (Piper and Rabett 2007, Piper et al. 2008).

During the 20th century, Tigers became extinct in western Asia and were restricted to isolated pockets in the remaining parts of their range. They were extirpated on the island of Bali in the 1940s, around the Caspian Sea in the 1970s, and on Java in the 1980s. This was the result of habitat loss and the ongoing killing of Tigers and declining of Tiger prey. Today, their fragmentation and partly degraded ranges extend from India in the west to China and Southeast Asia. The northern limit of their range is close to the Amur River in Southeastern Siberia and the only large island they still inhabit is Sumatra. Since the beginning of the 20th century, Tiger's historical range has shrunk by 93%. In the decade from 1997 to 2007, the estimated area known to be occupied by Tigers has declined by 41% (Dinerstein et al. 2007).

The Bengal Tiger is found primarily in India (Table 1) with smaller populations in Bangladesh, Nepal, Bhutan, China and Myanmar. It is the most numerous of all Tiger subspecies with fewer than 2,500 left in the wild.

Table 1: Bengal Tiger estimated population in the world

S.N	Country	Estimated Population		
		1999	2004/5	2013
1	India	2500		1706
2	Bangladesh	362		440
3	Myanmar	124		00
4	Nepal	93	123	198
5	Bhutan	67		67
6	China	30		

Sources: Khan 2004; Dhakal et al. 2014

Bengal Tiger, once common throughout the Central and Northern part of the Indian – subcontinent and is currently isolated in a few pockets (Shrestha 2004). The geographical distribution of the Tiger once spanned Asia, from eastern Turkey to the sea of Okhotsk, USSR and over the last 50 years, its range has been greatly reduced, but Tigers are still found in a broad variety of forest types (Sunquist et al. 1985).

Present and past distribution of Tiger shows great plasticity according to various environmental conditions. Within the Indian subcontinent they inhabit tropical dry and moist deciduous forests, evergreen and mangrove forests, Tarai grasslands and mixed conifer-broadleaf forests in the Himalayan foothills and were reported 1000 meter above from the sea level (Majupuria and Majupuria 2006). The main habitat requirements appear to be some form of negative cover, a water supply, and sufficient prey.

The Tiger land of Chitwan National Park and other parts of lowland Nepal are admirably suited for supporting Tiger population due to cover of Sal (*Shorea robusta*) forest, grassland and adequate water regime maintained by rivers and abroad spectrum of herbivore populations (Shrestha 2004).

1.8 Tiger population and distribution in Nepal

Tiger called Bagh in Nepali (Majupuriya and Majupuriya 2006) have been conserved in many protected areas of lowland Nepal named as Parsa Wildlife Reserve (PWR), Chitwan

National Park (CNP), Banke National Park (BANP), Bardia National Park (BNP) and Shuklaphanta Wildlife Reserve (SWR) (Figure 1) and some districts such as Kailali and Bara of Nepal (Shrestha 1997, Dhakal et al. 2014)

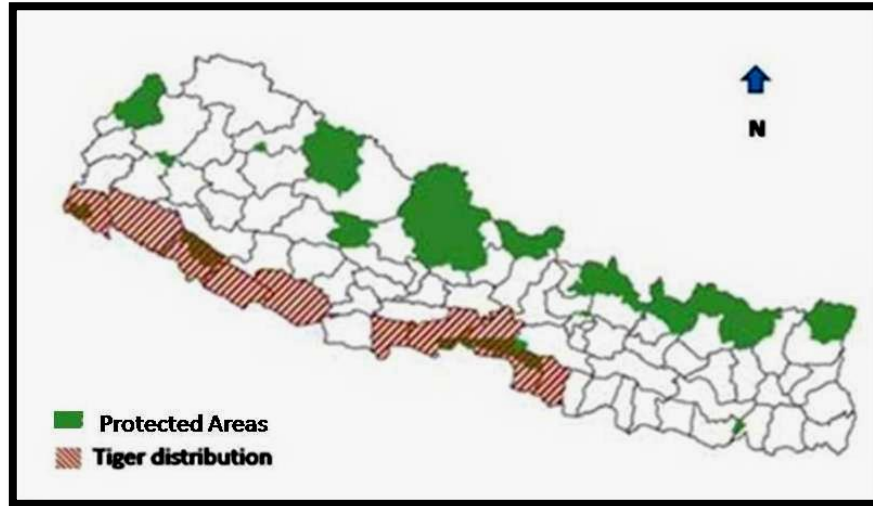


Figure 1: Tiger distribution site in Nepal (Source: IUCN 2014)

The Bengal Tiger population is increasing in Nepal since 1995/96. In around 1995, the estimated population of Bengal Tiger was around 100; among them the Chitwan National Park was holding around 49 individual adult Tigers (Table 2).

The reason for increasing of Tiger population in Nepal is due to conservation efforts initiated by many researchers, started NGOs, INGOs (WWF, IUCN etc) and Government of Nepal that have been planning as different activities such as Tiger Monitoring, Tiger conservation Action Plan, Tiger Project etc. Tarai Arc Landscape Program and establishment of National Parks and Wildlife Reserve were the conservation work for wildlife conservation in Nepal (Karki et al. 2011). Currently, this big cat population estimation seems to be at expected level. It is distributed along Churiya range especially southern plain area of Tarai region in Nepal. Along the Tarai plain there are some subtropical protected areas and Tigers are concentrated in those areas where dense forests and prey species are abundant (Chalise 2008). Due to long-term conservation efforts of government the population of Tigers seems increasing and it seems to adhere international interest of doubling its number in near future (Table 2).

Table 2: Bengal Tiger population in protected areas of Nepal

Protected Area	1995/96	2005	2008/9	2013
Chitwan National Park	48-49	50-60	91	120
Banke National Park				4
Bardia National Park	30-32	32-40	18	50
Parsa Wildlife Reserve			4	7
Shukla Wildlife Reserve	15-16	16-23	8	17
Total estimation population	93-97	98-123	121 (100-194)	198

(Source: DNPWC 2007; Karki 2011; Dhakal et al. 2014)

1.9 History of Tiger Conservation in Nepal

The history of Tiger conservation in Nepal dates back to as early as the 1930s when the forests in the lowland of Nepal were continuous from east to west with the Sal (*Shorea robusta*) species. The Tarai (lowland) forests were famous as hunting grounds of the ruling class and visiting dignitaries; several anecdotal records describe large – scale hunting expeditions in Nepal (Smythies 1942). In the 1950s, the government of Nepal undertook Malaria eradicating program and initiated a massive resettlement program in lowland Nepal, as a result much part of forests and wildlife habitats degraded. In 1973 the government of Nepal established protected area as a first national park in Nepal named Chitwan National Park and was initiated the Tiger ecology project (Dhakal et al. 2014).

In 1998, Bardia National Park was established as a prime habitat for Tiger conservation. It was realized that conserving Tigers within protected areas only was not adequate strategy; therefore landscape level conservation considered as a result, Tarai Arc Landscape Program was initiated in 2001 in Tarai Nepal. By the end of 2011, one National Park named as Banke National Park was added in Tarai lowland of Nepal for conservation of Tiger as well as other wild resources (Karki et al. 2011).

The Government of Nepal prepared and implemented the Tarai Arc Landscape Strategic Plan (2004 -2014) and the Tiger Conservation Action Plan for Nepal (2008-2012) which

have significantly contributed to the conservation of Tigers, co-predators, prey and in their natural habitats of Nepal (Dhakal et al. 2014).

1.10 Tiger's feeding ecology

Much of Tiger's daily activity cycle revolves around its food supply (Karanth 2003). The Tiger is relatively inactive during the day light, usually resting on its side, belly or back in a shady haunt or even partially submerged in a pool when it is hot. A Tiger feeds steadily for more than one hour and the longest feeding period recording is 145 minutes (Shrestha 2004). The Tiger eat its prey so completely that nothing remains for the scavengers. It is reported that intestine are generally left uneaten. It is peculiar to note that the Tiger returns to the same kill daily and does not mind the purified condition (Khan 2004).

Distribution of Tiger seems to be determined primarily by availability of large ungulates which Tigers preferentially select in all of the ecosystems across its predator's range (Biswas and Sankar 2002, Karanth 2003). Prey selectivity can be defined as the killing of prey types in frequencies that are different from those expected, based on their availability in the environment (Grey 2009). Prey choice by large felids, which ultimately determines the food habits of these predators, plays a key part in determining their life history strategies, including movement, habitat selection, social structure, geographical distribution and reproductive success (Sunquist and Sunquist 1989). Although Tigers kill prey ranging in size from amphibians to 1000 kg Gaur (*Bos gaurus*), the bulk of their diet is obtained predominantly from deer species (Grey 2009), which contribute up to 75% of the prey biomass requirement of the Tiger in most parts of its range (Sunquist 1981, Sunquist et al. 1999, Stoen and Wegge 1996, Biswas and Sankar 2002, Grey 2009).

Apart from livestock, the principal wild prey of Tigers in India and Nepal includes: Chital (*Axis axis*), Hog deer (*Axis porcinus*), Barasingha (*Cervus duvauceli*), Sambar (*Cervus unicolor*), Blue bull (*Bosephalus tragocamelus*), Muntjac (*Munticus muntjac*) and Wild boar (*Sus scrofa*) (Schaller, 1967). In addition, Tigers take Indian Porcupine (*Hystrix indica*), Langur (*Presbytis entellus*) and Rhesus Monkey (*Macaca mulatta*) (Schaller 1967, Sunquist 1981). Khan (2004) reported that the birds such as Lesser Adjutants are also common prey species for Tiger's diet in Sundarbans forest, Bangladesh.

The conclusion about the mean weight of larger species hunted by Tigers ranges between 82 kg and 114 kg (Sunquist 1981, Karanth and Sunquist 1995, Bagchi et al. 2003) which was studied in different potential sites of Tigers. Tigers also take larger prey such as Sambar (*Cervus unicolor*) 212 kg and domestic Buffalo (*Bubalis bubalis*) 400 kg, clearly displaying a preference for large prey when they are available (Biswas & Sankar, 2002). It has been estimated that a Tiger can eat 18 kg of meat in one meal and 112.5 kg in three nights. A Tiger drinks in a crouching position for about 15 to 30 minutes (Shrestha 2004). To be more economical, however, it normally preys upon large ungulates, weighing on average between 50 -100 kg (McDougal and Tshering 1998, WWF 1999).

Tigers tend to be active at the same time of the day when their preys are also active (Karanth 2003). Depending on the prey size and the number of Tigers feeding upon it, they stay with the prey for 1-7 days eating two thirds of it, including some fairly putrid meat and the remaining one third comprising of larger bones, rumen contents and intestine is normally discarded (Karanth 2003). Karanth and Sunquist (1995) suggest that the preference of gaur for open clearing in the forest, their crepuscularity (active before sunrise) and relatively poor eyesight make the species easier prey to locate and stalk. This would seem to suggest that anti-predator behaviour, rather than size, may be more effective defense against ambush predators (Karanth and Sunquist 1995). The under representation of chital and muntjac in the diet was thought to reflect avoidance of smaller prey or be the result of the diurnal activity patterns of these two species (Karanth and Sunquist 1995).

Similarly, Tigers in CNP were object to select for sambar, illustrating that when present, large prey will be selected for by these predators (Sunquist 1981). Stoen and Wegge (1996) found that other medium-sized prey species such as chital was killed in accordance to their proportion in the study area. The difference in the selection among medium-sized prey was thought to be the result of differences in their vulnerability. In the dry season, during which the study of Stoen and Wegge (1996) was undertaken, wild boar are mostly solitary or live in small groups, whereas chital live in relatively large groups and gather together on cut and burned areas. Biswas and Sankar (2002), on the other hand, it was found that Tigers in Pench National Park (PNP), India, selected for medium-size prey regardless an ample supply of large prey in the area.

In fact, selective predation by Tigers in PNP, an area with a large range in size of prey, was directed towards prey species with both medium and large body mass. PNP Tigers killed Sambar and wild boar more than their availability, with chital taken in proportion to their availability. Biswas and Sankar (2002) found that the predation rate on sambar in PNP was relatively lower when compared to studies undertaken in Bandipur Tiger Reserve (BTR), India, in 1983, CNP in 1977 and 1981 and in BNP in 1996.

In Nepal, specifically, the Tiger preys upon a wide variety of prey species, including sambar (*Cervus unicolor*), Chital (*Axis axis*), Hog deer (*Axis porcinus*), Barking deer (*Muntiacus muntjak*), Wild pig (*Sus scrofa*) etc. According to Seidensticker and McDougal (1993) sambar is the most preferred species for Tiger. Many researchers such as Grey (2009) and Thapa (2011, 2013), Chapagain (2013) concluded that Chital were major prey species for Tiger in Nepal. The role of dispersal in structuring in Chitwan Tiger population was studied in Royal Chitwan National Park, Nepal and there were thirty six adult and young Tiger studied to monitor movements and social interactions relative to dispersal (Smith 1993).

1.11 Human-Tiger Interaction

There has always been plenty of conflict between the Tiger and humans and are long age problems in this world including Nepal since many years. Due to their limited food resources and habitat shrinking on this earth, many Tigers are preying to domestic livestock and some time become victims in Nepal. In the history of Chitwan National Park, man eater Tigers are mostly transferred into captivity (Central Zoo) or killed by concern authority. Human-Tiger conflicts are common phenomena from the past and have become significant problems throughout periphery of protected areas system (Gurung et al. 2008).

Big cats, which play a vital role in maintaining the balanced ecosystem through prey-predator interaction, are now on the verge of extinction since their required large habitats, having been fragmented and degraded.

The high rate of human population growths and the successfully restored habitat in the community forests of Nepal have accelerated the conflicts due to the dispersal of Tigers into these forests where they share these resources (Bhattarai 2009). Shrestha (2004) mentioned that the major threats to the survival to this species include high degree of habitat

fragmentation, loss of quality habitat and prey species depletion, poaching for its body parts and retaliatory actions of victims. The combinations of these factors have led this species to the verge of extinction.

1.12 Objectives

The overall objective of this study was to find out the baseline information on prey selection by Tiger in Madi, Barandabhar and Kasara site of Chitwan National Park, Nepal.

The specific objectives were as follows:

- To describe the contribution of domestic animals to the diet of Bengal Tiger and
- To examine the diet composition of Bengal Tiger

1.13 Statement of the problem

Mostly domestic animals are easiest prey by Tiger predation, in and around the Chitwan National Park but researcher have not carried out any research on the contribution of domestic animal to the diet of Bengal Tiger. Therefore, this research was totally concentrated to find out the prey selectivity of Bengal Tiger in the study area. Many studies on Tigers by researchers have been conducted in different lowland protected areas of Nepal, but there are very few studies on the topics of prey selection by Tigers. Researches on feeding ecology or prey selection by Tigers have been less explored in Nepal compared to the other countries. The government of Nepal has set an aim to double the Tiger population by 2022 but has not provided enough thoughts on enlarged Tiger habitat (except, declaration of Banke National Park) due to growing human population and urbanization.

Several studies have been conducted on, human–Tiger conflict, hunting, loss of prey species and poaching, human disturbance and habitat degradation are the main causes of declination of Tiger. This study is concerned with the diet analysis of Tiger. For long term Tiger conservation, diet analysis of Tiger is a principal factor. Therefore, this has been initiated to contribute for long term conservation and management of Bengal Tiger in this region.

2 LITERATURE RIVIEW

2.1 Tiger's prey

Schaller (1967), Sunquist (1981) and Johansingh (1983) stated that Indian subcontinent represents Chital and Sambar are the major prey species for Bengal Tiger. Different factors like abundance of the prey species, temporal and spatial distribution, size, defenses, and anti-predator tactics determine the predator choice (Ackerman et al 1983, Sunquist and Sunquist 1989). Seidensticker and McDougal (1993) studied on Tiger's predatory behavior ecology and concluded Sambar is the most preferred species. The role of dispersal in structuring in Chitwan Tiger population and estimate prey was studied in Royal Chitwan National Park, Nepal and there were thirty six adult and young Tiger studied to monitor movements and social interactions relative to dispersal (Smith 1993).

The main weight - range of prey species hunted by Tigers between 82 – 114 kg, Chital and Sambars are the best weight category (Karanth and Sunquist 1995). Karanth and Sunquist (1995) suggest that the preference of gaur for open clearing in the forest, their crepuscularity (active before sunrise) and relatively poor eyesight make the species easier prey to locate and stalk. This would seem to suggest that anti-predator behaviour, rather than size, may be more effective defense against ambush predators (Karanth and Sunquist 1995). The underrepresentation of Chital and Muntjac in the diet was thought to reflect avoidance of smaller prey or be the result of the diurnal activity patterns of these two species (Karanth and Sunquist 1995).

Stoen and Wegge (1996) studied in lowland Nepal, and concluded that among the other medium - sized prey species chital was killed in accordance to their proportion in the study area. The difference in the selection among medium - sized prey species was thought to be the result of differences in their vulnerability. Stoen and Wegge (1996) stated on general behavior of some wild animals and found the wild pig are mostly solitary and live in small group where Chital live in a large group while he studied in dry season in lowland Nepal. However, Chital, Sambar, Barking Deer and Wild Pigs are more abundant in a prey composition of Tiger (Biswas and Sanker 2002). Biswas and Sanker (2002) concluded the

predation rate on prey species sometimes irregular such as Samber was found lower in PNP compared to CNP and BNP.

Diet of adult Tiger depends upon the habitat and their prey base, many study on feeding ecology of Tiger suggested that the Tiger's diet was found different in a different habitat. Many authors did researches on prey animals of all sizes, ranging from the adult bison (*Bos gaurus*), to the common langur (*Presbytis entellus*), to birds (Khan 2004). The Tiger is a territorial animal, which occupies a relatively large habitat and depending on the availability of the prey species. It's ideal habitat includes forests, with tall alluvial grasslands that have water. Prime habitat provides sufficient cover for concealment, for stalking its prey, and for hiding its kills (Bhattarai 2009).

2.2 Scat Analysis

Estimating on how many prey items of a particular species are represented by a collection of scat of predator is difficult to know (Putman 1984). Selective consumption of prey parts (e.g., hair and skeleton) and differential digestion of these components may induce errors in the estimation of prey consumed. Several workers have attempted to account for these sources of errors by developing correction factors relating fecal composition to prey consumed for specific predators and prey items (Gamber and Atkinson 1988). Gamber and Atkinson (1988) used scat analysis technique to determine the diet of carnivores, rely on identifying and quantifying undigested components of prey appearing in feces.

Feeding ecology of Tiger can be studied by scat analysis and there are a several methods (Reynolds and Aebischer 1991, Mukherjee et al. 1994 a,b). Mukherjee et al. (1994 a) used to technique for analysis of Asiatic lion. It was used to estimate the proportion of different prey species consumed by Tigers, and by using this method it was cost and time effective and many researchers such as Karanth and Sunquist 1995, Reza et al. 2001, Biswas and Sankar, 2002. Bagchi et al. (2003) used this method to know the prey abundance and prey selection by Tigers (*Panthera tigris*) in a semi-arid, dry deciduous forest in western India and found the high percent of domestic livestock to the Tiger's diet. Reddy et al. 2004, Khan 2004 and Andheria, 2006 also used this method to know Tiger's food habit.

Bonnin (2008) worked in the Karnali Floodplain of Bardia National Park, Nepal to know the prey selection by Tigers and prepared the reference hair library table for Tigers, their main prey and domestic livestock in BNP. Grey (2009), Ramesh (2010), Chapagain (2013), Thapa (2013), etc had followed scat analysis to know predatory behavior of Tiger.

3 MATERIALS AND METHODS

3.1 Study area

3.1.1 Location

The Chitwan National Park lies in center part of the Tarai (lowland) region and the park covers an area of 932 sq km between 27°16'56" to 27°42'14" N and 83°50'23" to 84°46'25" E (Thapa 2011). It is lies about 145 kilometers south from capital (Kathmandu) and sphere four districts such as Chitwan, Nawalparasi, Barha and Makawanpur of Nepal. The study area situated in a river valley basis or dun along the flood plains of Rapti, Reu and Narayani Rivers. The park also consists of many lakes such as Ox -bow lake, Bis Hajari Tal, etc. (Majupuriya and Majupuriya 2006). There were selected three location site such as Madi, Barandabhar and Kasara which was totally adjoining site with the National park (Figure 2).

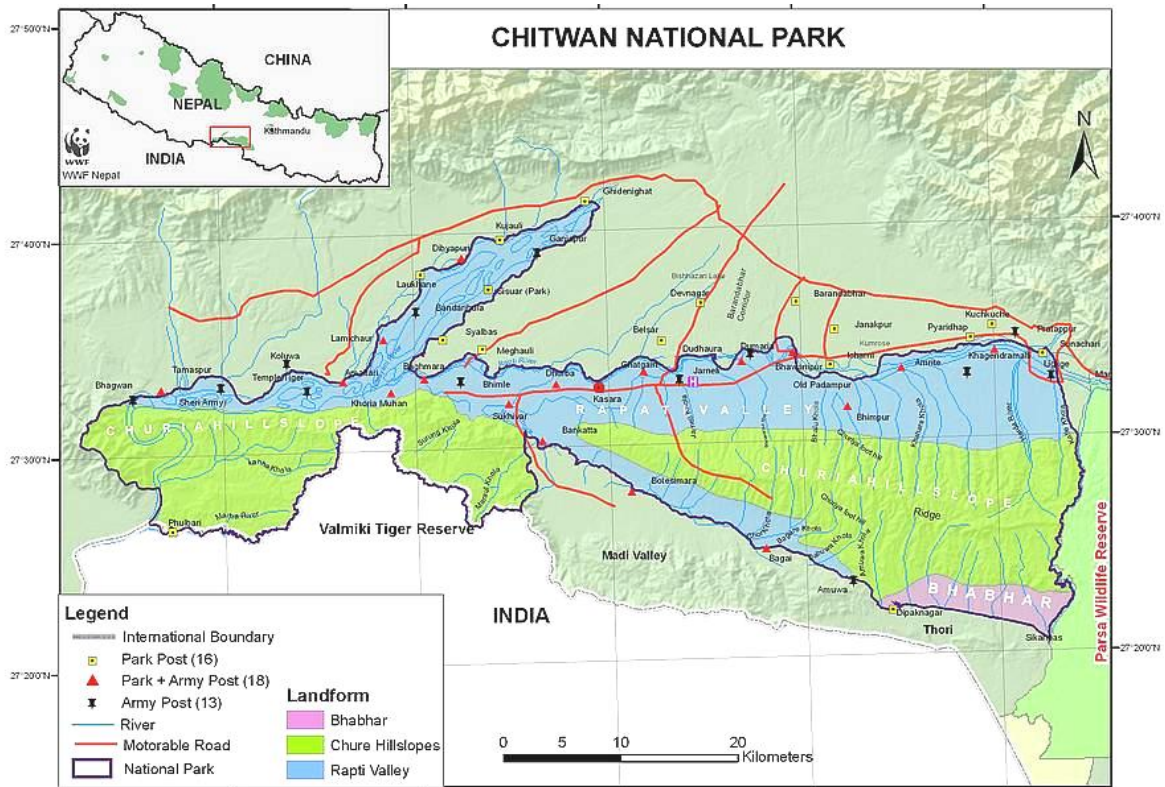


Figure 2: Location of study site in CNP, Nepal.

Kasara Site: Kasara is a Headquarter of the National Park and lies in northern part of CNP. The Rapti River and Tamor Tal is the main water sources for wild animal. **Barandabhar Site:** This is the main corridor site of the National Park. This site joins to the CNP with the Tikauli forest of Northern Chitwan. It helps to wild animal for immigration and emigration. **Madi Site:** Madi site lies in the southern part of National Park. Reu is the main river for water resources. Besides Reu River, Gaida Ghol, Bul Bule Tal and other small water resources were there.

3.1.2 Physical feature

The park that includes in its area a part of the Shivalik Hills and rises from about 113 m to over 789 m (Thanet 2010). It is covered with deciduous forests overlooking the flood plains of Narayani, Rapti and Reu rivers and has two hill ranges, namely Someshwor and the Churiya. (NTB 2010, Thapa 2011).

The Someshwor range in the southwest of the park is an extremely broken mountain mass, complex of deep ravines and steep eroded slopes (Thapa 2011). The Churia again extends westwards and reaches over 750 m in the Daunne hills on the western boundary of the park. Geo-morphologically the area can be divided into Siwalik Hills (Churiya range), valley, alluvial fans, river terraces and floodplains (Thanet 2010).

After Narayani River, the Rapti River is a major river system for Chitwan National park, the floodplain of the Rapti River extends from the eastern park border that varies from 1.5 to 5 km in width inside the park with similar width in the buffer zone. The Rew River is a third River system in CNP and following the south parts of the National Park. The floodplain of Reu River is containing grassland habitat. Between the two rivers the western end of the Churia range extends westwards as a forested ridge which gradually loses height from about 750 m on the eastern boundary to its western extremity near Sukhibhar where it falls to the combined floodplains of the Rapti and Reu River (Thanet 2010). Both northern and southern lower slopes of the Churia are gentle but steeply dissected by streams that drain between long finger-like spurs.

3.1.3 Biodiversity

Owing to its rich adornment of nature, Chitwan National Park was declared UNESCO Natural Heritage site in 1984 (NTB 2010). There are around 600 plants species, 68 species of mammals, 539 birds and 58 species of herpetofauna and 26 species of fish found in the park (Shrestha 2004, Majupuria and Majupuria 2006, NTB 2010). Among them 7 mammalian fauna (Tiger, Elephant, Fishing Cat, Dhole, Hispid Hare, Dolphin and Chinese Pangolin) has been listed as Endangered of IUCN Red list (www.iucnredlist.org).

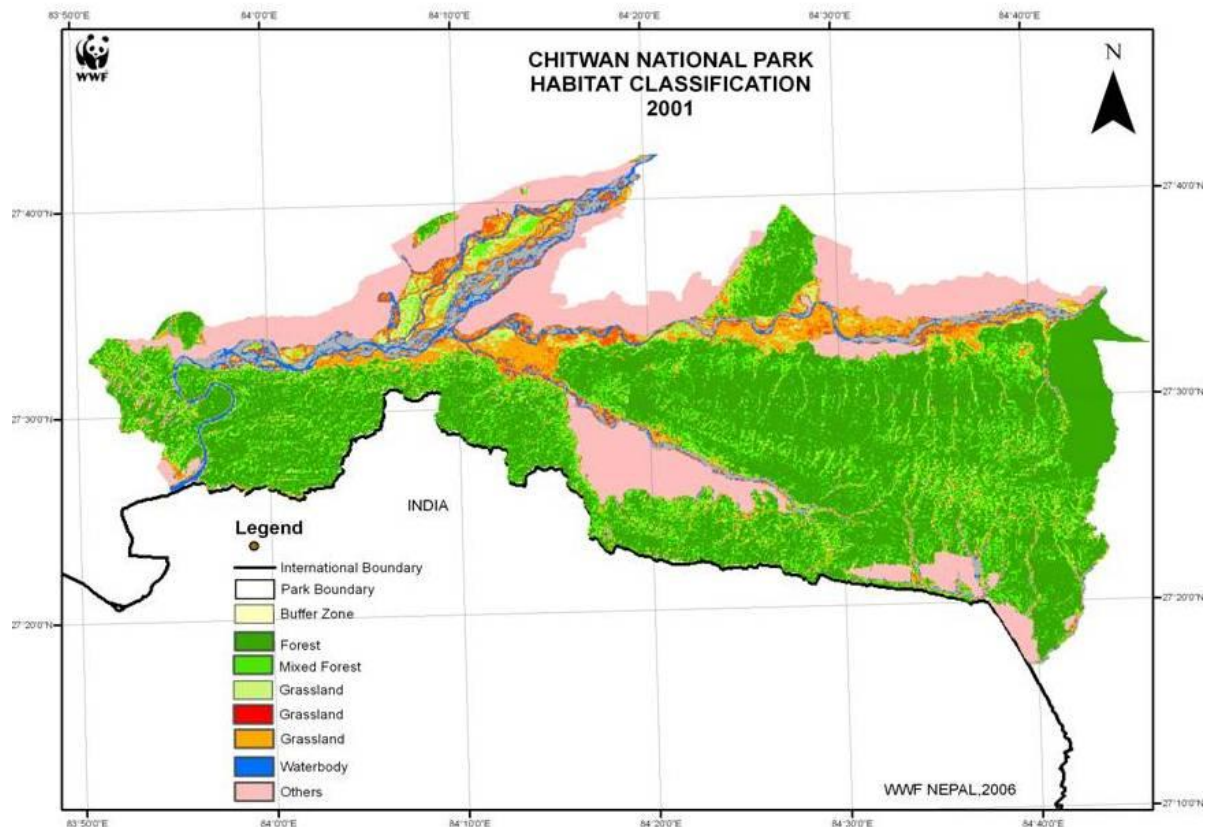


Figure 3: Habitat classification of Chitwan National Park

Many protected birds and herpetofauna are existing in the park including Bengal Florican (*Houbaropsis bengalensis*), White stork (*Ciconia ciconia*), and Giantt hornbill (*Buceros bicornis*), King cobra, Crocodiles and some species of frogs are being conserving by National Park. Many invertebrates and flora (Sal tree *Shorea rubusta*, Khayar tree *Accacia catechu*, Cotton tree *Bombax cibia*, Sissoo *Dalbergia sisoo*, etc) are containing in Chitwan National park (NTB 2010, DNPWC 2014).The grassland areas (Figure 3) are mainly located in the floodplains of rivers with over 50 different types of grass including elephant grass

(*Saccharum* spp.) which is good habitat for Tiger and critically endangered bird named as Bengal florican.

The highlights of CNP wildlife are the 503 Asian one horned rhinoceros and 120 Bengal Tigers that live in the dense forests of the park. Some other important animals are wild elephant (*Elephas maximus*, Linnaeus 1758), Leopard (*Panthera pardus*), Sloth bear (*Ursus ursinus*), Gaur (*Bos gaurus* Smith 1827), Blue bull (*Boselaphus tragocamelus*), Wild dog (*Cuon alpinus*, Hodgson 1833), Sambar (*Cervus unicolor*, Cuvier 1833), Chital (*Axis axis*, Erxleben, 1777), Barking deer (*Muntiacus muntjak*, Zimmerman 1780), Rhesus Monkey (*Macaca mulatta*, Hodgson, 1841), Langur (*Semnopethicus entellus*, Pocock, 1928), Jungle Cat (*Felis chaus*, Hodgson 1836), and Palm Civet (*Paradoxurus hermaphrodites*, Hodgson 1836), etc (Shrestha 2004).

3.2 Research materials

Zip locked plastic bags and gloves; GPS; Binocular; Camera; Topographic map; Measuring tape; Paper; pencil; books; microscope; chemicals (diethyl ether, ethyl alcohol, acetone), slides, nail paints, etc.

3.3 Research methods

3.3.1 Scat collection

Direct observation of Tigers' feeding ecology, however, is greatly hindered by the cryptic, solitary, and nocturnal nature of the predator (Grey 2009). Dense habitats in which the species preferentially hunts further hamper the observation (Sunquist and Sunquist 1989). The diet of the large carnivore can be determined by scat analysis for undigested prey hairs (Reynolds and Aebischer 1991, Mukherjee et al. 1994a, Bagchi et al. 2003). There are refined techniques for the analysis of scat (Mukherjee et al. 1994b) It is widely used field technique for assessing the food habits of large carnivore, including Tigers (Bodendfer et al. 2006).

The Tiger scats were collected opportunistically along the forest roads and trails or on grassland inside the core area of the national park. The Tiger scats were distinguished from those of leopards based on their size, appearance and their supplementary evidences in the

form of associated pugmarks and scarps (Ramakrishna et al. 1999). Scats of Tigers are larger with the lower degree of coiling and observed relatively larger distance between two successive constrictions of within a single piece of scats (Biswas and Sanker 2002). There were collected 85 scats of Tiger from different three sites and each collected scat was stored in zip locked plastic bag and labeled with date time and habitat.

3.3.2 Cuticle slides

Undigested remains in Tiger scats were analyzed to find out the diet of predators, as it is an efficient and widely used method (Schaller 1967, Johansing 1983, karanth and Sunquist 1995, Biswas and Sanker 2002). The hair remains of prey were used for species identification following Mukherjee, Goyal and Chellam (Mukherjee et al. 1994a). An each scats was washed with cold water and then hot water. After washing of all hair samples it was dissolved in mixture of ethyl alcohol and diethyl ether (1:1) in Petri disc. After 30 minutes it was removed and dried and then 20 individual hair samples was taken randomly and kept on slide. The slide was painted by transparent nail paint.

3.3.3 Medullar slides

The chemical acetone was used for making medullar slide. Already dissolved scat in ether and alcohol was again dissolved in acetone for several hours than as same methods were applied as a cuticle slide. Twenty hair samples were selected for preparing medulla from each sample. Three to four hairs of the same species were mounted on each slide.

3.3.4 Diet composition, scat size and volume of Tiger's scat

All samples were analyzed for prey species of Tiger. There were used both cuticle and medulla slides for identification of prey species from undigested hair materials. Reference hair library table (Prepared by Bonnin 2008) for Tigers were used for comparing the pattern, shape and diameter of cuticle and medulla slides. Photographic compare both cuticle and medulla with the reference key were used. Statistical tool “Mean” was used to find out the average diameter of scats of Tiger.

$X = \sum X / N$, Where X= mean and N= number

4 RESULTS

4.1 Scats shape, size and weight

Tiger's scats were found in road trails of dense forest and periphery of water resources of the study site. No scats were found from outside the wide trails such as grassland, river bank of inside the core area of National Park. A total of 85 scats of Bengal Tiger were collected based on pugmarks and scarps of Bengal Tiger from the study site. All collected samples were dried in sunlight and then weighted in the laboratory of Central Department of Zoology (CDZ) by general weighting machine. The small size scats were dominant and result was small sized up to 99 grams 44 %, medium sized 100 to 200 grams 42 % and large sized 200 + grams 14 % respectively. Among the samples percentage of scat samples the small sized scats were high 43.52% and large sized scats were represented 14.11 % (Table 3).



Photo 1: Pugmark of Bengal Tiger in CNP



Photo 2: Tiger's scat drying in laboratory

The diameters of all scats were taken in the laboratory of CDZ. The average circumference of Tiger's scat was measured range between from 3.0 to 6.2 inch and mean was 4.9 inch and diameter of scat 3.9 cm. Based on the scat's weight rate and diameter, it could be predicted that the maximum numbers of Tiger are in same age ratio and body size. Not any pugmarks and indirect evidence of young Tiger was recorded during study period.

Table 3: Scats weight of Tiger

Weight of scats		
Class	Number	Percentage
1 to 99 gram	37	43.52
100 to 200 gram	36	42.35
200 above gram	12	14.11

4.2 Slides Identification

The photographs were taken by the help of photographic microscope in different magnifying size such as 10X, 20X and 40X of all prepared cuticle and medullar slides. All taken photographs were compared with the reference key. In general, the cuticle slides of prey species of Tiger (Photo 3, 4 and 5) was studied on basis of structure while medullar slides were general width range as well as structure. Cuticle scale position of the all prey species was transversal. The cuticle scale pattern of some prey such as Cow and Buffalo were irregular and wave.

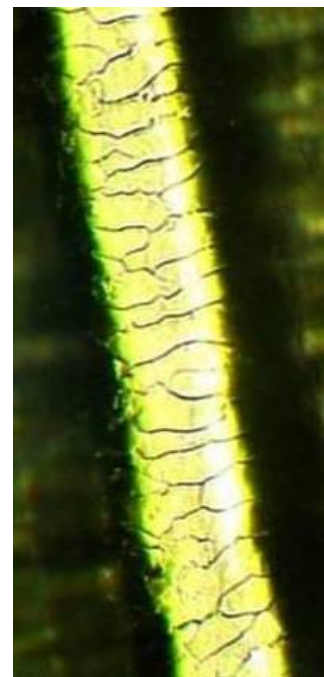
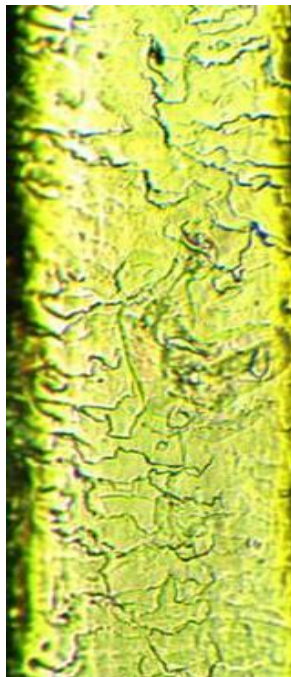
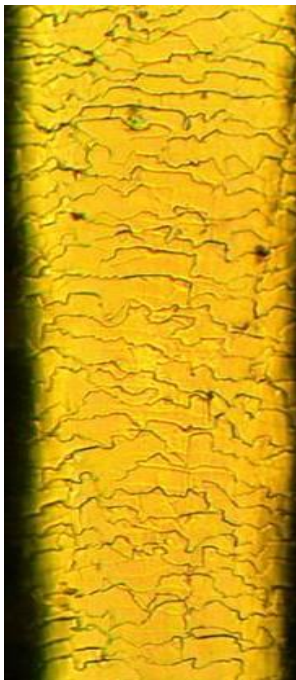


Photo 3: Samber Cuticle (400X), **Photo 4:** Cuticle Wild boar (400 X), **Photo 5:** Chital cuticle 400X

4.3 Species composition

In total 85 scats, there were 109 prey items contained. Sixty scats consists (70.58 %) with a single prey species, twenty three scats of Tiger (27.05 %) consists with a two prey species and two scats (2.35 %) consists with a three prey items. The result showed that Tiger preferred to single prey species for one meal. Occasionally it attacked more than two prey species (Figure 4) for per meal.

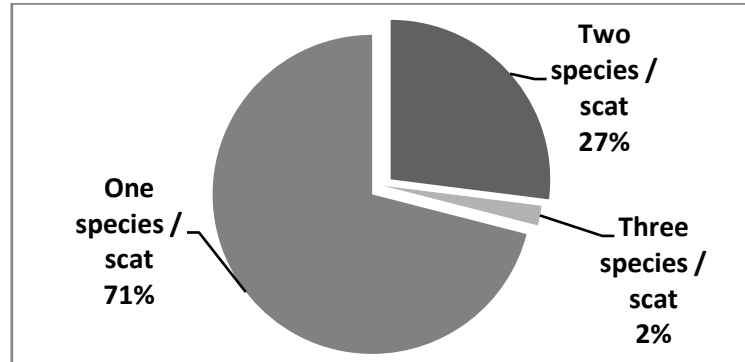


Figure 4: Species composition estimation from Tigers scat, CNP

4.4 Percent occurrence of prey species in Tiger scat

Chital (44.95 %) was a found as dominant prey species for food of Tiger in CNP. Second selected species was Sambar (22.93 %). In case of wild species, Gaur was the last choice for food for Tiger while body weight of Gaur was relatively higher than Sambar (Figure 5). Among the eight species, highest body weight was estimated domestic Buffalo (150 kg) and lowest Barking deer (30 kg) but there were not any relation found between body weight and prey choice for Tiger.

Note: CH=Chital; SA= Sambar; WB= Wild Boar; HD= Hog Deer; BD = Barking Deer; GU= Gaur; BU= Buffalo; CA= Cow

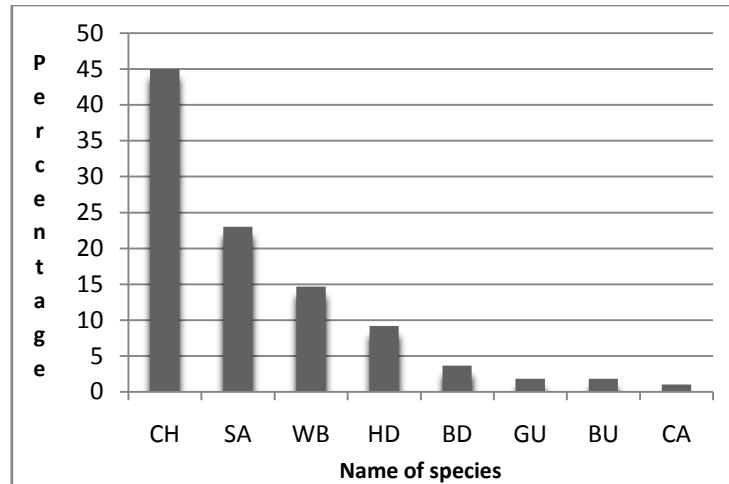


Figure 5: Estimated prey percentage of Tiger's prey species in CNP, 2014.

4.5 Prey composition

A total 8 prey species were identified in the 85 scat samples analysis. All prey items of CNP could not be found in the scats, the result showed Tigers could not kill to all prey species in CNP. Number of prey items, percent occurrence, and frequency of occurrence and relative biomass of eight preys (consumed by Tiger) has been shown in Table 4.

Table 4: Prey composition perceived used by Tiger in Chitwan area Nepal.

Prey	No. of Prey items	% of Occurrence	(A) Frequency of Occurrence	(B) Estimate Weight (Kg)	(C) Correlation Factor Y (Kg of prey/ scat)	(D)Relative Biomass Killed (%)
Chital	49	44.95	45.88	48	3.9	32.22
Sambar	25	22.93	28.23	62	9.4	47.79
Wild Boar	16	14.67	10.58	37	3.31	6.30
Hog deer	10	9.17	8.23	33	3.38	5.00
Barking deer	04	3.66	2.35	20	2.68	1.13
Gaur	02	1.83	1.76	85	9.5	3.01
Buffalo	02	1.83	1.76	150	9.0	2.85
Cow	01	0.99	1.17	120	7.9	1.66

$$D = (AXC) / \sum (AXC)$$

The estimated weight of Tiger's prey was taken from secondary sources (Bagchi et al. 2003 and Grey 2009). Chital was the major prey species (44.95 %) for Tiger's diet in Chitwan

National Park. Chital was reported as primary prey species for Tiger's diet due to medium sized body (48 kg) and large population. Next prey species for Tiger's diet was Sambar (23.29 %). The Sambar was reported bigger body size than chital. The biomass of Sambar was reported highest (47.79 %) and biomass of Barking deer was lowest (1.13 %). Tiger has preferred to large body weight (62 kg) and chosen Sambar as a primary prey in Chitwan National Park followed by medium sized (45 kg) chital. Domestic buffalo and cow has found a big weighted (Figure 6) prey species during this research period even they were easiest prey of the Tiger in CNP but it's less contribution (1.83 % and 0.9 %) respectively.

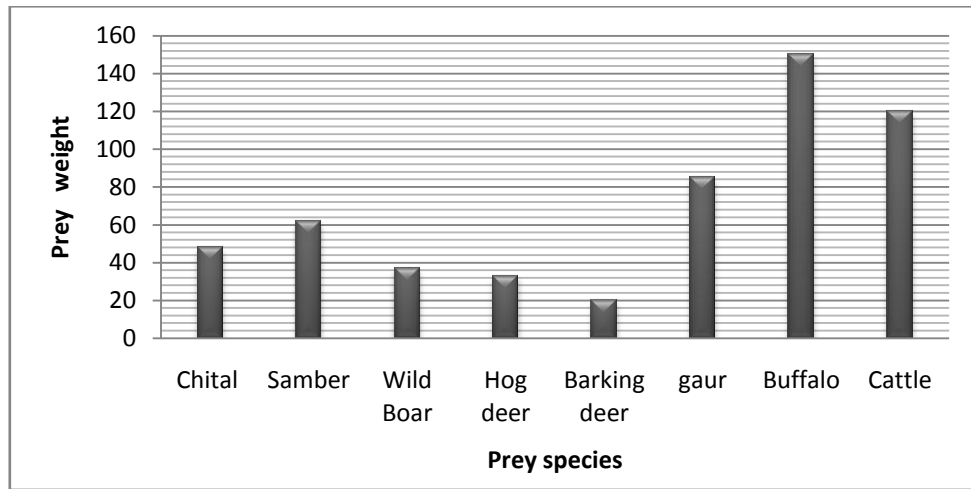


Figure 6: Estimated weight of prey species consumed by Tigers, CNP

4.6 Contribution of domestic animals

Tigers had been found pouncing upon livestock nearby the CNP. Since livestock were left (Photo 6) by the villagers in the boundaries or inside the CNP for grazing due to open grassland (Photo 7), they are attacked and killed by Tigers favouring them for their consumption. Tiger's diet (2.73 %) was domestic livestock (Buffalo 1.83% and Cattle 0.9 %). The result of the study suggested that a domestic animal in component of Tiger's diet was due to illegal grazing in some areas of CNP. The results of this study reveal that livestock made up a relatively small proportion in the diet of the Tiger in Chitwan National Park.



Photo 6: Cattle were grazing in CNP



Photo 7: Grass land area of CNP

5 DISCUSSIONS

5.1 Prey selection

Most of the researchers had stated that the primary prey species of Tiger were declining day by day in worldwide but conserving efforts were ongoing for their conservation in natural habitats. Across its global range, Tigers eat a variety of prey ranging in size from termites to elephant calves among which, primary prey species, mostly herbivores but sometimes replaced by langurs, small mammals, birds, lizards, fish, etc., and occasionally humans in the Chitwan National Park. Humans were killed by Tigers for their prey and also many people were injured due to human disturbances in Tiger's habitat. Due to the feeding nature, many scientists has reported that Tigers will also attack young elephants and rhinos (Nowell and Jackson 1996), and sometimes kill and eat leopards and their own kind, as well as other carnivores, including bears, weighing up to 170 kg, which they attack in their winter dens (Heptner and Sludskii 1972).

The leopard, young elephant and rhinoceros were not reported to the diet of Tiger still now and it might be due to the spotted deer, sambar, wild boar were the selected and dominant prey of Tigers in the Chitwan, Nepal. It was been reported that sometimes young rhinoceros and elephant had been injured by Tiger attack in CNP and other protected areas. Not any hairs of Monkey, Blue bull, Indian Porcupine, Langur, Goat and Sheep found in the scats of Tiger, where they were also potential prey species in Chitwan National Park and these species were reported from Karnali flood Plain of Bardia National Park as a Tiger's small diet component.

5.2 Contribution of domestic animal

In a many wildlife Reserve such as Panna Tiger Reserve (PTR), India, Bardia National Park, Nepal and other, the domestic animals are contributing to the diet of Tiger. According to Chundawat et al., (1999), in the PTR total contribution of domestic livestock for Park Tigers was 6.2 %. Researchers concluded that the absence of large prey species, the Tiger fed on small prey species and they might be domestic livestock. Similarly, Harsha et al. (2004) provided same types of data suggesting that regardless low densities of wild prey in

(Nagarjunasagar Srisailem Tiger Reserve) NSTR and high densities of livestock (60% of the ungulate density within the reserve), the total contribution of domestic livestock in the diet of the Park's Tigers was only 6.2%. Harsha et al. (2004) suggested that in the absence of large prey species, NSTR Tigers have adapted to smaller prey (<50 kg) and take domestic livestock only on rare occasion. Grey (2009) concluded that domestic animals are contributing 3.56 % of the total diet Tiger in Karnali Floodplain of Bardia National Park, Nepal. The contribution of domestic animals to the diet of Tiger is varying in different Protected Area. Bagchi et al. 2003 stated that domestic livestock make up 10 – 12 % of the Tiger's diet in a semi – arid, dry deciduous forest in western India. Increasing livestock densities within protected areas are also believed to increase the chances of domestic animals being preyed upon by predator (Sekhar 2003). Sekhar (2003) informs that domestic livestock, whose population in Sariska Tiger Reserve, India, increased by 45% from 1977 to 1992, have become a part of the regular food source for large carnivores. For the case of livestock predation, Dinerstein (2007) give argument that Tigers will not take livestock if wild ungulate prey is abundant. This was most likely a direct result of extensive livestock grazing in the park as reported by Bagchi et al. (2003). Sunquist (1981) reported that when livestock are available, Tigers will readily prey on them. To similar conclusions came Biswas and Sankar (2002), who observed that although livestock were not grazed in PNP, they accounted for 8.2% of all prey consumed by the Tiger's Park. Many researchers mentioned that the Tigers killed domestic livestock in the areas outside the boundaries of Park. Lamichhane (2011), Dahal (2012) and Chapagain (2013) analyzed tiger's scat in CNP and reported five wild prey species for Tiger's diet. There was not proportion of domestic livestock for Tiger's diet. Biomass of Barking deer was lowest for CNP. The biomass of Sambar and Chital was comparatively high and contributing a huge percentage to the Tiger's diet in CNP. Different factors can play role to take the livestock to diet of Tiger such as grazing in core area of CNP and Buffer Zone, corridor site etc. The study was conducted between Feb. to Apr. 2014 in CNP and that time was grazing period in fields, river site or where they found grass by villagers due to high temperature, lack of grasses and other foods for livestock. Thus small component of domestic livestock to the diet of Tiger was due to illegal grazing in CNP.

6 CONCLUSION AND RECOMMENDATIONS

The Chital was found as a principal prey species for Tiger in CNP, and there was a directly proportional to the Tiger. The finding of the research concluded that 2.73 % of total diet composition taken from livestock is not bad because in many protected areas the livestock are contributing to the diet of Tiger higher percentage than CNP. It might be controlled if grazing, in and around the Chitwan National Park could be avoided by domestic livestock. If the livestock will not be controlled for different activities in and around the National Park area then park-people conflict ratio may be increased because it was concluded that contribution of domestic animals to the diet of Tiger is due to illegal grazing.

The problem of human-Tiger conflict is directly related to people living around the park; therefore mitigation of this problem should be discussed jointly between the park management and local people. More than half of the problem Tigers removed was in the marginal or sub-optimal Tiger habitats. Impaired Tigers turning into man-eater due to old age or injury are easier to understand. The DNPWC should be involved with the local people for controlling the illegal grazing inside the CNP and create conservation awareness programe in the village. There are no areas set aside for livestock grazing in village it should be recognized along most of the river system or some parts of buffer zone forests and community forest outside the National Park.

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