# 1. INTRODUCTION

## 1.1 Background

The term population has its origin in the Latin word 'Populas', meaning people. A population refers to a collective group of organisms of the same species (or other groups within which individuals may exchange genetic information) occupying a particular space (Odum, 1996). The nature of population is determined by such factors as density, sex ratio, birth and death rates, emigration and immigration (Martin, 1999). These population characteristics are although best expressed as statistical functions, are the unique possession of the group and are not characteristics of the individuals in the group (Odum, 1996). But the population parameters result from the summation of individual characteristics (Krebs, 1994). Age and sex-wise population composition of an area indicates the viability and the growing trend of the population of that species, which is one of the main indicators of its management (Khanal, 2006). Study of population status of recently common animals such as spotted deer becomes important in the sense that their existing conditions will not convert into rare and endangered; and thereby extinct category in near future by their proper monitoring, conservation and management.

Distribution of population is the geographical arrangement of the organisms in space at a given time. It is affected by various limiting factors such as dispersal, habitat selection, interrelations with other organisms, temperature, moisture and other physical and chemical factors (Krebs, 1994).

The sum of the responses of an organism to internal or external stimuli is known as its behaviour. Certain categories of behaviour such as feeding, reproduction are seen in all animals but these activities involve different movements in different species and develop a different way. Therefore, it is the subject of interest to the ethologists how the behaviour of an animal in its natural environment may contribute to the survival of the maximum number of its relatives and offspring (Martin, 1999). Animal behaviour is the means of functional importance by which an animal maintains its relation with the environment. To the wildlife biologist, precise knowledge of population composition with regard to age and sex structure and animal behaviour is a basic necessity for intelligent conservation and management (Benton and Werner, 1966). Biological data, which include the current population status and understanding of behaviour, are vital for in-situ conservation of any wildlife species (Khanal, 2006).

## 1.2 Spotted Deer

Spotted deer (*Axis axis*), a cervid, is one of the common artiodactyls native to the tropical and sub-tropical forests of Bangladesh, India, Nepal and Srilanka. Axis deer are amazingly adaptable and for that reason, it is no accident that they are the most common ungulates in the region of the Indian and Srilankan monsoon forests (Kurt, 1990). This species of deer is not currently threatened and there is no special conservation status of spotted deer in IUCN Red List, CITES and US Federal List.

### 1.2.1 Evolution of Spotted Deer

The order artiodactyla appeared in the mammalian age in the Eocene epoch as a small rabbit-sized omnivorous animal and flourished in the middle of the Tertiary age when Savannah and Steppe replace much of the earlier forests. They have now the access to grasslands as a highly gregarious and large bodied runner. Some species became short-legged runners and other the long legged runners (Grzimek, 1976).

Cervids appeared in Eocene epoch of Tertiary period as small Chevrotain-like creatures, which browsed and ate fallen fruits. Like the Chevrotains, deer use fermentation in their gut to digest plant material more efficiently which is called rumination. In the Oligocene epoch, when the forests began to open up, ancestors of deer grew larger and formed herds for safety. The first horned deer appeared in the Miocene. They used their horns to fight (Grzimek, 1976).

The cervids are true ruminants. The males possess antlers which are solid bony outgrowths on head, shed and grown a new each year. The number of teeth in two jaws is thirty-two. Four parts of incisor-like teeth are at front of lower jaw. Five species of cervids are reported from Nepal- *Cervus duvauceli* (Swamp deer), *Cervus unicolar* (Sambar deer), *Axis axis* (Spotted deer), *Axis procinus* (Hog deer) and *Muntiacus muntjak* (Barking deer) (Majupuria and Majupuria, 2006).

### 1.2.2 Systematic Position

Class: Mammalia
Order: Artiodactyla
Family: Cervidae
Sub-family: Cervinae
Genus: *Axis*
Species: *axis*

The common Axis deer is also known as Chital or Spotted deer. The Spotted deer (*Axis axis*), one of the true deer is representative form of the genus '*Axis*'. It can be traced to the foothills of the Indian Himalayas and Island of Ceylon. Later, it was introduced into the Hawaiian Island in 1868 (Graf and Nichols, 1966).

It belongs to the order Artiodactyla in which fore and hind limbs bear two or four hoofed toes. Thus it is called even-hoofed ungulate. Among five digits, the first digit is absent and the second and fifth digits are reduced (Schaller, 1998).

The Spotted deer of the genus *Axis* has following four species:

i) *Axis axis* (Spotted deer) in India, Ceylon and Nepal.
ii) *Axis procinus* (Hog deer) in Northern India, Nepal, Burma, Srilanka, Indochina and Thailand.
iii) *Axis kuhlii* (Kuhl's deer or Bawean hog deer) in the Indonesian Island of Bawean.
iv) *Axis calamianensis* (Calamian deer) in Bussanga, Culion and a few other small islands in the Camalian group of the Philipines.

Ellerman and Morrison-Scott (1964) recognize following two sub-species of *Axis axis:*

*Axis axis axis* native to Nepal, India and Srilanka

*Axis axis ceylonensis* native to Srilanka (Ceylon)

*Axis procinus* has following two species:

*Axis procinus procinus* in Northern India, Nepal, Burma and Srilanka.

*Axis procinus annamiticus* in Thailand and Indochina.

Spotted deer (*Axis axis)* is the largest among four species and the most common type of deer in the deciduous monsoon forests, the thorn scrub regions and the dry grasslands of India and Srilanka (Kurt, 1990).

### 1.2.3 Physical Description

The spotted deer is a small cervid. It is often considered as the most beautiful among cervids due to presence of striking reddish brown coats marked by white spots arranged in undisciplined rows along their sides in both sexes. They have a black dorsal stripe and white bib on their neck, white inner legs, stomach and under-tail. Males have antlers which they shed annually. Antlers grow from high pedestals rounded in cross section, and only lightly rounded near lower quarter; beam simple, strongly concave in outline

and sharply inclined backwards at a point just above the pedestal. Males have darker facial markings with a more pronounced ‘scowling’ expression the older they get. Bucks are generally larger bodied than does with thicker necks and broader chests. The Spotted deer bucks can be in hard horn any time of the year because they grow and shed antlers on their own clock. So in one herd there may be a newly shed buck and a buck in the velvet. Stags may shed their antlers at any time of the year and then leave the herd to form all-male herds until new antlers have grown (Chalise, 2004).

Hawaiian Spotted deer have heavier and wider antlers than the Indian or Ceylonese deer (Graf and Nichols, 1966). Kurt (1990) measured 37 inches long antler on Hawaiian Spotted deer buck.

The bucks stand about 29 to 39.5 inches height at the shoulder and total body length is 35 to 43 inches (Kuikel, 2003). Its body weight at maturation varies from 145 pounds to 250 pounds. The doe stand about 26 to 33 inches height at the shoulder and weighs about 124 pounds (Schaller, 1998).

Pocock (1943) measured male axis skulls all range from 26cm to 30.2 cm and that of female range from 23.1 cm to 26 cm in Hawaii Island. It shows that Hawaiian deer do not differ greatly from the Indian deer. The axis deer has apparently lost none of its characteristics during more than 90 years of isolation and inbreeding from four original pairs (Graf and Nichols, 1966).

In Chitawan National Park of Nepal the weight of males averaged 71 kg and that of females is averaged 50 kg (Mishra, 1982). The antlers of yearling males consist of simple spikes, while adults carry three-tined antlers with brow tines and a forked beam (Schaller, 1967). Axis deer remains spotted throughout the life. Buck bears two antler beams up to 76 cm in length; generally three points on each bar (Graf and Nichols, 1966). The first set of antlers in yearlings consists of simple spikes, usually less than five inches long (Schaller, 1967).

Does are generally slightly lighter in colour than bucks, especially over the face and neck. Bucks have a black or dark brown diamond-shaped spot in the middle of their forehead and a black line that extends from the antler base to the eyebrow on each side of the head and continues from the eyebrow to the bridge of the nose, thus forming a black inverted chevron on the face (Graf and Nichols, 1966).

Melanism and albinism has been reported in Hawaiian and Indian spotted deer respectively. Melanism, i.e. an all black color is rare in deer. Graf and Nichols (1966) observed melanism in one matured buck on the leeward side in the Panakau Game Area in 1958. According to Lydekker (1893) there is a rare black variety of the spotted deer in which the spots are scarcely perceptible. Similarly, albinism i.e. an all white color apparently occurs, but is rare. One albino buck was reported to be seen in the mountainous country east of Kaunakakai, Molokai. A reporting on a captive albino stated that the albino bears antlers about 2 feet in length without tines; they are always in velvet of a pink flesh colour. He drops his antlers annually but the new ones grow in the same way. It has pink eyes, nose, ears and light colored hoofs. Three albino fawns were seen by Mrs. Marie Palit of Ranchi, India (Graf and Nichols, 1966). Nature guides of Bardia National Park, Nepal claim the observation of 2/3 albino variety of Spotted deer in the park roaming within Phantas and forest together with herd of Spotted deer (Field Visit, 2006).

Soft, short hairs on the coat of spotted deer provide a very sleek appearance. Sebaceous and apocrine glands present at the base of the hair shaft produce an oily liquid which makes the coat shine and helps to repel water. The coat of young fawns is somewhat heavier than that of the adults, but the hairs are finer, giving the fawns a fuzzy appearance. Bucks erect the hairs of neck, torso, tail and rump patch. When a buck is threatening another, he will erect the hair over most of the body, particularly that of white rump patch and the under tail so that he resembles angry, fluffed-up tomcat. Does have not been observed to fluff out their whole coat, but they erect the hairs of the rump patch and under-tail when excited (Graf and Nichols, 1966). There is no seasonal difference in the colour of the coat, except that during the cool season it is somewhat glossier, darker, and thicker than during the hot and wet season (Schaller, 1967).

The coat is clean by frequent licking; in fact, these deer are one of the cleanest of all wild animals (Graf and Nichols, 1966). The spotted deer possess a complex and effective system of visual, auditory, and olfactory signals of their own which serve to warn other members of the species of potential danger (Schaller, 1967). Like other deer, spotted deer have inter-digital glands between the toes of each hind hoof, and are indicated externally by a distinct line of dark hairs. The most noticeable and interesting of external gland in spotted deer is the infra-orbital gland located just below the inner corner of each eye which normally appears as a mere slit, and can be rapidly opened during excitement (Graf and Nichols, 1966).

The dentition of adult spotted deer shows presence of three pairs of incisors, one pair of canines, three pairs of premolar and three pairs of molars in the lower jaw. There are no incisors and canines, three pairs of premolars and three pairs of molars in the upper jaw. The formula for the Axis dentition is:

$$\text{i. } \frac{0-0}{3-3}, \quad \text{c. } \frac{0-0}{1-1}, \quad \text{pm. } \frac{3-3}{3-3}, \quad \text{m. } \frac{3-3}{3-3} = \frac{12}{20} = 32$$

In fawns there is a distinct upper canine tooth on each side, located and midway in the gap between the incisors and first pre-molar. These teeth are shed by the time the animal is one year old and the socket closes, leaving no trace of former canine teeth (Graf and Nichols, 1966).

### 1.2.4 Habitat and Food Habit

Spotted deer are primarily browser particularly during the dry season (Berwick, 1974) but they utilize open meadows grazing on short grasses in the moist semi-evergreen tropical forest (Schaller, 1967). The habitat of the Hawaiian Axis deer ranges from semi-desert types at altitude generally below 1500 feet to rain forest at the higher altitudes, reaching rainfalls of over 200 inches at 3000 feet to 4000 feet (Graf and Nichols, 1966). In Srilanka, on its southern most range, it used grasslands and the scrub grassland interface in the semidry deciduous forest of the Wilpartu National Park and concluded that its ability to use forest depends upon the maturity of stands since it does not reach above 1.5 m (Eisenberg and Lockhart, 1992). Smithsonian Tiger Ecology Project 1976, conducted in the then Royal Chitawan National Park showed distribution of spotted deer 51 per kilometer in grassland, 245 per kilometer in Riverine forest, 212 per kilometer in River bank; which confirms the Riverine forest habitat preference of spotted deer (Shrestha, 2003). They inhabit in scrub forest and grassland along the forest edges bordering on cultivation and grassland of altitude less than 1000m (Majupuria and Majupuria, 2006). Mishra (1982) also found spotted deer utilizing both the forest and grassland habitat and preferably the Riverine forest in the then Royal Chitawan National Park. Spotted deer has been reported to favor habitat patches broken by glades, meadows, grasslands and other features both in its indigenous and exotic environment (Dinerstein, 1980 and Ables, 1977). This herbivore, the most common species in Bardia responded to seasonal changes in leaf and shoots development by shifting the grass and browse proportion in their diet and by relative times spent in each habitat type. Biotic and a biotic factors, most notably fire and monsoon rains, trigger major changes in the

plant phenology which directly influence deer forage abundance and quality (Dinerstein, 1982). Spotted deer prefer newly cut and burned Phantas as feeding habitats (Moe, 1993) and rest in forest habitat during middle of the day (Naess and Anderson, 1993). They are nocturnal, but might feed until late in the morning. Spotted deer often feed on leaves, flowers and fruits that drop on the ground. They are sighted under trees where monkeys feed on leaves, fruits and flowers; some of which dropped to the ground as a result of the monkey activities at the tree tops (Mishra, 1982). In Kanha National Park, India, spotted deer were found to be waiting under foraging monkey troops at four different tree species (Schaller, 1967).

Spotted deer are tolerant to other ungulates and can be seen feeding with Blackbuck, Blue bull and Swamp deer. These animals frequent between open grasslands and light jungle, seldom penetrating into heavy forests. The food habits of spotted deer are very general and can exist quite easily on forbs and woody browse. In contrast to the white-tailed deer, which typically eats only a few foods, the spotted deer eats small quantities of large varieties of plant species. This broad spectrum diet gives it an advantage in competition with other deer (Ables, 1977).

Axis deer is mainly grazer in Texas (Ables *et al.* 1977), a browser in the Gir forest (Berwick, 1974) and feed on herbs in Tamilnadu, India (Johnsingh and Shankar, 1991). The deer is found mainly as a grazer in lowland Nepal. Fruits, leaves and seedlings from a wide variety of tree, shrub and forbs species are also utilized (Dinerstein, 1982).

### 1.2.5 Social Structure

Spotted deer is a gregarious mammal. The social organization of spotted deer is variable with small groups of two to twenty individuals common, but herds of more than hundreds animals can also be found. The herd size varies seasonally, increasing during the monsoon season (Schaller, 1967). Although spotted deer do congregate in large herds, the social structure of the species is loose with individuals readily joining and splitting from groups. The only stable relationship is between mother and calf (Mishra, 1982). The basic unit of herd appears to be the family group, usually composed of an adult doe, her yearling fawn, if she has one. If the yearling is a buck, he may leave his mother and strike out on his own as his first spike antlers mature, but it is not uncommon to see several spike antlered bucks remaining with a group of does and fawns. The yearling does apparently remain with their mother until their own first fawn arrives and in some cases even after they are nursing their own young (Graf and Nichols, 1966).

Males are non territorial and in Nepal male groups are common except for the peak mating season in April-May (Dinerstein, 1980).Except during and just after peak breeding season, most of the mature bucks tend to seek solitude or form bachelor groups of two or more animals. Harem-gathering and herding by large bucks is not common with the axis deer, although occasionally a large old buck will do so to a limited degree (Graf and Nichols, 1966).

Mixed sex/age groups are frequent in the rutting season (Khan and Vohra, 1992). Two additional associations commonly seen among spotted deer are all-male herds and nursery herds; the later consisting of only females with fawns (Fuchs, 1977).

### 1.2.6 Reproduction and Life span

Axis deer breed throughout the year. Males are fertile year round. Breeding, fawning as well as shedding and re- growth of antlers occur throughout the year. Most fawns are born from mid-November to April. The peak antler maturation and rut activity occur from April to August. Both sexes reach the puberty towards the end of their first year of age, although some females have been known to breed and conceive earlier (Waring, 1996). Sexual maturity and first breed of female is at 14 to 17 months of age. Males are probably capable of breeding as yearlings but must achieve adult size to compete for females. During the breeding period males below loudly and wander in search of receptive females (Ables, 1977). Multiple estrous cycles occur each year. Chapple *et al.* (1993) determined a mean estrous cycle of 19.3 days (range 17-21 days) and average gestation period of 234.5 days (range 228-239 days). The gestation period is of average seven and half months. Doe spotted deer come into breeding condition within a few months after giving birth once. Single fawns are norm; twinning is rare (Graf and Nichols, 1966), occasionally three youngs are born (Grzimek, 1972). Sometimes a doe gives birth twice a year. Prior to giving birth, a female leaves her yearling and other companions and seeks a secluded spot. The fawn is kept hidden for 2-3 weeks and is cared for only by mother. Usually, the fawn is left in a recumbent position in a well-protected place; the doe returns periodically to nurse the infant, often after an absence of 1-2 hours. When danger appears, the doe runs off alone leaving the fawn recumbent and hidden; the doe makes a “Yup” call as she bounds away as if to call attention to herself to draw the intruder away from her infant. Nursing lasts only 10-15 seconds and undoubtedly occurs periodically throughout the day. Fawns mouth vegetation in their first week and gradually begin to consume plant materials over the next month until considerable amounts of plants are taken. Weaning occurs soon after the fawns reach

four months of age; thereafter, fawns regularly consume water but not before (Graf and Nichols, 1966). Lifespan of spotted deer is 9 to 12 years in the wild but can live for over 20 years in captivity. Many spotted deer become victim of their predator in the wild before their natural death (Siegen, 2005).

## 1.3 Distribution and Status of Spotted Deer

Spotted deer is indigenous to Srilanka, India, Bangladesh and Nepal. The main distribution area in Nepal is throughout Tarai, with major concentrations in parks and reserves (Mishra, 1982). Spotted deer have been introduced to the former Yugoslavia, Western Republic of the former USSR, Andaman Islands, Australia, Hawaiian Islands and Texas (USA), Brazil, Argentina and Uruguay (Grubb, 1992). They are a favorite of zoological gardens around the world. Free ranging population exists in the continental United States, Hawaii and Australia. The species can be found in Texas, Florida, Louisiana, Mississippi, Missouri, New York, Oklahoma, New Jersy, Michigan and California and zoos in most states. The spotted deer was first introduced into Texas in the 1930s and now occurs in at least forty five countries. The largest number occurs on the Edwards Plateau where the semi-open, dry scrub forest vegetation resembles that of its native habitat in India (Ables, 1977). Eight spotted deer (three bucks, four does and a male fawn) were transferred to the Hawaiian Island in December 1867 and released to on Molokai Island in January1868. Later, several deer were transferred to Oahau; a herd was present on Diamond Head prior to 1898 and an additional herd became established in Moanahau Valley about 1910 (Waring, 1996). In 1920, twelve deer of the Molokai population were translocated to Lanai (Graf and Nichols, 1966). Deer populations flourished on Oahu, Molokai and Lanai. On Molokai, the population increased to 1000 within 20 years and reached nearly 7500 (Tomich, 1986). The spotted deer is distributed up to the elevation of 2150m (7000ft) or higher along the south, west and north-west borders of Haleakala National Park and in the Waikamoi Preserve managed by The Nature Conservancy (Waring, 1966).

## 1.4 Distribution of Spotted Deer in Nepal

Spotted deer inhabits in scrub forest and grass lands along the forest edges bordering on cultivation and grassland at altitude less than 1000 m. It is distributed in Bardia National Park, Chitawan National Park, Sukla-Phanta Wildlife Reserve, Parsa Wildlife Reserve and Koshi Tappu Wildlife Reserve. Spotted deer is also reported from districts of Bara, Bardia, Kailali, Jhapa, Sunsari, Saptari, Nawalparasi, Rupandehi, Chitwan, Mahottari, Kapilbastu, Dang, Banke and Kanchanpur (Majupuria and Majupuria, 2006). But the

exact population of spotted deer is not recorded in any National Park, Wildlife Reserve and other forests. However, long back a census was initiated on Chitwan and found 500 in number. In this reference, at least 2000 spotted deer might be possible in Tarai area (Chalise, 2001). Spotted deer are found rarely above an altitude of 1160m (3500ft) in their native Asian habitats, including Nepal (Schaller, 1967).

## 1.5 Value of Spotted Deer

Spotted deer is one of the most beautiful creatures of the nature. The lithe grace and lovely spotted coat have made it a favoured inhabitant of zoological gardens and parks of many countries for centuries. Because of its wide distribution and abundance, it has been the most persistently hunted deer for meat and sport in its native Nepal, India (Schaller, 1984). The earliest description of this animal is coated in the religious books of Hindu mythology, the Ramayana, Mahabharata and the Vedas of dated 2000-1500 B.C. It is also seen pictures of spotted deer together with Lord Gautam Buddha during his meditation for enlightment. It is probably the most favorite prey species of endangered Tiger (*Panthera tigris*). In Texas, the spotted deer, as sporting animal, provides a fine trophy. Its meat is of excellent quality which is almost fatless with just 1-2% of fat (Ables, 1977).

## 1.6 Rationale of the Study

Spotted deer, the most common ungulate species in Bardia (Dinerstein, 1982), is declining in number due to unfriendly and illegal activities of human being such as poaching, hunting, habitat fragmentation, entry of domestic animals etc. Only limited studies have been carried out about population characteristics, distribution and behavioural pattern of spotted deer in Nepal. Eric Dinerstein studied ungulate populations in 1980; Anderson and Naess accessed census techniques for wild ungulates in 1993; Stein R. Moe studied distribution and movement pattern of deer with emphasis on *Axis axis* in 1994 in Bardia National Park. H. R. Mishra studid the ecology and behaviour of spotted deer in 1982; Wemer and Mishra studied comparative breeding ecology of four cervids in 1987 in Chitwan National Park. Despite various conservation processes for the conservation and management of spotted deer, they are being seriously affected by human and non-human disturbances. This study extrapolates population characteristics, distribution and general behaviour of spotted deer which provides baseline information for effective conservation and management thereby to enhance long term survival of wild ungulates in Bardia National Park. Behavioural study play very important role for the conservation of any species (Manning and Dawkins, 1998 and Jhala, 1991).

## 1.7 Research Objectives

The main objective of the study was to collect ecological information on general behaviour and status of wild ungulate species of spotted deer (*Axis axis)* in Bardia National Park, Bardia. The specific objectives of the research were:

i) To estimate current population status of spotted deer in Bardia National Park.

ii) To explore the distribution of spotted deer in different Phantas of Bardia National Park.

iii) To document the general behaviour and diurnal activity pattern of spotted deer in Bardia National Park.

## 1.8 Limitations of the Study

This research work was carried out for the partial fulfillment of the requirement for Master's Degree in Zoology (Ecology). Following limitations were faced during the study period.

- Duration of the study was only 9 months, so year round seasonal activities could not be assessed.
- Night observation could not be made due to security and technical problems.

# 2. STUDY AREA

## 2.1 Physical Description

### 2.1.1 Location, Boundary and History of the BNP

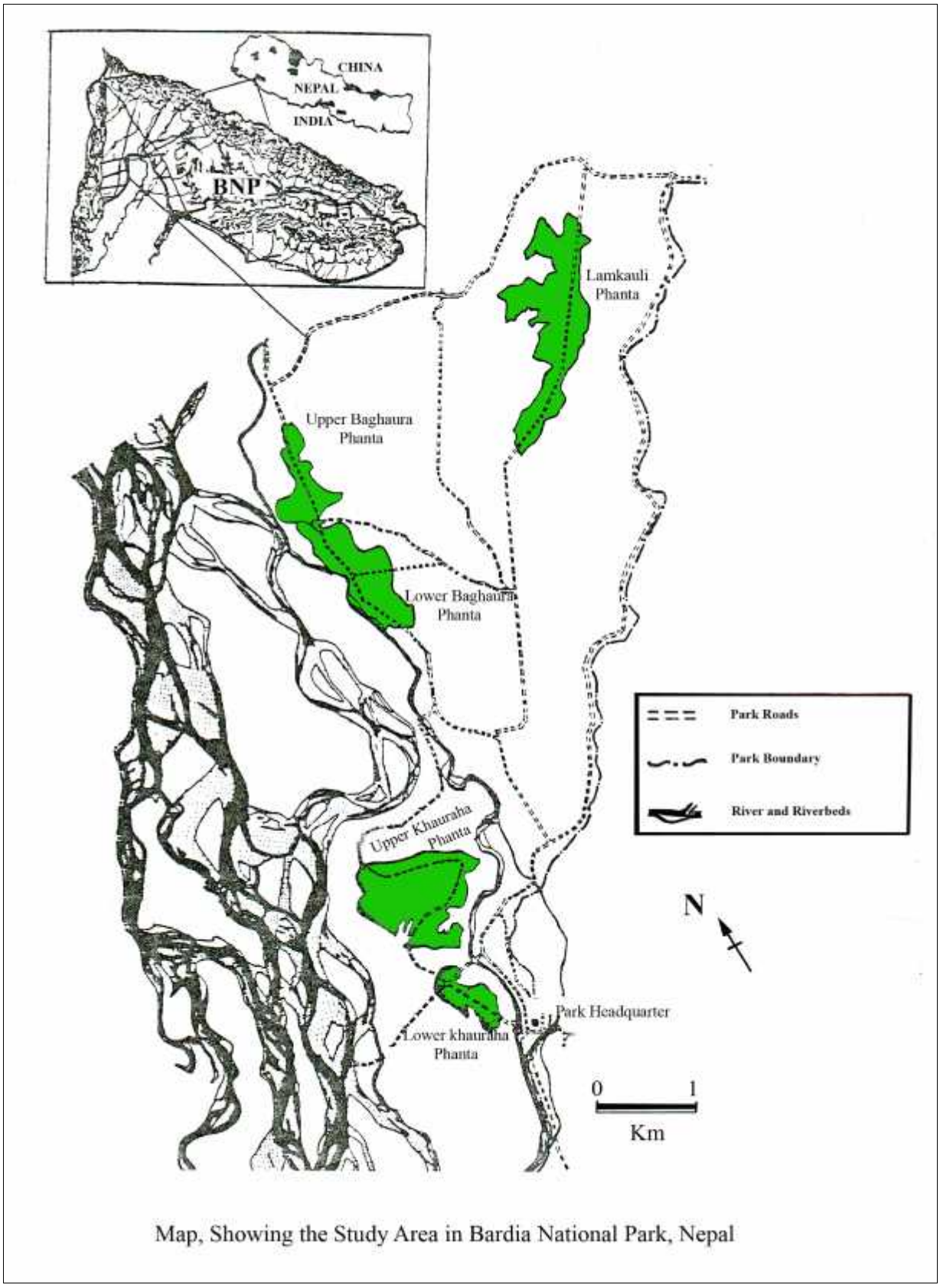
Bardia National Park is located along the east bank of Karnali River in the Mid-western Development region of Nepal. It is about 400 km far from the capital city, Kathmandu. The park extends between $28^0$ 15' to $28^0$ 40' N to $80^0$ 10' to $81^0$ 15' E (Moe, 1994 and Pokharel, 1993) with 968 square kilometer area in two districts: Bardia in the west and Banke in the east. It was originally set as a Royal Hunting Reserve in 1969; gazetted as Royal Karnali Wildlife Reserve with an area of 350 square kilometer in 1976; as Royal Bardia Wildlife Reserve in 1982; extended to include the Babai River valley in 1984 and gazetted as Royal Bardia National Park in 1989 by the then His Majesty's Government of Nepal (HMGN). After the political movement of 2006 (2062-2063 BS), the park has been renamed simply as "Bardia National Park" (BNP) by the Nepal Government (NG).

The crest of the Churia range (Siwalik) demarcates the northern boundary of BNP. The southern boundary follows the local limits of cultivation, part of east-west highway and forested buffer zones. Kohalpur-Surkhet road forms the eastern boundary of the park. The Geruwa River, a branch of the Karnali River (the largest perennial river of Nepal) determines the western boundary of BNP. This park occupies broad range of ecosystem such as flood plains, oxbow lakes, grasslands, sal forest and riverine forest in low land plain; while on the Churia range subtropical deciduous forest exists. Five major Phantas (Lamkauli, Upper Baghaura, Lower Baghaura, Upper Kahuraha and Lower Khauraha) are located in the south-western corner of the park (Map, 1).

### 2.1.2 Topography and Geology

Topography of BNP shows a distinct altitudinal gradient. The northern part forms the Churia (Siwalik) ridge which rises quite steeply to the crest reaching an elevation of 1441 m at Sukarmala, the highest altitude of the park. The southern section is characterized by a low-lying unbroken terrain with the lowest elevation of 152 m (Dinerstein, 1979).

## MAP OF THE STUDY AREA




Map, Showing the Study Area in Bardia National Park, Nepal

**Prepared By: Dhan Prasad Parajuli, Tribhuvan University, Kathmandu; 2007.**

The siwalik range is late tertiary in origin. The exposed rocks consist of fine-grained sandstone with pockets of clay, shale, conglomerate and freshwater limestone. Soils are young and are exposed to a great of erosion and landslide. The broad alluvial plain that slopes gently from the base of the siwaliks is called the Bhabar zone. The major composition of Bhabar deposits are boulders, cobbles, gravel and coarse sand interbedded with silt and clay. The broad and flat land beneath the Bhabar zone consist the older deposits of gangetic alluvium with beds of silt, clay, sand and pebble gravel to a very great depth. Drilling in this region has penetrated unconsolidated fluvial deposits at a depth of 457m without encountering bedrock (Bolton, 1976). Brown sandy loam types of soils are predominant in this area, which are mostly calacarious and slightly alkaline in nature. The park area also has a rich riverine flood-plain which contains coarse sand to fresh deposits of alluvial soil, silt, gravel and boulders (Khatri, 1993).

### 2.1.3 Drainage and Hydrology

The study area is irrigated by the tributaries of Karnali River. Geruwa is one of the major tributaries in which an average annual discharge recorded at the west Chisapani is 1346 $m^3$ (Upreti, 1992). The south-western part of the park is also drained by a number of tributaries from the siwalik belt. The Khauraha River is another prominent drainage in the western side. Originally it was a small locally managed canal in 1975. After the lapse of time the small canal has modified itself as a sizeable river. This river has created an island with Geruwa River which is known as Khauraha Island. The Babai River originates in the east and flows west wards for about 40 km inside almost to the centre of the park, then winds southwards from Parewa Danda. Similarly, there is also contribution of Aurai and Ambasa Nalas in the west and Karolia and Mand Nalas in the east of the park. A number of seasonal streams originate from southern slopes of the Churiya irrigate the lower Bhabar zone during the monsoon period.

### 2.1.4 Climate

The BNP has a subtropical monsoonal climate with annual rain between June and September. The different seasons identified in this study area are cool-dry season from October to February, hot-dry season from February to May and monsoon season from June to October. The first part of the dry season from October to February is relatively cool with temperature gradually increasing towards the end of the dry period with a peak in mean maximum temperature close to $40^0$C in May (Dinerstein, 1979a).

There is variation in temperature and rainfall from southern part towards northern part. The northern part receives more rain and records lower temperature than the southern region (Upreti, 1992). The monsoonal wind originating from the Bay of Bengal blows from east towards the west of Nepal during rainy season, so the western Tarai receives less rain than the eastern Tarai and is relatively drier (Khanal, 2006).

At Rani Jaruwa Nursery of Bardia district, average annual mean rainfall recorded during 1994 to 2004 was 1307.4 mm. Maximum annual rainfall was recorded as 1659 mm in 1995 while minimum as 830 mm in the year 2004 (Figure, 1).

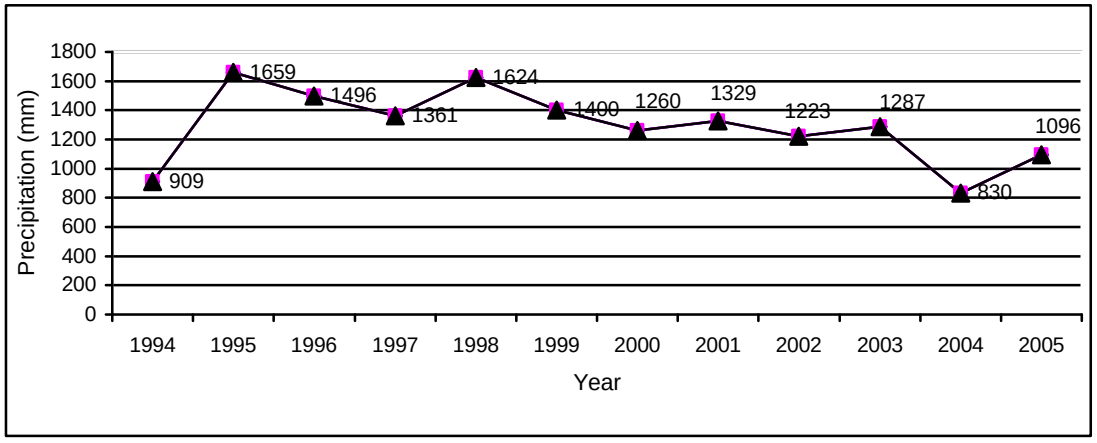



Figure 1. Annual Rainfall at Rani Jaruwa Nursery, Bardia (Source: Department of Hydrology and Meteorology, NG, 2007).

Almost 90% of the rainfall occurs at June to September during the Rainy season of this area. Bardia district, being in western Nepal receives less rainfall than the eastern Terai during the rainy season, the rainfall during which occurs from the monsoon coming from the Bay of Bengal (Khanal, 2006). The average monthly rainfall as recorded in the Rani Jaruwa Nursery of Bardia District is as follows (Figure 2).

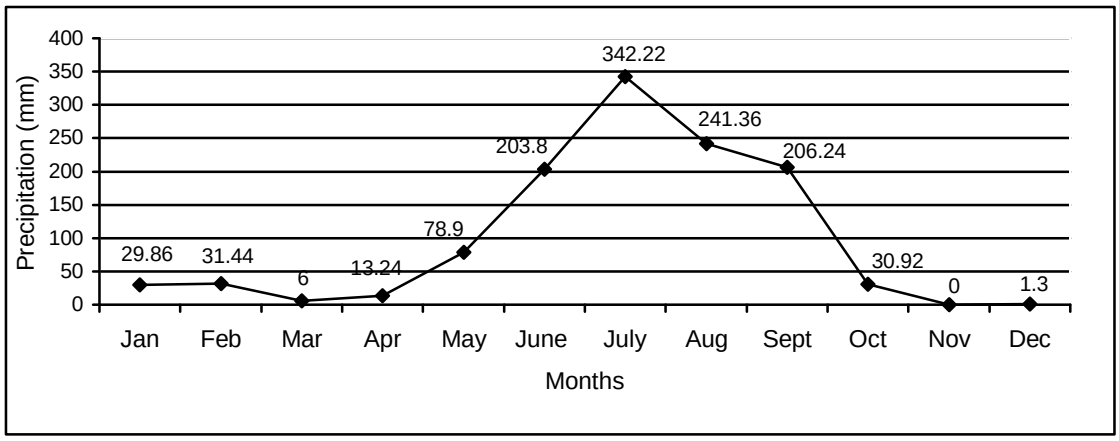



Figure 2. Average Monthly Rainfall at Rani Jaruwa Nursery, Bardia (Source: Department of Hydrology and Meteorology, NG, 2007).

The Maximum and minimum temperature recorded in Gulariya Municipality is 42 $^0$C and 7.7 $^0$C respectively (GM, 2001). The average monthly temperature of Rani Jaruwa Nursery is highest in the month of April, May and June while it is lowest in the months of January, February and December. The average annual mean maximum and minimum temperatures recorded at Rani Jaruwa Nursery from 1994 to 2004 were 30.86 $^0$C and 17.89 $^0$C respectively (Figure 3).

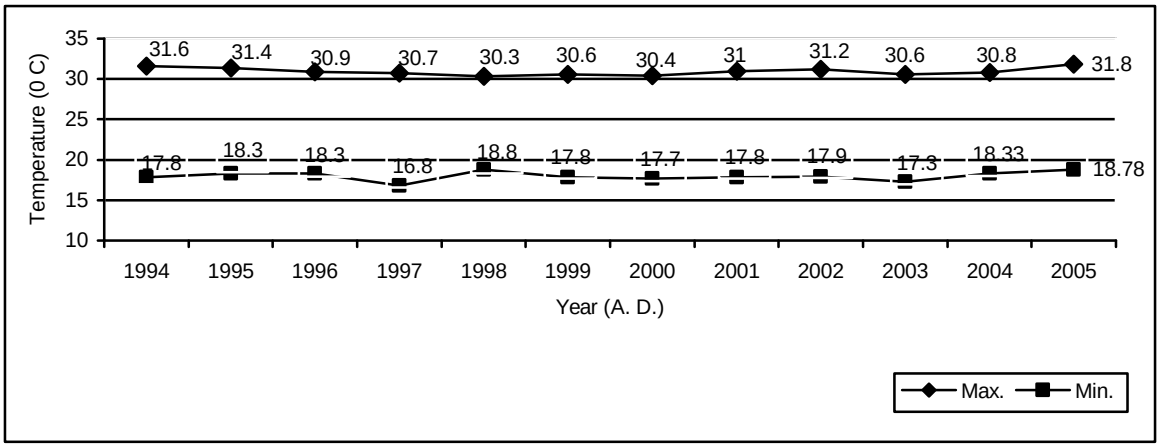



Figure 3. Annual mean Maximum and Minimum Temperature in Rani Jaruwa Nursery 1994-2005 (Source: Department of Hydrology and Meteorology, NG, 2007).

The average maximum temperature of the area is highest in the month of April, May and June while the average minimum temperature of the Rani Jaruwa Nursery recorded is in December, January and February. The average maximum temperature recorded is 36.96 in May (Figure 4)

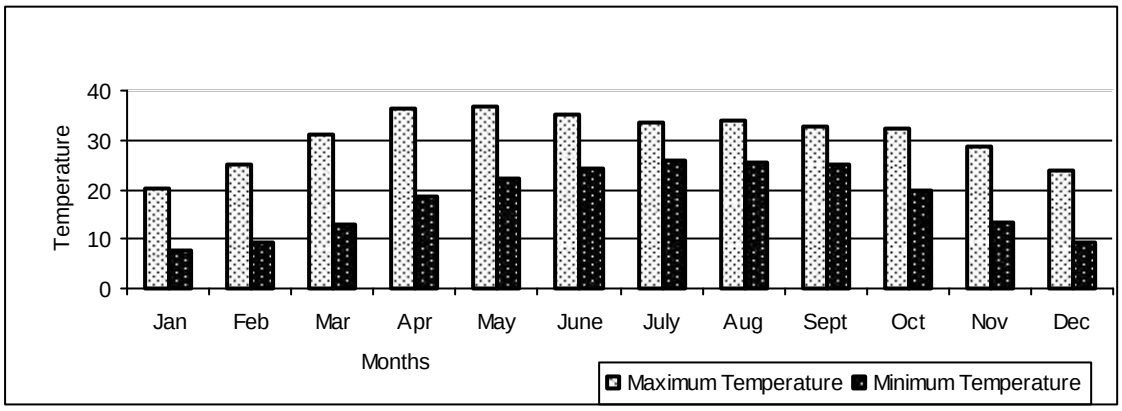



Figure 4. Monthly Variation of Maximum and Minimum Temperature in Rani Jaruwa Nursery, Bardia, 2000 - 2005. (Source: Department of Hydrology and Meteorology, NG, 2007).

The western Terai of Nepal is relatively drier area. The average annual Relative Humidity measured at Rani Jaruwa Nursery (2000-2004) is found lowest (80.79) in 2002 while others are above 83 (Figure 5).

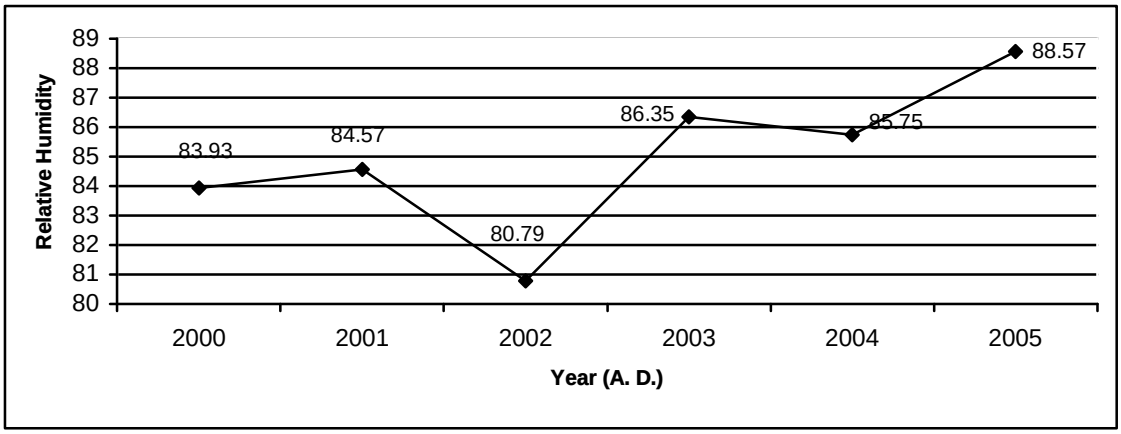



Figure 5. Annual Relative Humidity in Rani Jaruwa Nursery, Bardia (2000 – 2005). (Source: Department of Hydrology and Meteorology, NG, 2007).

## 2.2 Biological Description

### 2.2.1 Flora

The floral communities of BNP range from early successional grasslands in the Karnali floodplain in the west to climax sal forest in the east (Dinerstein, 1982 and1979a). Small pockets of grasslands, locally known as Phantas are found within the forested areas. There are five major Phantas, all dominated by *Imperata cylindrica* (Field visit, 2006). These Phantas are the result of cultivation and domestic stock grazing before a Royal Hunting Reserve was established in 1969. *Imperata cylindrica* was the first invader species after cultivation (Dinerstein, 1979a).

The forest of BNP has been classified as “moist semi-deciduous forest” in the Bhabar zone (Stainton, 1972; Chapman and Seth, 1968). Later in 1979, Dinerstein made a critical vegetation analysis and classified the park vegetation into six types. Jnawali and Wegge (1993) modified the Dinerstein’s classification of vegetation into seven types. They are: 1) Sal (*Shorea robusta)* Forest, 2) Khair-sissoo (*Accacia catechu-Dalbergia sissoo)* Forest, 3) Moist Riverine Forest, 4) Mixed Hardwood Forest, 5) Wooded grassland, 6) Phanta and 7) Floodplain Grassland.

**1. Sal Forest**

*Shorea robusta* exists as the dominant species in "Sal forest" in the lower alluvial plain. It is restricted to the steep south facing Churia and forms a mixed forest of S*horea robusta, Terminalia alata, Anogeisus latifolia,* and *Pinus roxburghii.* There is also dominancy of *Terminalia tomentosa* and *Buchanania latifolia* in association with *Shorea robusta.* It is estimated that sal forest covers nearly 70% of the vegetation of BNP. The sal forest extends in the dry Bhabar lowland and southern slopes of Churia Hills. Similarly, *Terminalia belerica, Casearia tomentosa, Adina cardifolia, Eugenia janbolana, Mallotus philippensis, Bauhinia racemosa, Dillenia pentagyna, Schleichera trijuga, Ehretia laevis, Lagerstroemia parviflora, Holorrhanthus pubisence* etc are other associated species of sal forest. *Phoenix acaulis,* a palm species is most conspicuous in the under storey of hill sal forest. In lowland sal forest *Terminalia tomentosa* forms an important association with *Shorea robusta* in the eastern part while *Buchanania latifolia* in the western part of BNP. The understorey is relatively open with some shrub species like *Flemingia macrophylla.*

**2. Khair-Sissoo Forest**

This type of forest is dominated by Khair (*Accacia catechu*) and Sissoo (*Dalbergia sissoo*), grows on the alluvial floodplain and extends along the Geruwa, Babai and Aurahi River with isolated patches. Some of such patches are open with grass coverage and good visibility especially on the well drained flat areas. Simal (*Bombax ceiba*) and *Streblus asper* are the main associate species of such forests. The dense understorey covers mainly two species, *Murraya koenigi* and *Callicapra macrophylla;* and sometimes *Callicapra oppositifolia* (Rai, 1998).

**3. Moist Riverine Forest**

This forest is characterized by the domination of evergreen of tree species such as *Mallotus philippensis, Ehretia laevis, Ficus glomerata, Syzigium cumini, Trewia mudiflora* and even *Bombax ceiba*. These types of forests extend in patches along the courses and in depressions. The understorey is relatively open with two dominant shrub species *Murraya koenigi* and *Callicapra macrophylla* and resembles to moist deciduous forest described by Stainton (1972).

**4. Mixed Hardwood Forest**

This type of forest grows in small patches and is originated due to human interference. *Caseria tomentosa* and *Schleichera trijuga* are dominant tree species of such forest. It is

similar to riverine forest but differs by a higher density of the shrub layer and a more open grown tree layer. *Bombax ceiba, Garuga pinnata, Adina cardifolia,* and *Mitragyna parviflora* are other important associate tree species of mixed hardwood forest (Pokharel, 1993).

**5. Wooded Grassland**

These grasslands are covered with less than 20% scattered tree species (Moe, 1994). The features of the wooded grassland are more or less similar to the Savannah type. They are found on Khaurah Island and are locally known as 'Dabdabe Phantas' and 'Simal Phantas'. The common tree species are *Bombax ceiba, Adina cardifolia, Bauhinia malabarica, Mallotus philippensis* and *Carreya arborea*. Among the grass species *Imperata cylndrica* is most dominant; and *Saccharum spontaneum, Vetiveria zizanioides, Cyperus kyllingia, Erianthus ravennae* and *Cymbopogon flaxuous* are common.

**6. Floodplain Grassland**

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

**7. Phanta**

The word 'Phanta' is an anglicized form of Nepali word 'Phant' (i.e. open flat land). These were previously cultivated fields and naturally revegetated open grasslands. There are five major Phantas- Lamkauli, Upper Baghaura, Lower Baghaura, Upper Khauraha and Lower Khauraha in BNP. These Phantas are mainly dominated by grass species *Imperata cylindrica* while Northern (Upper) Baghaura is dominated by the tall grass species *Narenga porphyrocoma* (Moe, 1994). Other common grass species of these Phantas are *Vetiveria zizanioides, Saccharum spontaneum* and *Erianthus ravennae.*

### 2.2.2 Fauna

Bardia National Park is rich in faunal diversity. This park provides important natural habitat for varieties of wildlife including endangered species of Tarai-Nepal. There are 32 species of mammals and more than 250 species of birds (Majupuria and Majupuria, 2006 and Dinerstein, 1979). The Greater Indian one-horned Rhinoceros (*Rhinoceros unicornis*), Royal Bengal Tiger (*Panthera tigris*) and Barha Singha or Swamp Deer (*Cervus duvauceli*) are worldwide endangered mammalian species of this park (Moe, 1994). Other endangered species include Elephant (*Elephas maximus*), Hispid hare (*Caprolagus hispidus*), Pigmy hog (*Sus salvinus*), Leopard cat (*Felis bengalensis*), Gangetic dolphin (*Platanista gangetica*) and Gharial (*Gavialis gangeticus*). Similarly,

Blue bull (*Boselaphus tragocamelus*), Striped Hyaena (*Hyana hyena*), Smooth coated otter (*Lutra perspicillata*), Ghoral (*Nemorhaedus goral*) are rare species reported from this park.

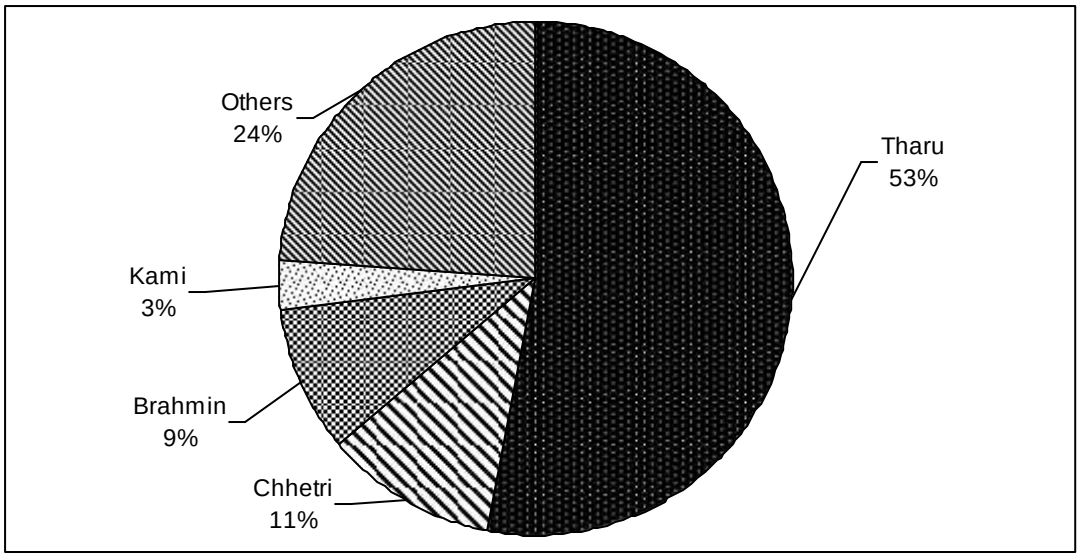
The common ungulates are spotted deer (*Axis axis*), Sambar (*Cervus unicolor*), hog deer (*Axis procinus*), Four-horned antelope (*Tetraceros quadricornis*), barking deer (*Muntiacus muntjak*) and wild boar (*Sus scrofa*). Spotted deer is probably the most important prey species of the tiger population (Wegge *et al.* 1991). Outside the national park Blackbuck is found in Khairapur that is also under the management of BNP.
Langur (*Semnopithecus entellus*), Rhesus monkey (*Macaca mullata*), common leopard (*Panthera pardus*), Jungle cat (*Felis chaus*), Fishing cat (*Felis viverrinus*), Palm civet (*Paguma larvata*), Mongoose (*Herpestes species*), Large Indian civet (*Viverricula indica*), Wild dog (*Cuon alpinus*), Jackal (*Canis aureus*), Sloth bear (*Ursus ursinus*), Percupine (*Hystrix species*), Bandicoats (*Bandicota species*) etc are common mammals of BNP.

The important avifauna of this park include 10 species of Wood peckers, 7 species of Dronges, 5 species of each Herons, Doves, Bulbuls, 4 species of each Egrets, Parakeets, Kingfishers, Bee-eaters, Barbets; 3 species of pigeons, Cormorants, Painted stork, Merganser duck, Red Jungle fowl, Flycatcher, Sunbirds, Bar-headed goose, Comb duck, Common Peacock, Red-wattled lapwing and Babblers (Majupuria and Majupuria, 2006).

The rare birds of this park are Giant pied hornbill, Sarus Crane (*Grus antigone*), Lesser florican (*Sypheotides indica*), Bengal florican (*Eupodotis bengalensis*), Black-necked stork (*Xenorhynchus asiaticus*), Lesser adjutant stork (*Leptotilus javanicus*) etc.

### 2.2.3 Ethnic Communities and Land Use

The total administrative area of Bardia district is 2025 square kilometer with about 3, 82,649 total populations (CBS, 2001). Bardia National Park occupies nearly half of this area. The park is surrounded by 17 Village Development Committees (VDCs). There is dominancyof Tharus, the indigenous ethnic group of western Tarai. In addition, Chhetri, Brahmin, Kami and other ethnic groups have been immigrated from different districts such as Dang, Pyuthan, Jajarkot, Arghakhanchi, Gulmi, Baglung, Kaski etc. after malaria eradication in 1960 (Figure 6).




Figuere 6. Cast wise Demographic Presentation of Bardia district (Source: CBS, 2001)

The main occupation of the people in Bardia is agriculture and 58,214 hectares of land has been under cultivation (Pokharel, 1993) of different crops like rice (*Oryza sativa*), maize (*Zea mays*), wheat (*Triticum aestivum*), mustard (*Brassica campestris*) and varieties of pulses. The annual crop production is very low and gradually declining every year due to repeated cultivation of only three crops rice, wheat and maize (Khatri, 1993). Therefore the local people are compelled to rely on wild plant species. Shrestha (1993) found 87 wild plant species (34 vegetables, 6 roots and tubers, 40 fruits and 7 mushrooms) are usually consumed by local people, which contribute 13.8% of the diet of Tharus and 4.1% among the non-Tharus. Lack of income generating sources of local people is the prime factor that compels the illegal entry and utilization of the park. Numbers of grass-cutters, firewood and vegetables collectors are seen daily around the Lower Kahuraha Phanta. Net-traps, rope-traps and wire-traps are noticed on the way along the riverside where spotted deer and other ungulates visit frequently for drinking the water. It shows the involvement of the people in trapping, hunting and illegal poaching of wildlife for their food and commercial benefits. Cattle grazing around and inside the park seems to be a common practice in the lack of grazing land. Livestock grazing in the park areas including Phanta prior to 1975 was very common (Dinerstein, 1980 and Bolton, 1976) where 279.2 individuals per square kilometer of the livestock and 43.3 to 49.7 individuals of wild ungulates used to compete for similar type of resources in the same area. This trend has increased the habitat destruction and disturbance for wild herbivores and chance of infection of domestic cattle diseases. Grass

cutting is permitted inside the park for the local people for a period of two weeks during mid winter.

The rivers like Aurahi, Babai and branches of Karnali irrigate the cultivable land of Bardia and provide fishing area for the local people, especially Tharus. But, these activities severely affect on the life cycle and survival of aquatic biodiversity. The seasonal tourism in Bardia has provided few employment opportunities to limited local people and hotel owners.

## 2.3 The Core Research Area: The Phantas

The intensive research work was conducted within five major Phantas- Lamkauli, Upper Baghaura, Lower Baghaura, Upper Khauraha and Lower Khauraha; mostly at Lower Khauraha Phanta because of abundance of spotted deer and easier accessibility from the headquarter, Thakurdwara of the park. These areas lie in the south-western part of the park. The area is flat with elevation between 100-200 m (Moe, 1994). Jnawali and Wegge (1993) categorized Lower Khauraha and Upper Khauraha as 'Wooded grassland' and Upper Baghaura, Lower Baghaura and Lamkauli as 'Phanta' type. The term 'Phanta' is used in this study to represent both the wooded grassland and open grasslands for convenience, but not to distort the core meaning of wooded grassland.

Lower Khauraha is located in the Khauraha Island approximately 0.5 km west of the park headquarter across the Khauraha River. The total area of the Phanta was measured 0.36 square kilometer [length 650m and average breadth (225+465)/2m], which was explained as 0.34 square kilometer by Pokharel (1993). Simal (*Bombax ceiba*) is the dominant among the scattered tree species of this Phanta. Hence, it is locally known as 'Simal Phanta'. Short grass species, *Imperata cylindrica* dominates the grassland. *Saccharum spontaneum* and *Narenga porphyrocoma* represent tall grass species, relatively lower density than in Baghaura Phanta. But, shrub and tree species are relatively with high density than other Phantas. Khauraha River forms the eastern boundary of this Phanta. The western and southern boundaries are demarcated by mixed hardwood and moist riverine forest along a branch of the Geruwa River. Similarly, hardwood forest lies towards the north. Two jeep-roads cross each other within Phanta dividing the habitat into four parts. The crossed point is locally called 'Chauraha' (i.e. four ways). These four parts were named as Block A, B, C and D during this study and data of population and behaviour were taken separately. The branches of scattered trees and triangular broad base is Simal trees of the Phanta provide suitable and safe

environment for ethologists sand animal researchers. Wild elephant frequently visit along the northern edge of this Phanta while tiger visit occasionally. Elephants were encountered many times during this study while only the pugmarks of tiger were recorded in this Phanta. The observation of spotted deer, wild boar, barking deer, rhesus monkey, Langur, birds including the pea fowl etc. are most common.

Upper Khauraha is also located within Khauraha Island approximately 0.5 km north-west of the Lower Khauraha and approximately 1 km from park headquarter, Thakurdwara. It is larger (0.95 $km^2$) than the lower Khauraha (0.36 $km^2$). Both tall and short grass species and shrub species are similar to that of the Lower Khauraha, while dominancy of scattered tree species is different. Dabdabe (*Garuga pinnata*) forms dominant tree species among the scattered trees of this Phanta. Hence, this Phanta is locally known as 'Dabdabe Phanta'. There is Khauraha River in the east, moist riverine and mixed hardwood forest along the branch of Geruwa River in the south and west respectively. Northern boundary is formed by mixed hardwood forest. The jeep road passes across the Phanta in 'C' shape and divides the habitat into two parts.

Lower and Upper Khauraha Phanta are separated by a narrow strip of mixed hardwood forest dominated by *Ficus glomerata, Mallotus philippensis* and *Syzygium cumini*. There is no fact information to prove that Khauraha Phantas were ever settled or cultivated like Baghaura and Lamkauli.

Lower Baghaura is located at about 3.5 km north-west from the park office. Its area is 0.84 $km^2$ and it forms typical open grassland dominated by *Imperata cylindrica*. There is relatively lesser shrub species and scattered tree species than the Khauraha Phantas. The eastern and southern boundaries of this Phanta are distinct with sal forest dominated by *Shorea robusta* and *Terminalia tomentosa*. The Khauraha River forms western boundary. A narrow strip of forest between Upper and Lower Baghaura forms northern boundary.

Upper Baghaura lies towards the north and adjacent to the lower Baghaura. It is approximately at 4 km distance from the park headquarter. Its area is 0.59 $km^2$. The south-west part is somewhat similar to the wooded grassland of Khauraha due to presence of more shrub and tree species while the northern section is dominated by the tall grass species *Narenga porphyrocoma*. The Khauraha River lies in the western edge of this Phanta.

Lamkauli Phanta is located at about 5 km north from the park headquarter. It covers 1.11 $km^2$ area. It is biggest and longest among the five Phantas. The name 'Lamkauli' is derived from the Nepali word "Lamo" (means long). This Phanta is dominated by the short grass species *Imperata cylindrica*. The northern part consists tall grass species *Saccharum spontaneum*. There are three man made ponds – two at the centre of the Phanta and the next one at the northern corner. These ponds are constructed to fulfill the water demand of wild animals, especially during dry season. A wooden tower is present at the mid-eastern part of the Phanta, which is utilized for watching and photographing wild animals. This tower is locally called as "Machan". This Phanta is relatively drier because it is surrounded by sal forest dominated by *Shorea robusta* and no proper drainage system nearby it.

Baghaura and Lamkauli Phantas were under cultivation prior to 1975 (Dinerstein, 1979). During the field visit small pieces of mud pot were found at the western edge of Lower Baghaura along the bank of Khauraha River. It is the evidence that Baghaura Phanta was not only cultivated but also settled in the past.

# 3. METHODOLOGY

## 3.1 Preliminary Field Survey

A preliminary field survey was made to Bardia National Park from 31st October to 5th November, 2005 under the direct supervision of the Academic Supervisor. The survey investigated the core research site, general location and distribution of spotted deer in the park. Similarly, information about the present population status of the spotted deer was collected by the discussion with park authorities (Chief Warden, Rangers and Game scouts), naturalists, nature guides, elephant drivers and wildlife officials from INGOs and NGOs (including BCP, TAL and NTNC). Besides, the study area was visited on foot and by bicycle. Techniques for behavioural data collection, direct observation, observation through binoculars and photography were practiced.

## 3.2 Field Survey

The actual field survey was initiated from 1st April to 10th May, 2006 for spring season and another visit was made from 15th September to 29th September, 2006.

## 3.3 Population Status

### 3.3.1 Population Census

Population status of spotted deer was determined by using direct count method. Binocular of 12x50 mm was used for keen observation. The census was especially concentrated within five major Phantas of the park in support of three experienced senior and junior nature guides. Tree trunk, Machan and back of Simal tree were used for observation so as to reduce the error of counting. The total counting was done age wise and sex wise and repeated several times for more replications. During the total count, the exact total numbers were different at the same place in different replicates. Hence to reduce biasness, total population was estimated by using statistical theorem as given by Quenoiilli (1956).

$$N = 2n_k - n_{k-1} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where, N = Estimated Population

$n_k$ = Highest Value of Observed Population , and

$n_{k-1}$ = Second Highest Value of Observed Population

The approximate upper confidence limit ($N_u$) at 100 (1-a) % is obtained by:

$$N_U = n_k + \left(\frac{1-a}{a}\right)(n_k - n_{k-1}) \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where, $N_U$ = Upper Confidence limit of population, and

a = the level of test

Similarly, at given confidence limit, the lower limit of population is given by:

$$N_L = n_k$$

Hence, the range of the total number N is given by:

$$N_L < N < N_U$$

This method was also used by Erickson and Siniff in 1963 for aerial survey of brown bears along a series of streams during a Salmon run in U. S. A.

### 3.3.2 Population Density

The total number of individuals of a species per unit area is known as population density. It may be in fraction or in whole number. On the basis of area occupied, population density can be expressed as i) Crude density and ii) Realized or Ecological density.

i) Crude Density refers to the total number of individuals present in the total area of habitat available for them. Statistically, crude density is computed as:

$$\text{Crude Density (D)} = \frac{\text{Total Number of Individual (N)}}{\text{Total Area of the Habitat (A)}}$$

ii) Realized or Ecological Density refers to the total number of individuals present in the actual area of habitat available for them. Statistically, Ecological density is computed as:

$$\text{Ecological Density (E.D.)} = \frac{\text{Total Number of Individual (N)}}{\text{Area of Actual Habitat } (A_h)}$$

### 3.3.3 Age and Sex Composition

Spotted deer were observed everyday to develop a method for classifying different age and sex composition. Age and sex structure were determined by observing animals through binoculars (12x50 mm) from a distance. The spotted deer are also known to follow Rhesus monkey troops to feed on the leaves and fruits dropped by the monkeys. In fact, it is a standard method to mimic the chatter of monkeys to lure the deer (Chaudhary, 1966). If imitated by someone adept in the art and accompanied by shaking

and shedding of branches, leaves, buds and fruits, the deer would arrive within minutes. I also practiced it and counted them age wise and sex wise from a short distance.

Three age groups of spotted deer were distinguished as mentioned by Schaller (1998).

**a) Fawns (<1 year)**

They have lighter brown coloured coat with white spots, smaller size and always remain in association with their mothers. In absence of antlers, urination posture is basically used for the identification of sex classes among fawns. Similarly, the area that is licked by the doe after suckling the neonate is another key to identify the sex of neonate (Khanal, 2006).

**b) Yearlings (1 Year < 2 Years)**

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

**c) Adult (>2 Years)**

Adult buck could be easily identified from the yearling males as they have antlers with tines. There is clear dorsal back stripe in both sexes while the male possess black marking on face. The adult female is larger than the yearling female. The adult buck has larger neck, muzzle and head than that of the adult female. The height at the shoulder of matured buck is greater than the matured doe.

### 3.3.4 Herd Composition and Size

Herds were identified as the group of individual(s) grazing, resting or moving together at the time of observation. A regular fusion and fission of herds were noticed during the study period. For the better statistical representation of the average herd size the method prescribed by Martin (1977) was used. For this, the total number of spotted deer observed during the study period was divided by the total number of herds observed during the same time.

$$\text{Average Herd Size} = \frac{\text{Total Number of Individual Observed}}{\text{Total Number of Herds Observed}}$$

Different herd types were identified among different age and sex groups of spotted deer. They were mixed herd (Males + Females + Fawns, with loose aggregation), male band (Males of different age group), breeding herd (A mature buck with breeding does), a buck with a doe during the breeding period, female-fawn herd (mature and yearling does with fawns), single doe with her fawn, bucks with fawns, a single buck, a single doe, the group of females (mature and yearling does).

### 3.4 Distribution

Distribution of spotted deer during winter and early dry season were recorded within approximately 30 $km^2$ areas between Lamkauli Phanta, Baghaura Phantas, Khauraha Phantas and their surroundings. 45 different samples of spotted deer were analyzed to compute the types of distribution. The statistical formula as described by Odum (1996) was used to calculate the ratio of variance to the mean value $\left(\frac{s^2}{\bar{x}}\right)$.

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

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

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

Where, the variance $\left(S^2\right)=\frac{1}{n}\sum\left(x-\bar{x}\right)^2$

$\bar{x}$ = mean value

To investigate the significant differences in distribution of spotted deer in different studied samples Chi-square Contingency test was conducted.

$$\text{Chi}-\text{square}\left(\chi^2\right)=\sum\frac{(O-E)^2}{E}$$

Where, O = Observed value and E = Expected value

### 3.5 Diurnal Activities and General Behaviour

For the behavioural study of spotted deer, nocturnal activities could not be studied due to technical and security problems for night observation within the park. Hence, only the diurnal activities of spotted deer were studied. Data for behavioural analysis were

collected by the “Scan Sampling” and “Focal Animal Sampling” methods as described by Altman (1974).

Scan sampling method was utilized among different herds to determine the percentage of time used for an event. The duration of time utilized is taken as an important variable in behavioural data analysis. The different activities of spotted deer were classified into the following state and events.

- Feeding (Grazing and browsing)
- Alert (Standing with stamping of forelegs, producing alert voice and movement of ears towards external stimuli)
- Resting (Sitting or lying on the surface)
- Moving (Locomotion of different types and playing)
- Standing
- Others (Sparring, chasing, courtship, suckling, drinking, mating, licking)

The time schedule for behavioural data collection was divided into four shifts from early morning to evening as 6.00 – 9.00 morning shift, 9.00 – 12.00 noon as late morning shift, 12.00 to 15.00 as afternoon shift and 15.00 to 18.00 as evening shift. The successive events or states of spotted deer were recorded at the interval of five minutes. Besides, any noticeable events observed were recorded. Careful attention was given to identify age and sex composition and their activities. Different locations of the sighting of the herds among different Phantas and their numbers were carefully observed and noted.

Focal animal sampling method was utilized for a well identified animal as ‘Focal animal’ by a continuous observation for three hours at the interval of one minute. Te quantitative data on the frequency, temporal sequence and duration of events and state behaviour were recorded by this method.

The keen ocular observation of activities of spotted deer aided by the binocular of 12x50 mm. The experienced senior and junior nature guides of BNP helped for taking the behavioural data continuously.

### 3.6 Vegetation Analysis

Vegetation of spotted deer habitat was analyzed by using ecological quadrate method. Four quadrates of 60x60 $m^2$ were randomly laid on different corners of forest around

each Phanta for the tree species analysis. Similarly, 12 quadrates of each 20x20 $m^2$ and 40 quadrates of each 1x1 $m^2$ were used in each Phanta for understorey shrubs and grasses respectively. The total tree species shrub species and grass and forbs of each quadrate were identified and counted. Some of the local vegetations were locally named and some unidentified species were collected and preserved as herbarium and taken to the Central Department of Botany, TU for the taxonomic recognization.

### 3.7 Questionnaire Survey

To make own self more informative about the spotted deer, questionnaire survey was conducted among the senior and junior nature guides of BNP who have been involved for years as the guide of tourists and keep on the spot information about the wild animals and vegetation. Both the open and closed type of questions were included. The questions were mainly focused on the following aspects:

- Location, size and composition of herd and distribution of spotted deer within the park.
- Behavioural activities such as selection of vegetation for food, resting site, sparring, mating, aggression, defense, alarm and other diurnal activities.
- Survival threats like poaching, hunting, trapping, etc. of spotted deer.

Besides, they also informed about the techniques to make ownself safe from the chance of accidents and encounter with wild animals such as tiger, rhino, wild elephant, leopard, snakes, bear, rhesus monkey etc. during the field visit which are vital tips for a research beginner.

### 3.8 Interview and Discussion

Formal and general interviews were conducted among park authorities such as Chief Warden, ranger, game scouts and other officials and discussed who have been directly involved for the conservation and management of spotted deer for several years. Similarly, general interviews and discussions were made with the officials of NGO and INGO like NTNC, BCP, TAL etc. who are locally working in collaboration with the park for the wildlife conservation and management.

# RESULT

## 4.1 Population Status of Spotted deer in Five Major Phantas of BNP

### 4.1.1 Population Estimation

Spotted deer, as a common animal could not be counted exact total number within the whole park by direct count method. They were counted at the different intervals of day shifts from early morning 06.00 hours to the evening 18.00 hours while grazing in and around the Phantas and at the junction between Phantas and forest. The first counting was done on November 2005, second and third counting was made on April, 2006 and September, 2006 respectively.

The total number of spotted deer population was found to be different in the same place at different time intervals. Therefore the maximum number and second maximum number of spotted deer observed in five different Phantas during the entire field visit duration (Table 1) were used to estimate the upper and lower range of population at 90%, 95% and 99% confidence limits (i, e. 0.10, 0.05 and 0.01 level of test respectively.

Table 1. Population Status of Spotted deer in five major Phantas of BNP in 2006

| S. N. | Phantas | Spotted deer Population Observed | |
|---|---|---|---|
| | | Maximum ($n_k$) | Second Maximum ($n_{k-1}$) |
| 1 | Lower Khauraha | 107 | 106 |
| 2 | Upper Khauraha | 115 | 114 |
| 3 | Lower Baghaura | 45 | 43 |
| 4 | Upper Baghaura | 56 | 54 |
| 5 | Lamkauli | 28 | 25 |
| Total | | 351 | 342 |

Among five major Phantas the maximum number of wild population of Spotted deer (115) were observed at Upper Khauraha Phanta and the least (28) in Lamkauli Phanta during the observation period.

Among five major Phantas of BNP, the percentage of spotted deer population was highest at Upper Khauraha (32.76%), followed by Lower Khauraha (30.48%), Upper Baghaura (15.95%), Lower Baghaura (12.82%) and the least at Lamkauli (7.98%) (Figure, 7).

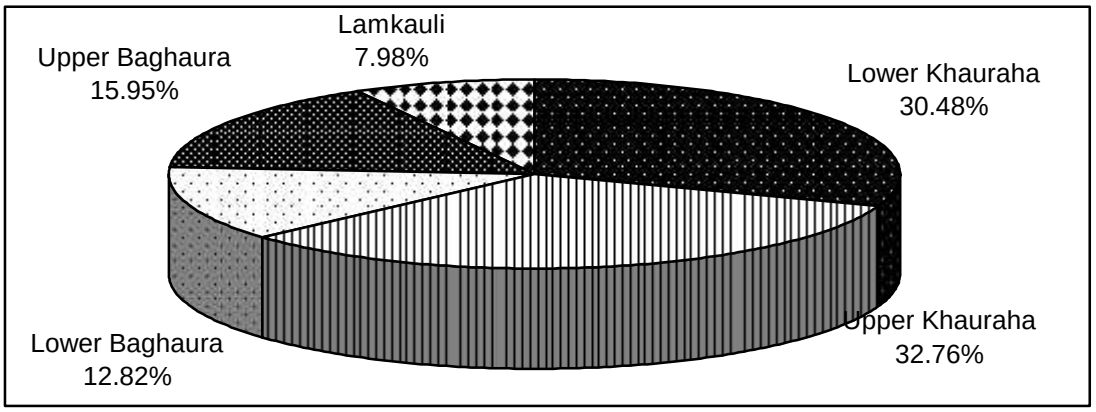



Figure 7. Percentage of Population of Spotted Deer in Different Phantas of BNP in 2006

On using the statistical formula given by Quenouilli (1956), the population (N) of spotted deer were found as: $N_U = n_k + \left(\frac{1-a}{a}\right)(n_k - n_{k-1})$

Where, $N_U$ = Upper limit of population, a = the level of test

At a given level of test, the lower confidence limit ($N_L$) is equal to the largest value of total number of individuals ($n_k$) i. e. $N_L = n_k$.

The population range was seen highest in Lamkauli Phanta where as the least range was computed in Lower and Upper Khauraha at all levels of test (i.e. 90%, 95% and 99% confidence limits). The lower limit of population was found to be highest as 115 in Upper Khauraha and the least as 28 in Lamkauli Phanta. At 90% and 95% confidence level the upper limits are highest as 124 and 134 respectively in Upper Khauraha while least as 55 and 83 in Lamkauli and Lower Baghaura respectively. But, at 99% confidence level the upper limit was highest as 325 in Lamkauli and least as 206 in Lower Khauraha. The population range at 95% confidence level of test is very close to the actual range of population of spotted deer in major Phantas of BNP (Table 2).

Table 2. Range of Population of Spotted deer in five major Phantas of BNP in 2006.

| **S. N.** | **Phantas** | **$N_L = n_k$** | **Range of Estimated Population (N)** | | |
|---|---|---|---|---|---|
| | | | **Levels of Test** | | |
| | | | **0.10 (90%)** | **0.05 (95%)** | **0.01 (99%)** |
| 1 | Lower Khauraha | 107 | 107<N<116 | 107<N<126 | 107<N<206 |
| 2 | Upper Khauraha | 115 | 115<N<124 | 115<N<134 | 115<N<214 |
| 3 | Lower Baghaura | 45 | 45<N<63 | 45<N<83 | 45<N<243 |
| 4 | Uppper Baghaura | 56 | 56<N<74 | 56<N<94 | 56<N<254 |
| 5 | Lamkauli | 28 | 28<N<55 | 28<N<85 | 28<N<325 |

### 4.1.2 Population Density of Spotted deer

The different ranges of estimated wild populations of spotted deer were used to find out the crude density (D) of spotted deer at five different Phantas of the park. The lower limit of crude population density was found to be highest as 297 individuals/$Km^2$ in Lower Khauraha and least as 25 individuals/ $Km^2$ in Lamkauli Phanta at all levels of test. Similarly, the upper limit of the crude density was found to be highest as 572 individuals/$Km^2$ (at 99% confidence limit) in Lower Khauraha and least as 50 individuals/$Km^2$ (at 90% confidence limit) at Lamkauli Phanta.

The range of crude density of Spotted deer was highest as 95 to 431 individuals/$Km^2$ (at 99% confidence limit) in Upper Baghaura and least as 121 to 131 individuals/$Km^2$ (at 90% confidence limit of test) in Upper Khauraha. At 90%, 95% and 99% confidence level of test the upper limits of crude density were highest as 322 and 350 and 572 individuals/$Km^2$ respectively all in Lower Khauraha Phanta while least as 50 and 77 individuals/$Km^2$ respectively in Lamkauli Phanta and 225 individuals/$Km^2$ in Upper Khauraha Phanta respectively. Similarly, the lower limits of crude density was found to be highest as 297 individuals/$Km^2$ in Lower Khauraha and least as 25 individuals/$Km^2$ in Lamkauli at all levels of tests (Table 3).

Table 3. Range of Crude Density (individuals/$Km^2$) at Five Major Phantas of BNP in 2006.

| S. N. | Phanta | Area ($Km^2$) | Range of Crude Density (D) | | |
|---|---|---|---|---|---|
| | | | Levels of Test | | |
| | | | 0.10 (90%) | 0.05 (95%) | 0.01 (99%) |
| 1 | Lower Khauraha | 0.36 | 297<D<322 | 297<D<350 | 297<D<572 |
| 2 | Upper Khauraha | 0.95 | 121<D<131 | 121<D<141 | 121<D<225 |
| 3 | Lower Baghaura | 0.84 | 54<D<75 | 54<D<99 | 54<D<289 |
| 4 | Upper Baghaura | 0.59 | 95<D<125 | 95<D<159 | 95<D<431 |
| 5 | Lamkauli | 1.11 | 25<D<50 | 25<D<77 | 25<D<293 |

### 4.1.3 Age and Sex Composition

The maximum numbers of spotted deer observed in five Phantas of BNP during the observation period were used to compute age and sex ratio in each Phanta.

The maximum number of spotted deer observed during the study period at Lower Khauraha Phanta was 107. Out of them, total males were 28 (26.17%), females 57 (57.27%) and fawns 22 (20.56%). The male to female sex ratio was computed to be 1:1.49 i.e. 49.12 bucks among 100 does. Among 40 adults, male to female sex ratio was

found to be 1:2.08 i.e. 48.15 adult bucks to 100 adult does. Among 45 yearlings, male to female sex ratio was found to be 1:2 i.e. 50 yearling bucks to 100 yearlings does (Figure 8).

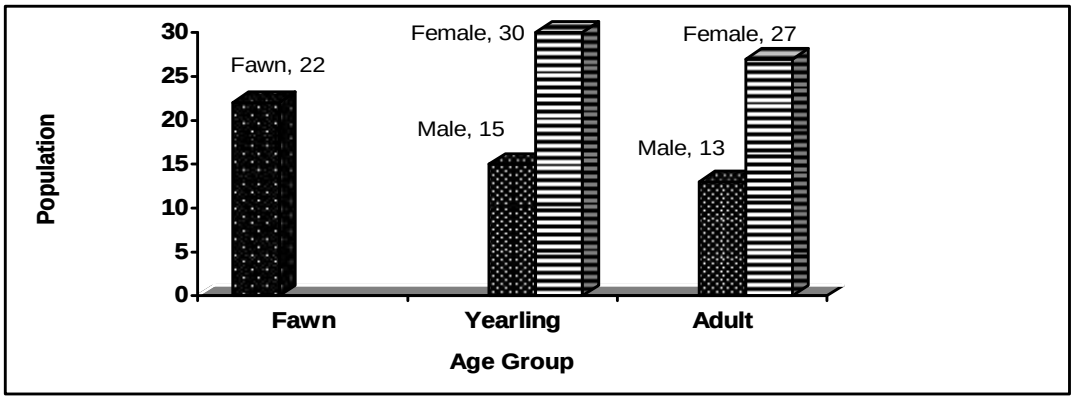



Figure 8: Age and Sex Composition of Spotted deer at Lower Khauraha Phanta of BNP in 2006.

In the above, yearling and adult age groups of wild Spotted deer population at Lower Khauraha Phanta of BNP, there were more females than males which departed significantly from 1:1 sex ratio ($X^2 = 9.894$, d. f. = 1, $p<0.05$).

The maximum number of spotted deer observed during the study period at Upper Khauraha Phanta was 115. Out of them, total males were 29 (25.22%), females 63 (54.78%) and fawns 23 (20%). The male to female sex ratio was computed to be 1:2.17 i.e. 46.03 bucks to 100 does.

Among 43 adults, male to female sex ratio was found to be 1:2.3 i.e. 43.33 adult bucks to 100 does. Among 49 yearlings, male to female sex ratio was computed to be 1:2.06 i.e. 48.48 yearling bucks to 100 yearlings does (Figure, 9).

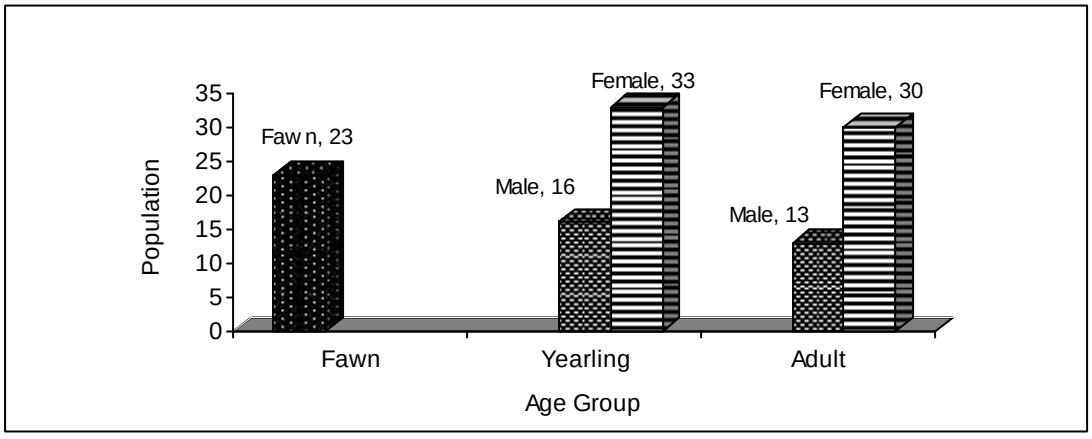



Figure 9: Age and Sex Composition of Spotted deer at Upper Khauraha Phanta of BNP in 2006.

In above yearling and adult age groups of wild population of spotted deer at Upper Khauraha Phanta of BNP, there were more females than the males which departed significantly from the 1:1 sex ratio. ($X^2$ = 12.565, d. f. = 1, $p<0.05$).

At Lower Baghaura Phanta of BNP, the maximum number of spotted deer observed was 45. Out of them total males were 11 (24.44%), females 20 (44.44%) and fawns 14 (31.11%). The male to female sex ratio was computed to be 1:1.82 i.e. 55 bucks to 100 does. Among 17 adults, male to female sex ratio was found to be 1:1.83 i.e. 54.54 adult bucks to 100 does. Among 14 yearlings, male to female sex ratio was found to be 1:1.8 i.e. 55.55 yearling bucks to 100 yearlings does (Figure 10).

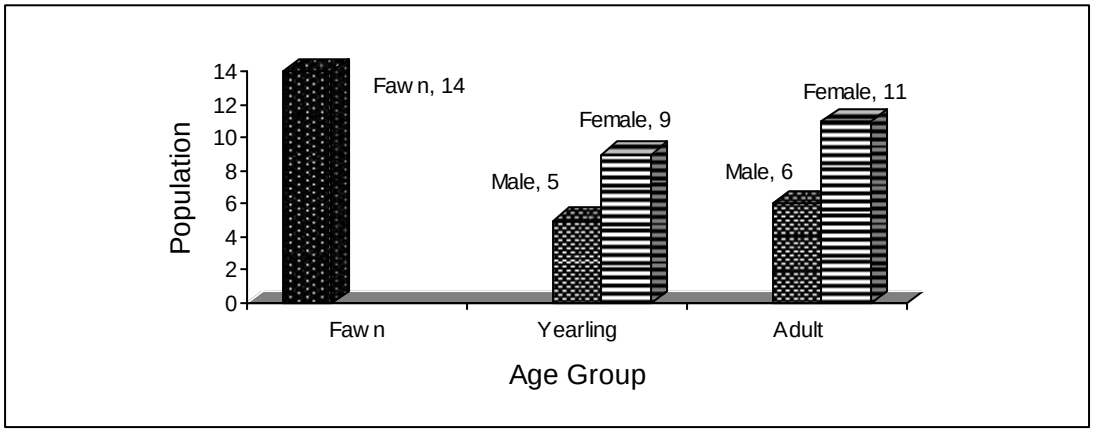



Figure 10: Age and Sex Composition of Spotted deer at Lower Baghaura Phanta of BNP in 2006.

In above yearling and adult age groups of wild population of spotted deer at Lower Baghaura Phanta of BNP, there were more females than the males, but, in no age group did this depart significantly from the 1:1 sex ratio. ($X^2$ = 2.612, d. f. = 1, $p<0.05$).

The maximum number of spotted deer at Upper Baghaura Phanta was recorded 56 during the study period. Out of them, the total males were 10 (17.86%), females 30 (53.57%) and fawns 16 (28.57%). The male to female sex ratio was computed to be 1:3 i.e. 33.33 bucks to 100 does. Among 26 adults, male to female sex ratio was computed to be 1:3.33 i.e. 30 adult bucks to 100 adult does. Among 14 yearlings, male to female sex ratio was computed as 1:2.5 i.e. 40 yearling bucks to 100 yearling does (Figure 11).

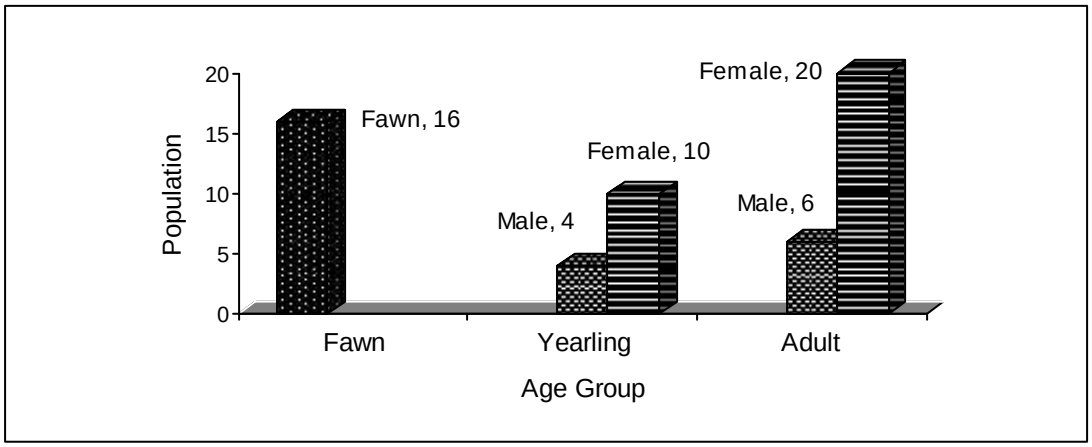



Figure 11: Age and Sex Composition of Spotted deer at Upper Baghaura Phanta of BNP in 2006.

In above yearling and adult age groups of wild population of spotted deer at Upper Baghaura Phanta of BNP, there were more females than the males that departed significantly from the 1:1 sex ratio. ($X^2 = 10.00$, d. f. = 1, $p<0.05$).

At Lamkauli Phanta of BNP, the maximum number of spotted deer observed during the field visit was 28. Out of them, the total number of males were 8 (28.57%), females 13 (46.43%) and fawns 7 (25%). The male to female sex ratio was computed to be 1:1.625 i.e. 61.54 bucks to the 100 does. Among 11 adults, male to female sex ratio was found to be 1:1.75 i.e. 57.14 adult bucks to 100 adult does. Among 10 yearlings, male to female sex ratio was found to be 1:1.5, i.e. 66.67 yearling males to 100 yearling does (Figure 12).

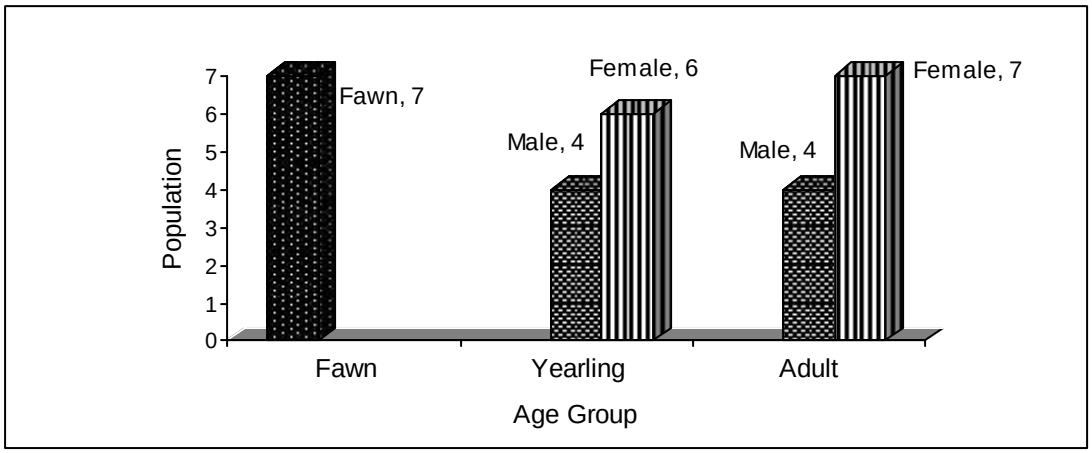



Figure 12: Age and Sex Composition of Spotted deer at Lamkauli Phanta of BNP in 2006.

In above yearling and adult age groups of wild population of spotted deer at Lamkauli Phanta of BNP, there were more females than the males, but, in no age group did this depart significantly from the 1:1 sex ratio. ($X^2 = 1.19$, d. f. = 1, $p<0.05$).

### 4.1.4 Herd Size and Composition

The fluid groups or herds of native spotted deer were noticed changed in size temporarily and continuously in different Phantas of Bardia National Park during the observation period. The group fusion-fission system of the fluid group formation and dissolution were common observations during the research. Rainfall, wind blow, availability of drinking water and palatable vegetation, season, sun struck, crown coverage of tree for shading, time of the day and disturbances from predator, visitor etc. were seen as major limiting factors of bringing variations in herd size of spotted deer. The average herd size was found to be of 16.76 individuals which were computed from 8,683 individuals counted among 518 herds during the study period. Among them the most common herds were mixed herds (76%), followed by female-fawn group (16%). The male band and single isolated male or female were least seen. The largest herd size of 84 individuals including males, females and fawns of different ages were observed at Upper Khauraha Phanta during the 17.55 hours evening of 24$^{th}$ September, 2006 when the weather was cooler with slow and pleasant blow of wind.

## 4.2 Distribution Pattern of Spotted Deer in Major Phantas of BNP

The questionnaire survey reported that the distribution of spotted deer was concentrated towards northern-west corner of the BNP, where plenty of open grassland and water resources had been providing suitable habitat for their survival. The general study area was about 30 km$^2$ covering Khauraha Island, Baghaura Island, Lamkauli Phanta and their adjoining shrub-lands, water holes and forests. A total population of 832 individuals was recorded from sixteen different locations during field visit. Among them, highest number of individuals was recorded from Upper Khauraha Phanta (115) and that of least in Khauraha River bank (12) (Table 4).

Table 4. Population of spotted deer in 16 different locations of BNP in 2006.

| S. N. | Block | No of Herds | Total Population | Locations |
|---|---|---|---|---|
| 1 | A | 2 | 28 | Riverine forest between Khauraha river and park Headquarter. |
| 2 | B | 5 | 75 | Riverine forest between Lower Khauraha Phanta and Khauraha River. |
| 3 | C | 2 | 12 | Khauraha River bank. |
| 4 | D | 4 | 107 | Lower Khauraha Phanta. |
| 5 | E | 3 | 46 | Mixed Hardwood forest between Lower Khauraha and Manau River (A branch of Karnali River). |
| 6 | F | 2 | 59 | Grassland on the bank of Manau River. |
| 7 | G | 3 | 34 | Mixed Hardwood forest between Lower Khauraha Phanta and Upper Khauraha Phanta. |
| 8 | H | 3 | 115 | Upper Khauraha Phanta. |
| 9 | I | 15 | 109 | Sal-sissoo forest between Upper Khauraha and Lower Baghaura Phanta. |
| 10 | J | 1 | 17 | Khauraha Riverside between Upper Khauraha and Lower Baghaura Phanta. |
| 11 | K | 2 | 45 | Lower Baghaura Phanta. |
| 12 | L | 3 | 28 | Sal forest from east to Lower Baghaura Phanta. |
| 13 | M | 2 | 56 | Upper Baghaura Phanta. |
| 14 | N | 3 | 32 | Sal forest between Upper Baghaura and Lamkauli Phanta. |
| 15 | O | 2 | 28 | Lamkauli Phanta |
| 16 | P | 3 | 41 | Adjoining Sal forests of Lamkauli Phanta. |
| Total | | 55 | 832 | |

The variance to mean ratio was used to determine the distribution pattern of spotted deer among different blocks. The calculated value of variance to mean ratio was found to be 19.61. Since the value of $\left(\frac{s^2}{\bar{x}}\right)$>1, the result has shown clumped or uneven type of distribution of spotted deer in BNP.

Chi-square Contingency test was used to test the significant differences in distribution of spotted deer in different observed blocks. The calculated value of Chi-square at 15 degree of freedom and 0.05 level of significance was found to be 313.83 which is greater than that of tabulated value 24.996. The higher calculated value of chi-square showed significant difference in population distribution of spotted deer among different study blocks of BNP.

### 4.2.1 Distribution Pattern of Spotted Deer in the Intensive Study Area

A total population of 107 individuals of mixed herds of spotted deer was observed among four different blocks A, B, C and D of Lower Khauraha Phanta (Table 5). Among them highest population was found in Block B, which was dominated by *Imperata cylindrica* and least population was found in Block C, that was dominated by *Saccharum spontaneum*.

Table 5: Population of spotted deer in different study blocks of Lower Khauraha Phanta in 2006

| Blocks | Habitat Type | Total Population |
|---|---|---|
| A | *Imperata* dominated | 27 |
| B | *Imperata* dominated | 33 |
| C | *Saccharum* dominated | 23 |
| D | Forbs dominated | 24 |
| Total | | 107 |

The ratio of variance to mean $\left(\frac{s^2}{\bar{x}}\right)$ of spotted deer population among four different study blocks was found to be 0.567. Since the value of $\left(\frac{s^2}{\bar{x}}\right) < 1$, the type of distribution was regular or even within the lower Khauraha Phanta of BNP.

In the Chi-square contingency test, the calculated value of Chi-square at 3 degree of freedom and 0.05 level of significance was found to be 2.270 which is lesser than that of the tabulated value 7.815. The lower calculated value of Chi-square showed that there was no significant difference in the distribution of spotted deer population within different study blocks of Lower Khauraha Phanta of BNP.

# PHOTO PLATES

A yearling spotted deer following her mother

A female-fawn herd in alert posture

A matured female spotted deer

A matured male spotted deer in velvet

A threatened female about to escape away

Spiked yearling male in alert posture

A termite mould licked by spotted deer

A female spotted deer drinking water from water hole in rainy season

## 4.3 General Behaviour and Diurnal Activity Pattern

### 4.3.1 General Behaviour

#### 4.3.1.1 Social Behaviour

The spotted deer were found to have gregarious in nature. They like the company of others of their own kind. It was common for small groups to rest, feed and travel together. A single buck, doe or small groups frequently leave their bedding spots and drift together to the larger herds while feeding. When left behind, individuals were seen hurry to catch up with the main group. Harem-gathering and herding by elder bucks was not commonly seen, although occasionally a large old buck with large antlers used to do so to a limited degree. The common belief that bucks are the leaders of the herd, or that they will protect the does and fawns from danger were not experienced among the social interaction of wild spotted deer in the park. When the danger threatened and a group took flight, it was rarely a buck that leaded them off, but rather an old doe.

The social aggregation of spotted deer was found very loose and temporary. The assemblage was easily broken and united during the minute danger and disturbance. The groupings were affected by climatic change, food and water availability and season. Larger groups were noticed during evening with slow blow of wind and plenty of palatable grass for grazing. They used to follow well-used trails that form a network throughout their range during traveling to and from feeding grounds and rivers. The herd used to travel in queue especially in the narrower trail, and generally leading by an elder female.

The most common herds were mixed herds with larger numbers of does followed by smaller number of fawns and bucks, female-fawn herds consisting of elder doe, younger doe with her fawns; breeding herds consisting elder male with does at the rut season. The male band consisting 2 elder and 6 younger bucks were seen only twice during the whole field visit. The single isolated male and isolated females were occasionally seen traveling and grazing within the middle of Phantas during afternoon of April between 10.00 to 16.00 hours. In isolation the buck was seen grazing well but that of the doe was traveling more with occasional grazing. The doe started well grazing only after mixing with the larger herd. The fawns had frequently been observed playing during 9.00 to 11.00 hours in the morning and 17.00 to 18.00 hours in the evening of April. Playing was in the form of leaping back and forth, random and zigzag run through the brush. While playing, the tail was held up with the hair flared out and the infra-orbital scent glands frequently opened wide in excitement. Sometimes they were seen playing with head butting fights.

The spotted deer were seen resting in small groups under the tree-shed after feeding at noon of April. They used the tree-shed during the rainy season too. When a group of spotted deer felt threatened, a short and sharp ‘Yowp!’ sound was uttered only once and almost were instantly flight away within few seconds.

#### 4.3.1.2 Territorial Behaviour

The aggressive and bullying natures of bucks were evident in fawns, more developed in pike bearing bucks and well developed among adult bucks. The fawns used to butt each other to get the preferred food. The fawns were also seen butting their mother for getting petted from their mother. The spiked bucks were seen more aggressive towards each other and also towards does. They frequently used their weapons to bully and shove does that get in their way. Two spiked bucks with about 10-12 inch needle-sharp spike antlers approached each other, stalked stiff-legged and pawed the ground. Then, they put their heads together and began to shove back and forth each other. They battled for 2-3 minutes but none of them were seen as winner i.e. the battle was ended in draw. Meanwhile they resumed their normal grazing as though they were not in battle but in play. The adult bucks were seen normally aggressive towards the younger bucks during breeding season. They dominated the younger bucks and chased them away from the group of does.

The hard-antlered bucks dominated those in the velvet. The "signpost" habit reflecting territorial behaviour was observed among the bucks. On the evening of 5$^{th}$ April at 17.05 hours a matured buck at the western edge of Lower Khauraha walked up to the bush, lowered his antlers, and brushed them through the twigs with a back and forth motion. Sometime, the motion was up-and-down swing. This process was repeated for three times. Then he scraped the ground alternately with each front foot many times, and then brushed his antlers through the twig again. More than 15 such scraps were noticed within the way from Lower Khauraha Phanta to Upper Khauraha Phanta. Mostly signpost scraps were found around the resting areas. One large buck in velvet was observed to stand on his hind legs and brush his antlers through the twigs of an Asare tree. The scene was seen like fighting of the buck with tree.

The matures bucks were occasionally engaged in friendly shoving matches, but usually they kept out of each other's way, bristling as they passed but stepping wide of each other. The threatening attitude of buck was performed by raising the hair on the neck and body, making them appear larger, the tail was partly raised heads were tilted partly sideways and the chin was tucked in. Their face wrinkled up, with the lips curled back. The scent glands spread wide open, ears laid back and eyes rolling up widely; they began to stalk back and forth slowly and threateningly with legs hold stiffly and hind leg dragging the ground at each slow step. They produced low hisses with each breath. They were pawing the ground with front feet and hooking at grass with the antlers. During the rut period the large buck had swollen neck and hard antlers. His aggressiveness was seen at its peak. Serious fights were noticed between two bucks with wounded necks but no bucks were killed by fighting. During the fight, the bucks jerked their head down, raised

their body hair and neck hair, tail was partly raised, legs hold stiffly and hind limb dragged the ground with full energy. They pushed each other in back and forth. Low hissing sound was frequently heard together with the sound of striking their antlers each other. But, no spark from the antler striking was observed. A doe used to bite and sometimes strike with her front feet to the younger does when she was interfered by the later while grazing. Except this, no other aggressive behaviour was observed among females.

#### 4.3.1.3 Feeding Behaviour

Lower Khauraha was chosen as the core study area for the feeding behaviour of spitted deer. The Phanta was divided into four blocks namely: Block A, Block B, Block C and Block D on the basis of the relative density of the dominant plant species and availability of scattered trees (Table 6).

Table 6: Study Blocks and Habitat Types in Intensive Study Area

| **Block** | **Habitat Type** | **Dominance %** | **Major Tree Species** |
|---|---|---|---|
| Block-A | *Imperata* dominated | 55.52% | *Bombax ceiba* |
| Block-B | *Imperata* dominated | 47.21% | *Bombax ceiba* |
| Block-C | *Saccharum* dominated | 42.93% | *Mallotus phillippensis* |
| Block-D | Forbs dominated | 47.20% | *Mallotus phillippensis* |

The spotted deer are truly herbivorous. They are mainly grazer and seldom browser. They preferred open grassland. They were mostly observed grazing on block A (46.73%) and block B (25.43%) which were dominated by *Imperata cylindrica*. Only playful grazing was noticed towards the western side of block D (17.19%), which was dominated by forbs. The grazing in Block C (10.65%) was comparatively less preferred. Block C and block D were used for resting during the scorching Sun of mid-day April. The semi-dry naturally fallen leaves of *Mallotus philippensis* and *Bombax ceiba* were seen fed by spotted deer (Table 7).

Table 7: Number of herds of spotted deer observed in different blocks in 2006

| Block | Habitat Type | No. of Herds Observed | Percentage of Herds |
|---|---|---|---|
| Block-A | *Imperata* dominated | 193 | 46.73 |
| Block-B | *Imperata* dominated | 105 | 25.43 |
| Block-C | *Saccharum* dominated | 44 | 10.65 |
| Block-D | Forbs dominated | 71 | 17.19 |
| Total | | 413 | 100 |

A troop of *Rhesus* monkey was seen frequently together with the herd of spotted deer. The fresh buds and leaves of *Mallotus philippensis, Bombax ceiba, Syzygium cumini* etc fallen during the feeding of monkeys were fed by the spotted deer. Sometimes Langur monkeys (*Semnopithecus entellus*) performed the same job with the deer.

Out of 202 hours of study, the total time invested by spotted deer on feeding was 140.05 hours (69.33%), followed by walking 22.93 hours (11.35%), resting 18.76 hours (9.29) alert 17.07 hours (8.45%) and others 3.19 hours (1.58%). The highest percentage of grazing population was recorded around 16.00 hours (89%) and that of the lowest around 12.00 hours (27%). After 15.00 hours grazing percentage was increased and remained nearly constant till the evening (18.00 hours) (Figure 13).

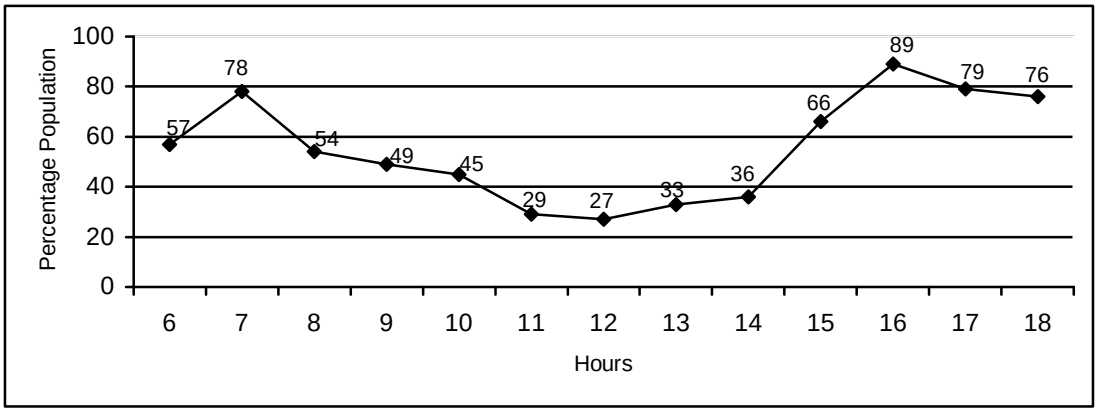



Figure 13: Percentage of grazing population of spotted deer in BNP

The first preference of spotted deer for grazing was *Imperata cylindrica*. The young stem and leaves of *Saccharum spontaneum, Cyanodon dactylon, Desmostachya bipinnata, Tamarindus indica, Medicago denticulre* etc. and forbs of different varieties were other palatable grazing items of second preference. The spotted deer in and around Khauraha Phanta were seen drinking water from the natural source of water in the Khauraha River-beds 2-4 times per day during the April. The drinking hours were around 10.00 hours in the morning, 14.00 hours in the afternoon and 18.00 hour in the evening. However, they used the clear water for drinking which were collected within the pits of the ground surface after rain. But, they were not seen drinking muddy water of the surface pits and flooding water of the river.

The traces of soil licking by spotted deer were most common within the road and open spaces of the park. Red and black soils were preferred for licking. About 10-15 cm deep horizontal depressions at the base of a termite mould made by licking was recorded within the Sal forest along the edge of Baghaura Phanta. A rare case of browsing was recorded on 5$^{th}$ April. A matured buck on the way to Khauraha River from the Khauraha Phanta approached to the edge of the forest and stopped. He displayed his head upward

towards a twig of a tree, the hind legs fixed swiftly on the ground, fore-limbs folded and got stand with hind limbs. Then leaves of the tree twig were browsed by making the head parallel to the surface within 30-40 seconds. This process was repeated for three times. But the browsing by female and fawns were not recorded during this study period.

The questionnaire survey carried out in Thakurdwara and Bankhet VDCs revealed that the case of crop raiding in the vicinity of BNP was not much serious. The majority (90%) of the respondents reported that crop damage by spotted deer was negligible. The rest (10%) of the respondents whose cultivated lands were adjacent to the park boundary reported minor damages of garden pea, lentil, potato leaves, mustard plant, young buds of corn, wheat, Rahar, black gram etc during winter season.

#### 4.3.1.4 Sexual Behaviour

Sexual behaviour of spotted deer was seen among breeding herds. A matured buck in hard antler approached to the back of the matured doe. He sniffed the female genitalia and curled lips. The doe stepped forward at 2-3 meter. Then the buck chased her for about 15 minutes. During this period, the younger males were chased or terrorized by the dominant male. The chasing of female was interrupted many times within a short circle. The pre-orbital glands of the buck were everted. When the doe became passive the buck raised it muzzle in a typical head up display, kept his chin on her rump and licked her genitalia. Then he raised his forelegs and jumped over the doe, made genital contact and pushed her forward. The doe bowed her body with a characteristic loop. The genital contact was then detached within 10-20 seconds.

The breeding buck had swollen neck, dark hair on the fore head, large antlers with shorter hairy basal pedicel and distal longer tines with or without velvet. Similarly the breeding doe had larger and protruded eyes, slimmer body and longer muzzled appearance. The doe was seen careless towards her growing fawns during the rut period.

#### 4.3.1.5 Anti-predatory Behaviour

The spotted deer were seen grazing in and around open grassland so as to access the long distance vision towards their natural predators. In the case of danger they flew away with high speed and dispersed towards different directions. They re-aggregated gradually one by another when the danger was disappeared. The hiding of deer towards bush and forest from the open grassland in the case of danger or disturbance and their reappearance after the disappearance of danger were seen like the “hide-see” game of children. The spotted deer were vigilance about the possibility of attack from their predator (such as tiger,

leopard, hyena etc) while walking along the bank of Khauraha River for drinking. They stepped slowly out of the edge of forest one by one, scanned well around the area, approached to the water, again scanned on all direction for confirmation of no danger and started drinking water. The common anti-predatory behaviours of spotted deer observed during the field visit in BNP were as follows:

#### 4.3.1.5.1 Alert Posture

When the spotted deer were disturbed or any stranger approached near them alert posture was noticed in which they stood vertically stretched out neck, raised ears and tail and ready for immediate flight if necessary. They were curiously looking towards disturbance. The ears were seen ready to receive further sound from the danger and the eyes ready to confirm the presence of danger.

#### 4.3.1.5.2 Alarm Call and Foot Stamping

When the animals were alarmed they gave sign of danger to other members by stamping their feet on the ground. One of the matured doe of the herd confirmed the presence of danger and she started to give the alarm call with "yeap!" sound with continued repetition for about 4/5 minutes. Two hind feet were alternately stamped on the ground by the caller with waving of ears. After 2/3 minutes, the first caller doe became silent with alert posture and the call was further continued for 4/5 minutes by another mature doe. The alarm call was leaded by the does but not by the bucks.

#### 4.3.1.5.3 Alert Flight

The only one means of prevention from the predator or any other danger was to escape away with high speed with a series of high gallops. The animals were in alert flight only after the confirmation of danger. On the way of Khauraha River bank, a small group of 13 spotted deer when disturbed at once by our research team, one of the matured doe jumped from about 2m cliff of river bank and crossed around 3.5m width of the river at a single gallop. During the jungle visit, many smaller and larger groups of spotted deer were seen at rest under tree shades at the noon of April. They were alerted and took a sudden flight with or without alarm call. In the case of minor disturbance, they stopped their first alert flight after crossing about 100m to 200m distance from the place of disturbance and looked back towards the danger to confirm whether the danger still existed or not.

### 4.3.2 Diurnal Activity Pattern

Diurnal activities of spotted deer were recorded from the April to July 2006 and in September 2006 during the second field visit. The total jungle time was 313 hours and animal contact time was 202 hours. The observation period was divided into four shifts; 6.00 hours to 9.00 hours, early morning shift; 9.00 hours to 12.00 hours, late morning shift; 12.00 hours to 15.00 hours, afternoon shift and 15.00 hours to 18.00 hours, evening shift. The data of 12 hours continuous observation was made by manipulating data of two successive days with identical climatic conditions. The direct ocular observation was aided with binocular. Most of the observations were made from the tree twigs and range of vision was widened by removing the tree twigs and leaves and by changing the position of observation. Scan Sampling Method and Focal Animal Sampling Method as explained by Altman (1972) were utilized to record behavioural data of the herd and individual animal respectively. The percentage of time invested for their different activities were computed as follows:

#### 4.3.2.1 Early Morning Activities of Mixed Herds

A total 1120 individuals of the mixed herds were scanned for the study of activities of early morning shift (6.00 hours to 9.00 hours). Most of time was invested for feeding (63%) followed by walking (14%), alert (13%), resting (8%) and others (2%) of the early morning (Figure 14).

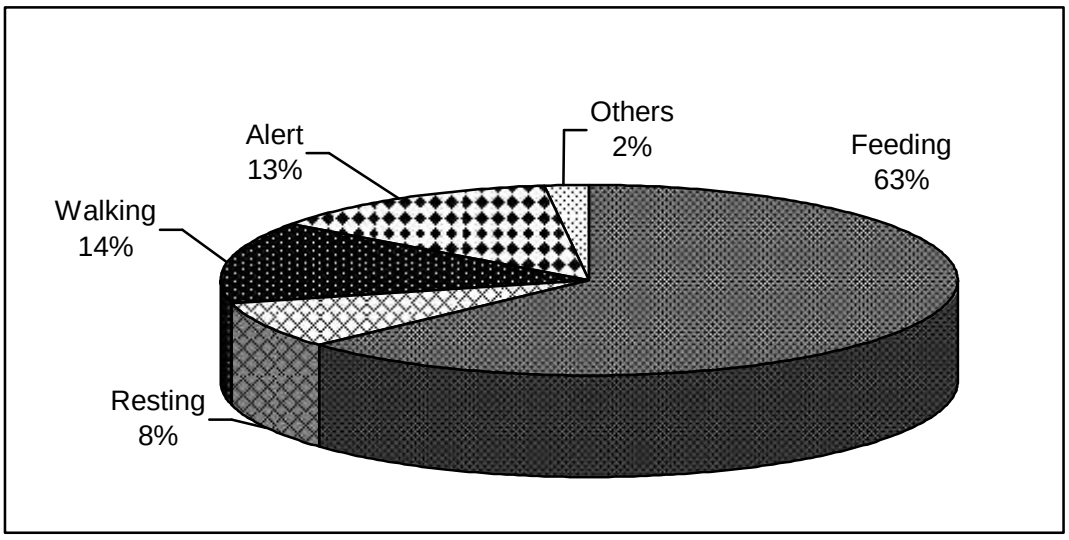



Figure 14: Early morning activities of mixed herds of spotted deer in BNP in 2006.

#### 4.3.2.2 Late Morning Activities of Mixed Herds

A total population of 192 individuals of the mixed herds was scanned for the study of activities during late morning shift. The time invested by the mixed herds was more on feeding (41%) followed by walking (21%), resting (19%), alert (14%) and others (5%) of the late morning. The activities like antler brushing by spiked bucks and sparring by adult bucks were remarkable events during this period (Figure 15).

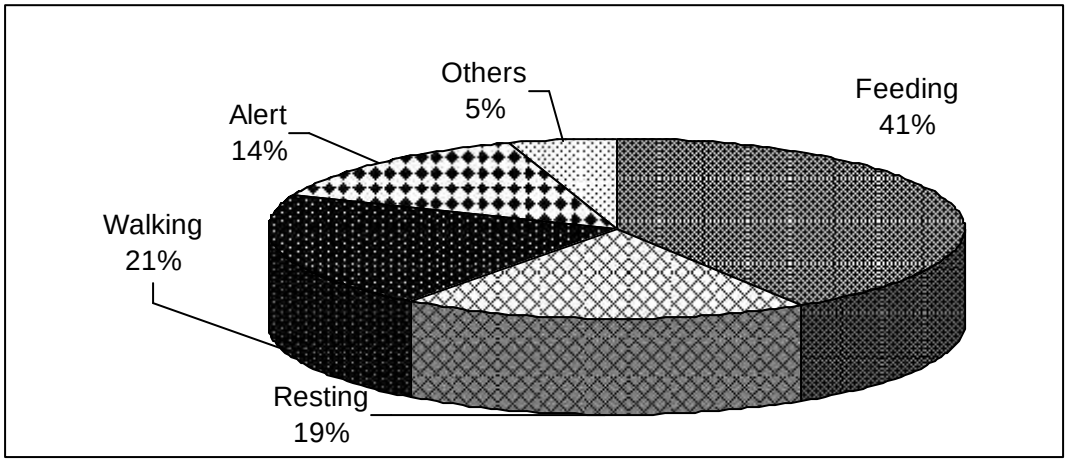



Figure 15: Late Morning activities of mixed herds of spotted deer in BNP in 2006.

#### 4.3.2.3 Afternoon Activities of Mixed Herds

A total population of 682 individuals of the mixed herds was scanned for the study of activities during late afternoon shift. The animals were found to spend more time on feeding (32%) followed by resting (28%), alert (21%), walking (18%) and others (1%) of the afternoon (Figure 16).

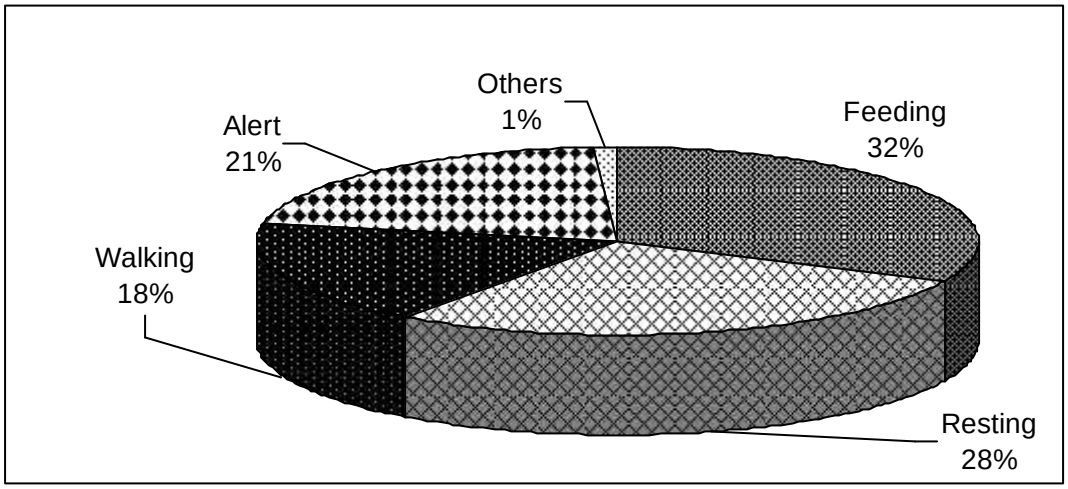



Figure 16: Afternoon activities of mixed herds of spotted deer in BNP in 2006.

#### 4.3.2.4 Evening Activities of Mixed Herds

A total of 3364 individuals of the mixed herds were scanned for the study of activities of spotted deer during the evening shift. The animals spent maximum time on feeding (78%) followed by walking (12%), resting (5%), alert (4%) and others (1%) of the evening time (Figure 17).

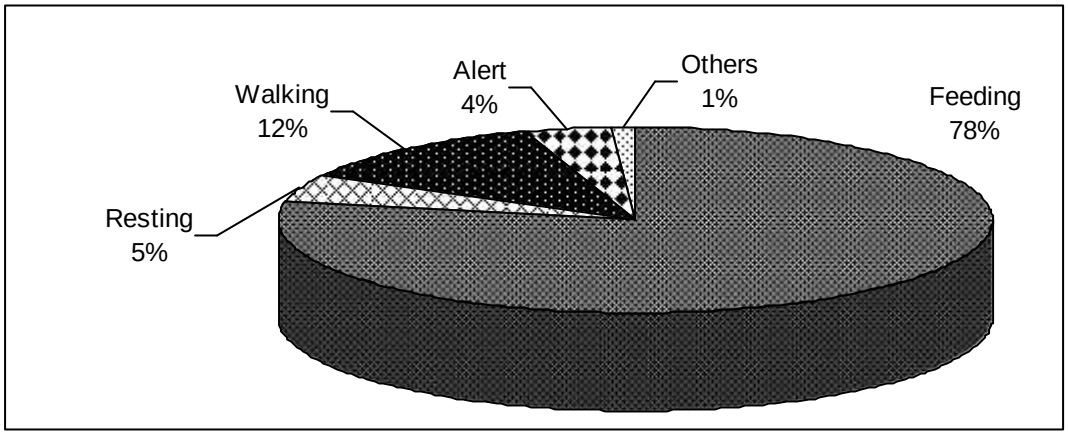



Figure 17: Evening activities of mixed herds of spotted deer in BNP in 2006.

#### 4.3.2.5 Diurnal Activities of Spotted Deer in BNP

A total of 5253 individuals of mixed herds of spotted deer were observed during the whole observation period from 6.00 hours early morning to 18.00 hours in the evening. Out of 5253 individuals, almost 3642 individuals (69.33%) were engaged on feeding followed by 596 individuals (11.35%) on walking, 488 individuals (9.29%) at rest and 444 individuals (8.45%) on alert posture. Similarly 83 individuals (1.58%) were engaged in other activities of the day (Figure 18).

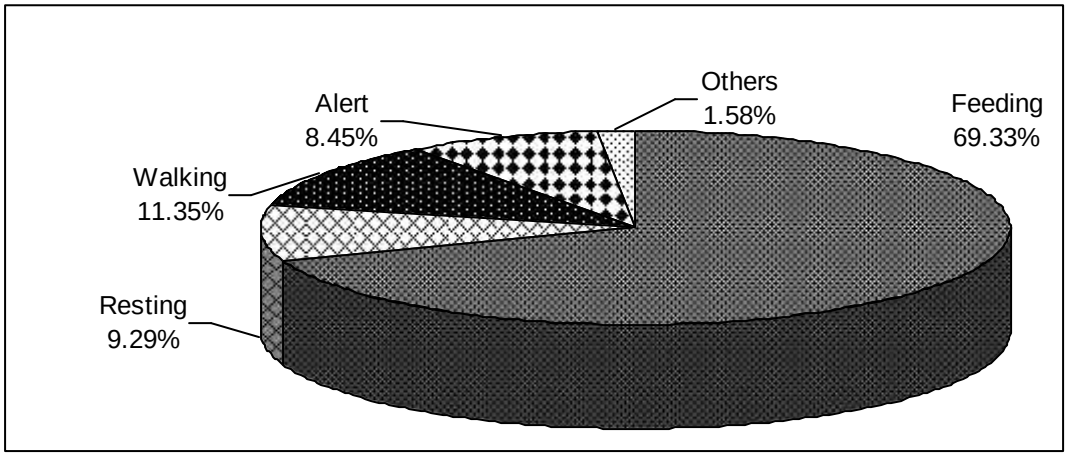



Figure 18: Diurnal activities of mixed herds of spotted deer in BNP in 2006.

Feeding was the most common activity of spotted deer in BNP. They spent maximum time on feeding during evening shift of 15.00 hours to 18.00 hours followed by 63% in the early morning shift from 6.00 hours to 9.00 hours; 41% in the late morning shift from 9.00 hours to 12.00 hours and the lowest 32% in the afternoon shift from 12.00 hours to 15.00 hours of the day. The second prior activity was walking. The animals spent maximum time (21%) on walking during late morning shift from 9.00 hours to 12.00 hours followed by 18% on afternoon shift from 12.00 hours to 15.00 hours, 14% on early morning shift of 6.00 hours to 9.00 hours and 12% on evening shift of 15.00 hours to 18.00 hours. The spotted deer were seen alert frequently when stimulated by minor or violent auditory or visual signals. They spent almost 21% time on alert during afternoon shift from 12.00 hours to 15.00 hours followed by 14% on late morning shift, 13% on early morning shift and 4% on the evening shift of the day. The deer were seen resting mostly (28%) during the afternoon shift followed by 19% on late morning shift, 8% on early morning shift and only 5% on evening shift of the day. Other activities like sparring, antler brushing, licking, suckling, sniffing, playing, butting etc. were least seen among all other activities. They invested 5% time on alertness during the late morning followed by 2% on early morning and 1% each on afternoon shift and evening shift of the day (Figure 19).

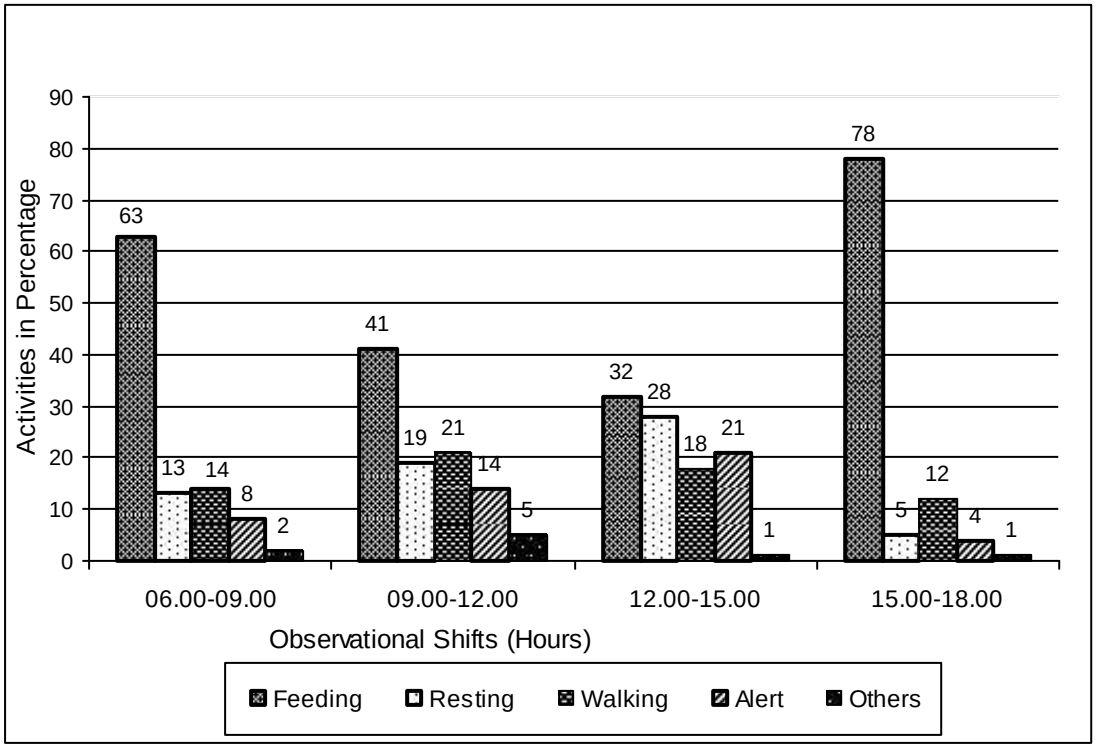



Figure 19: Percentage of Diurnal Activities of Spotted Deer in BNP in 2006.

## PHOTO PLATES

Research Supervisor guiding at the research field

Langur-spotted deer association seen in study area

A female-fawn herd heading towards Phanta from forest

Spotted deer utilizing the tree shade at Lower Khauraha Phanta in hot-dry season

*Narenga porphyrocoma* in rainy season

A group at Lower Khauraha in cool dry season

A doe suckling her fawn

Two female spotted deer grazing on the forbs

# 5. DISCUSSION

## 5.1 Population Status of Spotted Deer

Dinerstein (1979b) recorded 32 species of mammals in BNP, out of which, spotted deer is by far the dominating one among the larger mammalian (Moe, 1994). Kuikel (2003) reported a total of 357 individuals of spotted deer in 543.19 square kilometers BNP-Extension Area, which was the biggest population (55.52%) among the wild ungulates.

The actual census of commonly found animal, spotted deer was not done before this study in BNP. A total of 832 individuals of spotted deer were counted from 16 different locations from about 30 square kilometers area of north-western corner of the park which include the major Phantas and their adjoining areas on April 2006 through visual count method. However, forest dwelling and secretive nature of the animals were the major constraints in addition to climatic and disturbance factors for the visual count.

Schaller and Spillett (1966) noticed 45 deer per square mile density of spotted deer in the Keoladeo Ghana Sanctuary. Kuikel (2003) reported 3.4 deer/ $Km^2$ in the mixed forest, grassland, riverine forest and Sal forest of BNP-Extension Area. Naess & Andresen (1993) recorded Ecological density of spotted deer 225.3-384.5 deer/$km^2$ in RBNP, Dinerstein (1979) recorded the ecological density of 29.7 – 33.9 deer/$km^2$, Seidensticker (1976) recorded 17.3 deer/$km^2$ in RCNP, Eisenberg and Lockhart (1972) recorded the ecological density of 12 deer/$km^2$ in Wilpattu National Park, Srilanka and Spillet (1967) recorded the ecological density of 12.3 deer/$km^2$ in Bharatpur, India. Karna (1992) reported densities ranging between 1.3 to 2.06 deer/ hectare at 95% confidence level of test in IOF Forest, Hetauda, Nepal. This study computed average crude densities ranging between 118.4 to 165.2 deer/$km^2$ at 95% confidence level of test in Phantas of BNP. The comparative decrease in the range of densities of spotted deer in the park may be because of hunting, poaching and unsecured habitat during the national political conflict of last one and half decades.

Kurt (1990) explained occasional occurrence of 800 or more members of spotted deer in a herd in India and Srilanka. Tak and Lamba (1984) observed mixed herds of over 500 individuals in India. In Texas, average monthly herd size varied from 2-15 individuals (Fuchs, 1977) whereas in India, 5 to 38 were noted by Schaller (1967). De Silva and de Silva (1993) observed 27% of the total herds of 2-4 individuals in Rahuna National Park,

Srilanka. Moe (1994) found more than 100 individuals in a single herd in BNP. This study revealed mean size of mixed herd 16.67, with 84 being the largest.

Schaller (1967) noted all-male herd of 23 individuals while Talk and Lamba (1984) recorded that of 92 individuals in Indian National Parks during the months of April. In a single herd of Hawaiian spotted deer, Graf and Nichols (1966) observed usually 7 to 8 individuals in Lanai Island; commonly 15 to 20 individuals and occasionally of 97 individuals in Molokai Island. Siegen (2005) reported a common herd of 20 to 30 individuals and occasionally up to 100 individuals in India. Commonly, herds of 13 to 23 individuals and occasionally of 84 individuals spotted deer were observed in this study. The size of group is often considered a fundamental attribute of the social organization of mammals (Jarman 1974; Wilson 1975; Clutton-Brock 1980; Rodman 1988), and is described using measures such as the mean group size and Jarman's (1974) typical group size (Raman, 1997).

Sex and age ratios indicate the existing status of the animal population. It also informs whether the population is increasing, decreasing or remaining constant. The ratio of bucks to does in an introduced spotted deer population in Hawaii was found to be 77:100 in 1959 (Nichols, 1960); and 70:100 in Indian spotted deer in Corbett Park during the peak of the rut from May to July (Schaller, 1967). Tamang *et al.* (1976) found sex-ratio of adult male: female as 59:100 in Chitwan National Park. The average sex ratio of bucks to does was found to be 49:100 in BNP. The comparative lower sex ratio of BNP than those of Hawaii and India may be because of improper management of park habitat which prioritizes illegal selective hunting of adult bucks for antler and flesh. Selective predation has a possible effect on the adult sex ratio. The disproportion of adults may be due either to an unequal sex ratio at birth or higher male fawn mortality or both.

### 5.2 Distribution of Spotted Deer in BNP

Spotted deer prefers secondary Sal forest, riverine forest and grassland with good understorey of grasses, forbs and tender shoots, over mature inferior forests (Thapa, 2003). This nature of distribution pattern of the animal fits well with its opportunistic and dual foraging strategy (Schaller 1967, Mc Kay and Eisenberg 1974, Dinerstein 1979 b, Martin 1987, Mishra and Wemmer 1987, Moe and Wegge, 1994). The abundance of spotted deer was homogenous in all habitat types (Annual Wildlife Monitoring Report July 2003- June 2004). But the spotted deer were found to be concentrated in the major phantas of BNP during this study.

The result from the study of 16 different locations of about 30 $km^2$ area of Western Park showed clumped or uneven type of distribution, which is the most common pattern of distribution among the larger mammals. But the study on Lower Khauraha Phanta only showed regular or even type of distribution. It may be due to more competition in smaller sampling area and more or less uniform habitat among four different study blocks of the Phanta. This finding supports the idea of Odum (1971) that random distribution may occur where competition between individuals is severe as seen in Lower Khauraha Phanta and "clumped" population require larger area as seen in about 30 $km^2$ area of 16 study locations of the park.

The majority of animals were seen towards less disturbed but cut grasslands while minority towards River bank where they visited comparatively less. The upper Khauraha Phanta, which showed presence of maximum number of spotted deer population, is less disturbed by the predator and visitor. But Lower Khauraha Phanta is mainly disturbed by the legal visitors. Lamkauli Phanta is severely disturbed by the illegal visitors from nearby villages while Upper and Lower Baghaura Phantas are disturbed by the natural predators like tiger, hyanena, leopard etc. Spotted deer as a fearful animal visit to the river bank very carefully and occasionally. It is probably because of distinct vision by the natural predator and hunter.

### 5.3 General Behaviour and Diurnal Activity Pattern

The mixed herds and female-fawn herds were most commonly seen social groups of spotted deer in BNP. All male herd, single male and single female were occasionally found. Breeding herds of single matured buck with adult does were observed only during breeding season. Kurt (1990) reported that spotted deer herds occasionally include 800 or more numbers in the deciduous monsoon forests, the thorn scrub regions and dry grasslands of India and Srilanka. Such a large herd was not found during this study period. The largest herd of 84 individuals of spotted deer was observed during evening of April at Upper Khauraha Phanta of BNP. True herd formation, on the order of that of the North American elk or the European red deer, does not take place with the *Axis* deer (Graf and Nichols, 1966). The frequent fusion and fission of spotted deer groups were found during grazing, walking or any other disturbance.

Kurt (1990) explained social organization of spotted deer according to following principle. At the centre of the herd is an adult male deer or a small group of unusually

strong male deer with black napes, black-and-white facial marks and magnificent antlers. Around them are females, juveniles and fawns. At the edge of the group are other, weaker males and males who have just shed antlers or whose antlers are still covered with velvet. But such specially organized groups were not seen in BNP during this study. The rest position of the male, female and fawns were found to be variable and disorganized.

Spotted deer were seen foraging at all hours of daylight; yet when mid-day hours were sunny and hot; they tended to seek tree shade and were not out in the open foraging on grasses. The number of individual grazing deer observed during each hour of observation at BNP was bimodal distribution in activity with a morning peak at around 07.00 hours and an afternoon peak at around 16.00 hours. Waring (1966) accounted similar distribution trend in activity with a morning peak from 07.30-09.30 hours an afternoon peak at 14.30-16.30 hours at the Papaka region of the Ulupalakua Ranch of Maui, Hawaii. Tak and Lamba (1984) found the feeding activity peaked at dawn and sunset during the hot as well as cold seasons in India. However, in rainy season, feeding was in bouts at various hours presumably because of intermittent rain and abundance food.

Medium sized body and bite size of spotted deer makes them adaptive to both browsing and grazing (Bell 1971, Jarman 1974). Dinerstein (1979 b) reported that during the cool–dry season in lowland of Nepal, spotted deer tend to favor browsing a wide variety of plants in Sal forest when grazing species become dormant and less nutritious.
Schaller (1967) reported preference of spotted deer for the riverine forest is due to occurrence of green forage throughout the year, shade and nearness to water in such habitat. Spotted deer feed mainly on fallen leaves and fruits of trees, as grass and edible shrubs are scarce (Raman *et.al*. 1996). Spotted deer drinks water at least once a day and usually twice a day during the hot season (Schaller 1967), and accessing water is convenient from the riverine forest that grows along the water courses. In cool seasons, spotted deer remain in grassland during the day in order to trap heat from the sun (Tak and Lamba 1984, Schaller 1967). So both the foraging and weather conditions are important in distribution pattern of spotted deer in different habitats (Thapa , 2003).

Grazing activity was found to occur throughout the day in Srilanka but tended to lessen during midday hours when shade-seeking among trees replaced grazing on grasslands (de Silva and de Silva, 1993).

Schaller (1967) recorded the rate of feeding about 90 bites per minute. Graf and Nichols (1966) noted Molokai/Lanai spotted deer grazed when grass was green and abundant; browsing occurred when grass was scarce or when browse was particularly palatable and accessible. The spotted deer were seen drinking 2-4 times in the hot of April in BNP. How often Axis deer drink appears to depend on season and availability of water (Waring, 1966). Schaller (1967) concluded at least two trips (at sunrise and late in afternoon) were made to water each day during hot season; fewer trips were made in other seasons.

They were also seen licking the soil on the way and bare ground of forest, probably to maintain the salt and mineral demand of their body. The true herbivore spotted deer in the Sunderbans apparently eat small red crabs of an unidentified species, the remains of which have been found in the rumen (Stanford, 1951). Butting of fawns each other and wit their mother were primary symptoms of territorial behaviour. The aggressiveness of spiked bucks towards each other and towards does was probably because of imitation of production of sex hormones. The battles of spiked bucks were ended in draw after 2-3 minutes. Similar cases of battle were recorded by Graf and Nichols (1966) among Hawaiian spotted deer.

Schaller (1967) explained four types of overt aggressive behaviour in hard -antlered mature buck such as 1) Walking directly at the opponent, 2) Jerking the head downward or sideways to point the tip of the antlers briefly at him 3) Lunging forward with head lowered and 4) Chasing him over a distance of five or more feet, often with antlers pointing forward. During this study, serious fights were noticed between two adult bucks with wounded neck. Low hissing sound was produced at intervals of fight. A dull sound was produced on striking their antlers. Graf and Nichols (1966) reported apparent sparking from the rough striking of antlers in Hawaiian axis deer. But such spark was not noticed during this study period. The head-up display is a common and characteristic among adult bucks in which one buck approaches stiff-legged with rather jerky steps, neck stretched upward and muzzle pointing obliquely toward the sky exposes the white throat patch, ears are partially laid back (Schaller, 1967). The territorial male raised his tail vertically and approached to the opponent by which the later was slightly stepped back.

Rutting males are known to join groups of females to form mixed group more frequently during the rut (Schaller, 1967; Khan and Vohra1992). The main rutting season seems to

be between March and June, and although most young are born in winter, a few fawns are seen in all seasons (Mishra and Jefferies, 1991). During the April, mostly males were with rutting females and successful mountings were observed in BNP. A matured and dominant buck approached to the back of the matured doe, sniffed female genitalia and curled lips. He was able to copulate the female after about 15 minutes of chasing. The characteristic head up display was seen in the buck.

According to Pocock (1910) and Crandall (1964) spotted deer have been known to interbreed with the closer species, hog deer (*Axis porcinus*) in captivity (Schaller 1967). However, no such sexual interactions between spotted deer and hog deer were noticed in wild during this study period. Mishra and Jefferies (1991) reported birth of only one fawn after a gestation period of about 7 months, with females going into estrus again very soon after in Chitwan National Park. Grzimek (1972) accounted birth of one to three young in Indian spotted deer. During this study, single fawn was seen walking and grazing with single mother.

The diurnal activities patterns of spotted deer were observed during April to July and September, 2006. A total of 5,253 individuals of mixed herds of different age and sex groups were used for the study of diurnal activities. The result showed that the most common activity of the daytime was feeding (69.33%), followed by walking (11.35%), resting (9.29%), alert (8.45%) and others (1.58%). The spotted deer remains engaged in feeding from about one hour before sunrise to two to three hours after dawn and approximately one hour before and after dusk, depending upon the meteorological condition (Mitra, 1986).

Schaller (1967) noted peak feeding hours for between 07:00 to 08:30 hours in the morning, least between 10:00 to 16:00 hours and again continue grazing until about 21:00 hours and after that foraging continued until past midnight. In this study, the feeding time was found to be peaked in the evening as 78%, followed by 63% in the morning, 41% in the late morning and least as 32% in the afternoon. Spotted deer rests twice daily- the hours before the daybreak and from mid morning to mid afternoon (Mitra, 1986). Schaller (1967) noted resting of spotted deer from 03:00 hours to sunup in the forests of Kanha and Corbett Park in hot season. This study revealed that they spent maximum time of rest in the afternoon (28%), followed by late morning (19%), early morning (8%) and least in the evening (5%). It is because of hot season in which they spend most of the daylight hours in the tree-shade.

# 6. CONCLUSION

A total of 832 individuals of spotted deer were counted from 16 different locations including major Phantas at about 30 $km^2$ area of northern west of BNP. Among 351 deer of the Phantas, the highest population was recorded as 115 (32.76%) in Upper Khauraha and least as 28 (7.98%) in Lamkauli Phanta. The highest population range was found in Lamkauli Phanta and least in Lower and Upper Khauraha Phantas at all levels of tests. The Crude Density of spotted deer was found to be 27.73 deer/ $km^2$ among total study area of BNP. Among the major Phantas, the highest crude density was found in Lower Khauraha Phanta ranging between 297 to 350 deer/ $km^2$ and least as 25 to 77 deer/ $km^2$ in Lamkauli Phanta, at 95% confidence limit. The average sex ratio was found to be 48.99 bucks to 100 does with more females than the males in all the Phantas. The sex ratio of the deer in Lower Khauraha, Upper Khauraha and Upper Baghaura departed significantly from the 1:1 sex ratio. However, the ratio did not depart significantly in Lower Baghaura and Lamkauli Phantas. The average mixed herd size was computed as 16.76 individuals, being 84 individuals as highest mixed herd in the park.

Distribution pattern of spotted deer was clumped with significant difference in distribution of population in sixteen different study blocks of the park. However, it was found to be regular with no significant difference in the population of four study blocks of Lower Khauraha Phanta.

The most common social aggregation was mixed herds and female-fawn herds. Breeding herds were seen only in breeding seasons. The male herd and single isolated male or female herds were seen occasionally. The social groupings were fluid with loose aggregation that changed time to time due to climatic effects, natural factors and disturbances.

Fawns were least aggressive with minor butting each other either for food or for mother's pet. The spiked bucks were comparatively more aggressive to each other with short-term battle. The adult bucks were mostly aggressive during rut seasons. The "signpost" habit and sparring were common territorial behaviour of the bucks.

Spotted deer preferred *Imperata cylindrica*, *Saccharum spontaneum, Cyanodon dactylon, Desmostachya bipinnata, Tamarindus indica, Medicago denticulre* and other forbs on feeding. The feeding was peaked (78%) at 07:00 hrs. in the early morning, became least (27%) at 12:00 hrs. in the afternoon and again peaked (89%) at 16:00 hrs in the evening

that became more or less constant till late evening. They visited clean and natural water holes 2-4 times a day for drinking in the hot of April.

In the rut season, the matured male approached to the rut female with head up display, sniffed her genitalia and curled the lips. He also terrorized the younger males. After chasing the female for about 15 minutes in a circle, the matured buck was able to copulate.

The spotted deer preferred open and wider grasslands for grazing so as to access the long distance vision towards their natural predators. They scanned well before approaching to the water holes. Alarm call with "yeap!" sound, foot stamping and alert flight with long gallops were the common anti-predatory behaviours observed in BNP.

The spotted deer were engaged mainly for grazing in the daylight. They spent maximum day time (69.33%) on feeding, followed by waking (11.35%), resting (9.29%), alert (8.45%) and others (1.58%) such as mating, chasing, sparring, sucking, licking etc.

The illegal hunting poaching, grass cutting and other disturbances have been severely affecting the survival of ungulates of BNP. Grassland management, control of poaching, hunting, trapping and provision of artificial waterholes in the northern edge of Sal forests and grasslands may continue flourishment of spotted deer as one of the beautiful wild animal of BNP.

# 7. RECOMMENDATIONS

Spotted deer are probably the first and most attractive wild animals for the researchers, naturalists and visitors who enter legally to the park. They are good prey for the endangered natural predator, tiger. Therefore, conservation of spotted deer is also important for the conservation of tiger. Easier availability of spotted deer in the park has made the behaviorists convenient to detect wilderness behaviour of large mammal *in-situ*. They have high adaptability to a new environment which favors translocation towards desired Tarai forest either for wilderness habitat or for any other commercial animal farming. Many zoological garden of the world have been decorating by this beautiful creature. They are equally important for the Hindu and Buddha mythological point of view. Based on this study, following recommendations can be made for the management, monitoring, supervision and conservation of spotted deer in BNP.

i) Provision and management of artificial waterholes should be created in water scarce areas.

ii) To reduce the problem of shortage of grazing, space and possibility of transmission of cattle diseases to the deer entry of domestic cattle should be banned.

iii) Sowing and artificial dispersal of seeds of palatable grass species in different open patches of the forest may be alternative food provisioning to supplement natural foods in dry season. This practice has been successful in semi-enclosures like Mrigasthali forest near Pashupatinath of Kathmandu valley.

iv) Regular monitoring, yearly census and research of spotted deer in BNP should be done to acquire information about their status.

v) The rules and regulations for the wildlife conservation should be implemented effectively and efficiently together with the joint effort of park authorities, army and local people.

vi) Awareness programs should be conducted among local buffer zone people through their active participation.

vii) It is better to make short canals in the Phantas so as to replace unpalatable wetland grass by palatable grass like *Imperata cylindrica*.

viii) Naturally grown shrubs should be mechanically removed at the junction of grassland and forest to provide better grassland.

ix) Embankment of Karnali tributaries is essential to check the flooding towards grasslands and forest.

x) To improve the forage, the grassland should be cut and burnt in January- February.

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# APPENDIX

## Appendix I
**[Floristic Composition of the Study Area]**

| S.N. | Botanical Name | Local Name | Remarks |
|---|---|---|---|
| **Tree Species** | | | |
| 1 | *Acacia catechu* | Khair | |
| 2 | *Adina cardifolia* | Haldu | |
| 3 | *Aegle marmelos* | Bel | |
| 4 | *Bauhinia malabarica* | Tanki | |
| 5 | *Bombax ceiba* | Simal | Leaves preferred by spotted deer |
| 6 | *Buchanania latifolia* | Pyari | |
| 7 | *Careya arborea* | Kyamuno | |
| 8 | *Caseria tomentosa* | | |
| 9 | *Cassia fistula* | Rajbriksha | |
| 10 | *Cochlospermum religiosum* | Kumvi | |
| 11 | *Dalbergia sissoo* | Sisoo | |
| 12 | *Dillenia pentagyna* | Tatari | |
| 13 | *Ficus glomerata* | | |
| 14 | *Ficus recemosa* | Gullar | Leaves preferred by spotted deer |
| 15 | *Garuga pinnata* | Dabdabe | Leaves preferred by spotted deer |
| 16 | *Lagerstroemia parviflora* | Bot dhayero | |
| 17 | *Mallotus philippenensis* | Sindhure | Leaves preferred by spotted deer |
| 18 | *Mitragyna parviflora* | Kaim | |
| 19 | *Schleichera trijuga* | | |
| 20 | *Schleichera oleosa* | Kusum | Leaves preferred by spotted deer |
| 21 | *Semecarpus anacardium* | Bhalayo | |
| 22 | *Shorea robusta* | Sal | |
| 23 | *Streblus asper* | Khakshi | |
| 24 | *Syzygium cumini* | Jamun | Leaves preferred by spotted deer |
| 25 | *Terminalia bellirica* | Barro | |
| 26 | *Terminalia tomentosa* | Saj | |
| 27 | *Trewia nudiflora* | Vellor | |

| | | | |
|---|---|---|---|
| 28 | *Zizypus incurba* | Hade Bayer | Leaves preferred by spotted deer |
| 29 | *Zizypus rugosa* | Rukh Bayer | |
| 30 | | Khatkhajuga | |
| 31 | | Chhekardudi | |
| 32 | | Tendo | |
| **Shrub species** | | | |
| 33 | *Callicapra macrophyla* | Dai kamala | Non-potable to spotted deer |
| 34 | *Callicapra oppositifolia* | Bandebri | |
| 35 | *C lerondendron ifortunatum* | Bhati | |
| 36 | *Flemingia macrophylla* | Banaspati | |
| 37 | *Murraya keonigii* | Asare | Non-potable to spotted deer |
| 38 | *Solanum verbascifolium* | Dhursel | |
| 39 | *Zyzipus mauritiana* | Bayer | Preferred by spotted deer |
| **Grasses:** | | | |
| 40 | *Cynodon dactylon* | Dubo | Preferred by spotted deer |
| 41 | *Cyperus cephalotus* | Mothe | |
| 42 | *Desmostachy bipinnata* | Kus | |
| 43 | *Digitaria Ciliaris* | Banso | |
| 44 | *Imperata cylindrical* | Siru | Preferred by spotted deer |
| 45 | *Narenga porphyrocoma* | Hatti ghans | |
| 46 | *Phragmites karka* | Narkat | Not-potable to spotted deer |
| 47 | *Saccharum spontaneum* | Kans | |
| **Forbs** | | | |
| 48 | *Drymaria sp.* | Balu Jhar | |
| 49 | *Polygonum sp.* | Pire Jhar | |
| 50 | *Tamarindus indica* | Tinpate | Preferred by spotted deer |
| 51 | *Trifolium sp.* | Tinpate (Trifolium) | |

# Appendix –II

**[Questionnaire Survey with Nature Guides of Bardia National Park]**

Date… ……

1. Name of Respondent ……..… Age……..
   Sex……..... Village: …… Occupation……
   Working experiences in BNP: …… Years
2. Which animal is frequently observed in BNP?
   a. Spotted deer b. Wild pig
   c. Swamp deer d. Hog deer
3. Which site is mostly preferred by spotted deer for grazing?
   a. Phantas b. Riverside
   c. Road side d. Dense forest
4. Which grass do they prefer most for grazing?
   a. Siru b. Kans
   c. Dubo e. Forbs
5. In which time do you see the animals grazing in large numbers in Phantas?
   a. Early in the morning b. Late morning
   c. Afternoon d. Evening
6. Which plant leaves do they prefer for browsing?
   Please specify ……
7. Have you ever seen soil licking of spotted deer?
   If yes, Please specify the place ……..
8. Are they aggressive towards other animals?
   a. Yes b. No
9. In which seasons do the bucks fight?
   Please specify the season ……
10. Which animals are main threats for spotted deer in BNP?
    Please specify: ……..
11. What is the galloping distance of the spotted deer during violent disturbance?
    Please Specify the distance: ……..
12. What type of relation is seen between spotted deer and monkeys
    (Both Rhesus and Langur ) ? …….

13. Which of the monkeys give more reliable signs towards threat to spotted deer?

    a. Rhesus  b. Langur

14. Have you seen twins fawn of spotted deer in BNP?

    a. Yes  b. No

15. Which types of herds of spotted deer are common in the park?

    a. Male herd  b. Mixed herd

    c. Female–fawn herd  d. Breeding herd

16. What is the maximum number of individuals of spotted deer in a single herd during your observation?

    a. Less than 50  b. More than 50

    c. Less than 100  d. More than 100

17. Do the spotted deer herds prefer any special social organization during rest? Please specify ……

18. What can be done for the spotted deer conservation from the local people nearby the park?

    Please give your suggestions…….

19. In which time deer are seen drinking water?

    Please specify the time ……..

## Appendix III

**[Maximum and Minimum Temperature of Rani Jaruwa Nursery, 2000-2005** AD.]

| Year / Months | | Maximum Temperature ($^0$C) | | | | | |
|---|---|---|---|---|---|---|---|
| | 2000 AD | 2001 AD | 2002 AD | 2003 AD | 2004 AD | 2005 AD | Average |
| January | 20.1 | 19.9 | 22.9 | 18.2 | 20.1 | 18.9 | 20.24 |
| February | 23.2 | 27.1 | 25.9 | 24.8 | 25.1 | 25.8 | 25.22 |
| March | 30.0 | 31.6 | 31.3 | 29.6 | 32.2 | 31.6 | 30.94 |
| April | 36.0 | 36.5 | 35.2 | 37.2 | 36.6 | 35.8 | 36.30 |
| May | 36.9 | 36.0 | 36.9 | 37.9 | 37.1 | 37.6 | 36.96 |
| June | 33.7 | 34.0 | 36.6 | 36.5 | 35.7 | 39.7 | 35.30 |
| July | 32.5 | 33.7 | 34.4 | 34.5 | 33.3 | 33.6 | 33.68 |
| August | 35.6 | 34.8 | 33.3 | 33.2 | 33.7 | 33.2 | 34.12 |
| September | 32.6 | 33.8 | 32.7 | 32.0 | 33.0 | 34.8 | 32.82 |
| October | 32.4 | 32.5 | 32.2 | 32.2 | 31.9 | 31.9 | 32.24 |
| November | 28.1 | 29.3 | 29.2 | 28.5 | 27.6 | 28.9 | 28.54 |
| December | 24.2 | 23.8 | 24.0 | 23.1 | 23.4 | 25.5 | 23.70 |

| Year / Months | | Minimum Temperature ($^0$C) | | | | | |
|---|---|---|---|---|---|---|---|
| | 2000 AD | 2001 AD | 2002 AD | 2003 AD | 2004 AD | 2005 AD | Average |
| January | 7.8 | 6.9 | 8.1 | 7.5 | 8.2 | 7.7 | 7.70 |
| February | 8.5 | 9.1 | 10.2 | 8.3 | 10.0 | 11.7 | 9.22 |
| March | 12.4 | 11.7 | 12.9 | 12.7 | 15.0 | 15.6 | 12.94 |
| April | 18.5 | 17.0 | 18.5 | 17.6 | 20.8 | 19.0 | 18.48 |
| May | 23.0 | 21.9 | 23.0 | 19.6 | 23.0 | 19.5 | 22.10 |
| June | 24.8 | 24.5 | 25.2 | 24.0 | 23.3 | 26.1 | 24.36 |
| July | 25.2 | 26.5 | 26.5 | 25.9 | 26.1 | 25.3 | 26.04 |
| August | 24.0 | 26.3 | 25.5 | 25.9 | 26.0 | 25.5 | 25.54 |
| September | 25.0 | 25.3 | 24.2 | 24.7 | 25.1 | 25.2 | 24.86 |
| October | 20.3 | 20.2 | 19.3 | 18.8 | 20.1 | 18.5 | 19.74 |
| November | 15.0 | 13.9 | 12.7 | 13.3 | 12.5 | 12.5 | 13.48 |
| December | 7.8 | 10.5 | 9.4 | 9.0 | 9.5 | 7.4 | 9.24 |