

1. INTRODUCTION

1.1 Background

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). Behavioural study play very important role for the conservation of any species (Manning and Dawkins, 1998). 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). Biological data, which include the current population status and understanding of behaviour, are vital for in-situ conservation of any wildlife species (Khanal, 2006).

In the National Parks and Reserves of Nepal, deer are seen playing hide and seek in pleasant manner. 'A long-term planning and management can help to conserve the deer fauna which also provides a great economic return (Shrestha, 1981). The wildlife manager often has to strike a compromise between many conflicting interests. These may include the future viability of the habitat, the population size of the species within the particular area, the welfare of individual animals, the economic impacts of management practices, the traditional interests of the local human population, etc. Research into ethology and ecology can do much to provide this knowledge and to safeguard the interests of animal and plant communities in the world (Farland, 1981). Deer can be costly and need to be managed in the environment. It is clear that a cooperative approach is beneficial to deer management and that this is largely due to the 'common' nature of wild deer (Steffens and Schmid, 1996). Wildlife management which is an important branch of conservation is concerned with assuring the maximum possible populations of the game animals consistent with other land uses in the same area and with the number that the given habitat will support. This is attained by manipulating the balance of nature in such a way that the desired game species are favoured (Verma and Agrawal, 1998).

Deer management is about social and political relations as well as economic and ecological imperatives. The balancing of positive and negative aspects of deer population is examined in the work of Bullock (1999, p240) in the case of Scottish red deer. The basic role of wildlife management is to keep the wild animal population optimal, diversified and harmonized with the environment in order to satisfy the economic, recreational, scientific, educational and social needs of man (Shrestha, 2003).

1.2 Spotted deer

Spotted deer (*Axis axis*, Erxleben, 1777) 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). It is locally known as chital in Nepal (Shrestha, 2003). According to IUCN **Red List Category** it is listed as Least Concern because it occurs over a very wide range with large populations (Duckworth et al. 2008).

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. 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 unicolor* (Sambar deer), *Axis axis* (Spotted deer), *Axis procinus* (Hog deer) and *Muntiacus muntjak* (Barking deer) (Majupuria and Majupuria, 2006)

1.2.2 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. 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). The bucks stand about 29 to 39.5 inches height at the shoulder and total body length is 35 to 43 inches (Kuikel, 2003).

In Chitwan 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).

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:

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

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).

1.2.3 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, 1972). 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, 1979 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, 1979). 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, 1979).

1.2.4 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, 1979). 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).

1.2.5 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 bellow loudly and wander in search of receptive females (Ables, 1977). 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 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 Jersey, 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 January 1868. Later, several deer were transferred to Oahu; 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).

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 all the protected

areas of lowland except BCA in Nepal (Majupuria and Majupuria, 2006). Spotted deer are found rarely above an altitude of 1160m (3500ft) in their native Asian habitats, including Nepal (Schaller, 1967).). They are found scattered in lower number in the mid-hill, warmer valleys and forest areas. In this reference at least 2,000 Spotted deer (*Axis axis*) might possibly be distributed in Terai area (Chalise 2001, 2013). In Nepal, mainly in three places viz. Central zoo, Deer Research Center (Godawari) and Mrigasthali, for rearing Spotted deer in enclosure.

1.4 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 enlightenment. 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).

1.5 Rationale of the Study

Mishra (1982) studied the ecology and behaviour of spotted deer in Chitwan Wemer and Mishra (1987) studied comparative breeding ecology of four cervids in Chitwan National Park. Despite various conservation efforts for the conservation and management of spotted deer, they are being seriously affected by human and non-human disturbances. Behavioural study play very important role for the conservation of any species (Manning and Dawkins, 1998 ; Jhala, 1991). Very less studied have been carried out in Mrigasthali. This study helps to trace out the general behavior and management practices of the Spotted deer along with people's perception on present scenario of the species status which provides baseline information for effective management to enhance long-term survival of the Spotted deer in the study area.

1.6 Research Objectives

The main objective of the study was to assess the general behaviour and status of spotted deer (*Axis axis*) in Mrigasthali, Kathmandu. The specific objectives of the research were:

- i) To document the general behaviour and diurnal activity pattern of spotted deer in Mrigasthali.
- ii) To investigate the current management practices of Spotted deer in Mrigasthali.

1.7 Limitations of the Study

Following limitations were faced during the study period:

- i) Year round seasonal activities could not be assessed due to shorter duration study for academic purpose.
- ii) Night observation could not be made due to security and logistics constraints.

2. LITERATURE REVIEW

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).

Graf and Nichols (1966) reported apparent sparking from the rough striking of antlers in Hawaiian axis deer.

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.

Schaller (1967) noted resting of spotted deer from 03:00 hours to sunup in the forests of Kanha and Corbett Park in hot season.

Grzimek (1972) accounted birth of one to three young in Indian spotted deer.

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.

Mitra (1986) 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. Spotted deer rests twice daily- the hours before the daybreak and from mid morning to mid afternoon.

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.

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.

Mishra and Jefferies (1991) the main rutting season to be between March and June, and although most young are born in winter, a few fawns are seen in all seasons.

Raman *et al.* (1996) recorded Spotted deer feed mainly on fallen leaves and fruits of trees, as grass and edible shrubs are scarce.

Graf and Nichols (1966) butting of fawns each other and with 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.

Waring (1966) axis deer drink appears to depend on season and availability of water.

Moe and Wegge (1994) reported that the Spotted Deer preferred riverine forest during the hot dry- season where as they preferred Sal forest during monsoon season in Lowland of Nepal. They also noticed that grassland was preferentially utilized by female at night during the hot- dry season.

Raman *et al.* (1996) studied the seasonal habitat utilization of Spotted Deer in Guindy National Park and found that wood land was highly used in dry season where as scrubland and grassland was used in monsoon season. They also mentioned that maximum birth was occurred in January- February.

Khanal (2006) reported on general behavior and conservation practices on blackbuck in khairapur, Bardia.

Ghimire and Sherestha (2009) reported that in Sleshmantak (Mrigasthali), the abode of deer where the Pashupati Area Development Trust(PADT) committed erroneous introduction by realeasing low land ungulate(deer and antelope) in the Midhill environment.

3. MATERIALS AND METHODS

3.1 Materials

3.1.1 Physical Description

3.1.1.1 Location, Boundary and History of the Mrigasthali (Deer Park)

Pashupati is an ancient religious place located in Bāgmatī Zone, Central Region, Nepal at a distance on 5km, northeast of Kathmandu, Gausala. Mrigasthali (Deer Park) is next to Aryaghat which has mythological value. Mrigasthali deer park has a length of 1.28 kilometres. This area lies 1302.79m above sea level. Physically, it is situated between 85°20'57" to 85°21'04" and 27°42'20" to 27°42'26" east longitude and north latitude respectively(March 15,2014). Mrigasthali is the sacred area of Sleshmantak forest of Pashupati where deer are kept and the entire area is fenced with steel bars and gabion wires. The core area of Sleshmantak is known as Mrigasthali, the abode of deer where the PADT committed erroneous introduction by releasing low land ungulates(deer and antelope) in the Midhill environment (Ghimire and Sherestha 2009). Mrigasthali is spread over 4.8 ha area of land that is enough for only about 50 deer but there are around 75 spotted deer, 10 Blackbuck and 5 Barking deer, according to the PADT. PADT in 2004 where 2 Barking deer, 10 Spotted deer and 20 Blackbuck were introduced with the technical assistance of NTNC which are bought from central zoo. The forest in this area is sub-tropical.

Map of the Study Area

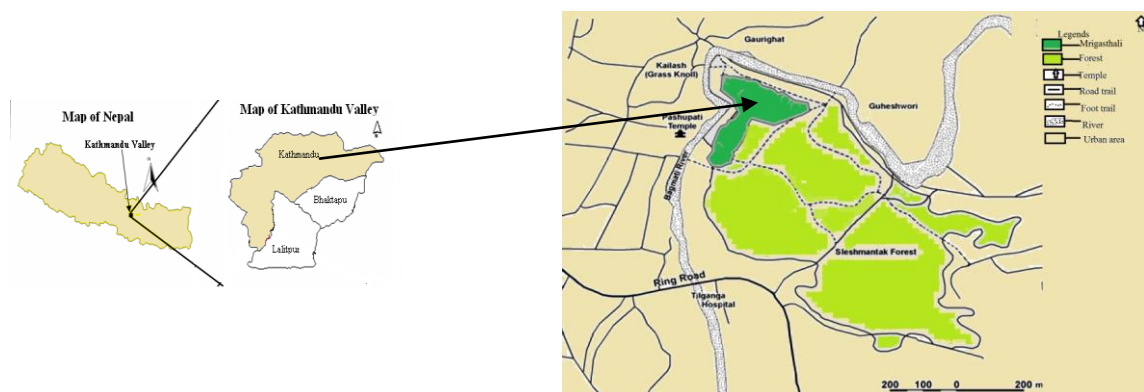


Figure 1: Map showing the study area.

3.1.1.2 Topography and Geology

The Pashupati area belongs to one of the valley plain terrace system of the Kathmandu valley and has been formed after the Bagmati river. The top soil is followed by thick sand and thin clay in alternate bands without large boulders which is characteristic of lacustrine sediments. The natural drainage system is controlled by the gullies pattern (Shakya, 1988).

3.1.1.3 Hydrology and Drainage

The Kathmandu Valley is drained by the multitude of tributaries that feed the main channel of the Bagmati river. So the Bagmati drainage system is the total system of down slope water flow from the point of the arrival at the ground surface in the valley. It consists of a branched network of stream channels, as well as the sloping ground surface that contributes overland flow and inter-flow to these channels. There are altogether 20 tributaries of the Bagmati River system within the valley (Pradhan 1998).

3.1.1.4 Climate

The meteorological data of the study area is based on record of Tribhuvan International Airport Meteorological Station which lies adjacent to the study area. The mean annual temperature in the Kathmandu Valley is 18⁰C. The coldest month is January with the mean temperature of 10⁰C. The warmest months are July and August, with an average temperature of 24⁰C. The valley has an annual rainfall of 1,400mm. The wettest month is July with an average rainfall of about 370 mm. November and December are the driest months, the average rainfall is less than 6 mm (URBAIR, 1997).

At Mrigasthali of Kathmandu district, average annual mean rainfall recorded during 2005 to 2014 was 1373.19 mm. Maximum annual rainfall was recorded as 1899.3 mm in 2013 while minimum as 836 mm in the year 2014 (Figure, 2).

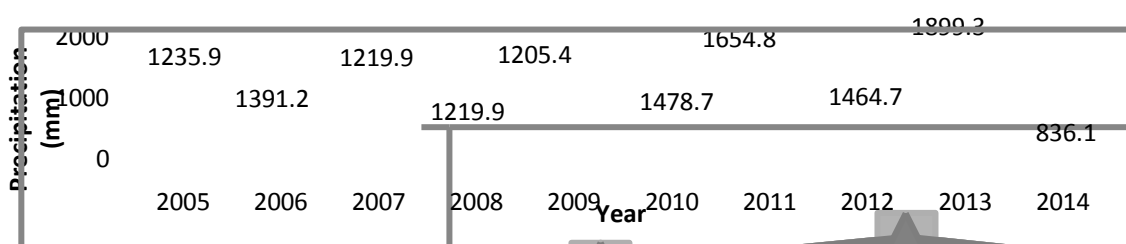


Figure 2. Annual Rainfall at Mrigasthali, Kathmandu (Source: DHM-2015).

Almost 90% of the rainfall occurs at June to September during the Rainy season of this area. The average monthly rainfall as recorded in the Mrigasthali of Kathmandu District is as follows (Figure 3).

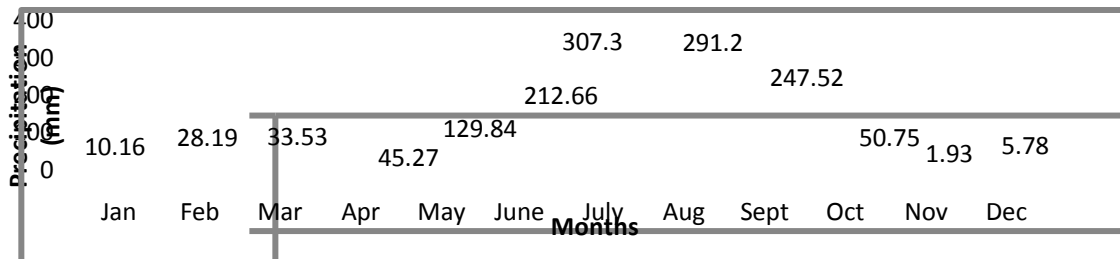


Figure 3. Average Monthly Rainfall at Mrigasthali, Kathmandu (Source: DHM-2015).

The average monthly temperature of Mrigasthali 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 Mrigasthali from 2005 to 2014 were 37.41 °C and 12.37 °C respectively (Figure 4).

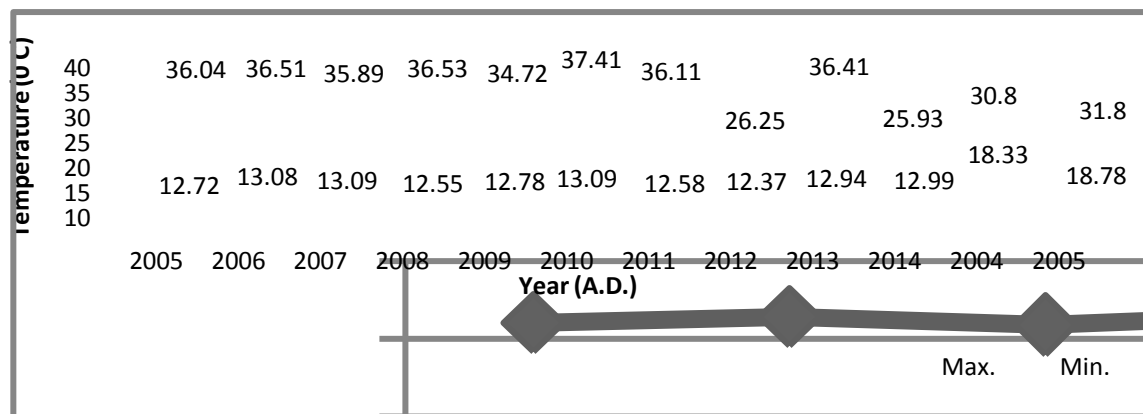


Figure 4. Annual mean Maximum and Minimum Temperature in Mrigasthali 2005-2014 (Source: DHM-2015).

The average maximum temperature of the area is highest in the month of May, June, July and August while the average minimum temperature of the Mrigasthali recorded is in November, December, January and February. The average maximum temperature recorded is 30.18 in June (Figure 5).

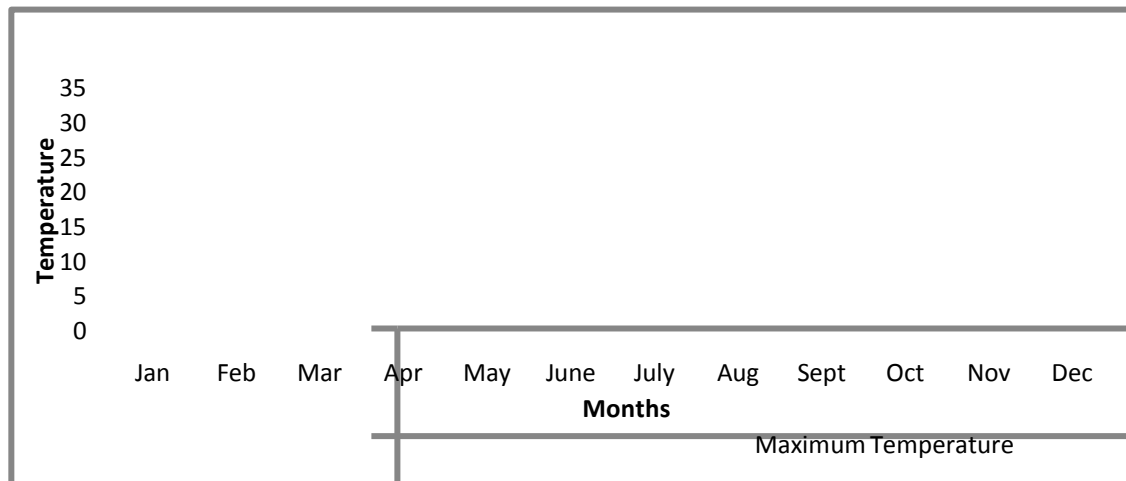


Figure 5. Monthly Variation of Maximum and Minimum Temperature in Mrigasthali, Kathmandu, 2005 - 2014. (Source: DHM-2015).

The average annual Relative Humidity measured at Mrigasthali (2010-2014) is found lowest (81.8) in 2014 while others are above 82 (Figure 6).

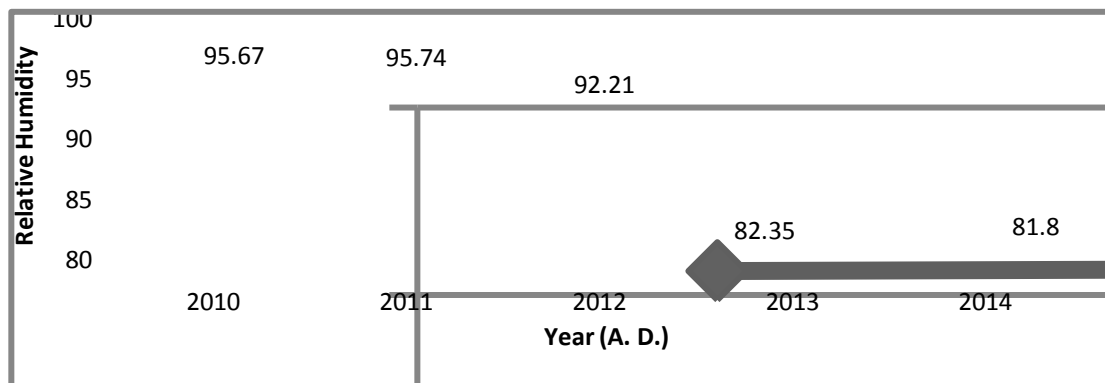


Figure 6. Annual Relative Humidity in Mrigasthali, Kathmandu (2010 – 2014). (Source: DHM-2015).

3.1.2 Biological Description

3.1.2.1 Flora

The vegetation of the study area is included in central mid-land of Nepal and considered as with sub-tropical vegetation (Stainton, 1972). The representative forest of Thimi, Bhaktapur and Tribhuvan International Airport are located in the Pashupati area (Tabata, 1986). In Sleshmantak forest 85 species of trees representing 6.4% of flora of Kathmandu valley (1,312 species, Malla et. Al 1986) were present and 32 species among them were

cultivated trees. The vegetation consists of mixed evergreen broad-leaved trees like *Schima wallichii*, *Quercus glauca*, *Q. lanata*, *Acer oblongum*, *Osmanthus fragrans*, *Michelia champaca*, *Myrsine capitellata*, *Myrica esculenta*, *Stranvaesia nussia*, *Ilex excelsa* etc. The gullies are occupied by *Alnus nepalensis*. Among shrubs *Justicia adhatoda*, *Randia tetrasperma*, *Clerodendron fragrans*, *Hymenopogon parasiticus*, *Lantana camera*, *Rubus ellipticus*, *Rhus parviflora* and *Sambucus adnata* are well represented. The exotic trees such as *Araucaria bidwillii*, *Callistemon citrinus*, *Caryota urens*, *Cinnamomum camphora*, *Eucalyptus citriodora*, *Gravillea robusta*, *Jacaranda momosifolia*, *Magnolia grandiflora*, *Nerium indicum*, *Populus deltoids*, *Salix babylonica* and *occidentalis* are planted for ornamental purpose along avenues. Trees like *Aegle marmelos*, *Cloerospondias axillaris*, *Elaeocarpus sphaericus*, *Juglans regia*, *Sapium mukorossi* are sparsely distributed (Sherestha, 2001).

3.1.2.2 Fauna

The study area supports some faunal diversity. The common ungulates are Spotted deer (*Axis axis*), Barking deer (*Muntiacus muntjak*) and Blackbuck (*Antelope cervicapra*). It sustains mammalian fauna such as Rhesus monkey (*Macaca mulatta*), Mongoose (*Herpestes edwardsi*), Jackal (*Canis aureus*), Jungle cat (*Felis chaus*), Yellow-bellied weasel (*Mustella kathiah*) and Small Indian civet (*Viverricula indica*). Among avifauna Common Pariah kite (*Milvus migrans*), Common myna (*Acridotheres tristis*), Blue rock pigeon (*Columba livia*), Crow (*Corvus splendens*), Spotted dove (*Streptopelia chinensis*), Indian Griffon (*Gyps indicus*), Spotted owlet (*Athene brama*), Black-headed shrike (*Lanius schach*) etc., are commonly found. Herpetofauna found are Common Asian toad (*Bufo melanosticus*), Bull frog (*Rana tigrina*), Common garden lizard (*Calotes versicolor*), Blind snake (*Rhamphotyphlops braminus*), Common wolf snake (*Lycodon aulicus*), Banded kurki snake (*Oligodon arnensis*) and Checkered keelback water snake (*Xenochrophis piscator*) (Sherestha, 2001).

3.2 Methods

3.2.1 Preliminary Field Survey

A preliminary field survey was done to Mrigasthali from 27st February to 2th March, 2014 under the direct supervision of the Academic Supervisor. The survey investigated the general behavior and management practices of spotted deer in the Mrigasthali. Similarly, information about the status of the spotted deer was collected by the discussion with park authorities (PADT). Besides, the study area was visited on foot. Techniques for behavioural data collection, direct observation, observation through binoculars and photography were practiced.

3.2.2 Field Survey

The actual field survey was initiated from 1st April to 15th May, 2014 for spring season and another visit was made from 10th January to 24th January, 2015 covering total park time 250 hrs in which animal contact time was 180 hrs.

3.2.3 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 three shifts from late morning to evening as 9.00 – 12.00 hrs as late morning shift, 12.00 to 15.00 hrs as afternoon shift and 15.00 to 18.00 hrs 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 note was made of the activity of the animals and any habitat factor affecting their behavior during the field visit. Movements of the herds were also 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. The quantitative data on the frequency, temporal sequence and duration of events and state behaviour were recorded by this method. The PADT officials of Mrigasthali helped for taking the behavioural data continuously.

3.2.4 Questionnaire Survey

To explore knowledge on behaviour and management practices done at Mrigasthali, questionnaire survey was conducted among the park authorities and visitors of Mrigasthali who have been involved for the spot information about the animals and vegetation. The questionnaire survey was conducted during the month of March, 2015. There were total 60 respondents. The respondents were selected by the random sampling method. Both the open and closed type of questions were included. The questions were mainly focused on the following aspects:

- Behavioural activities such as selection of food, resting site, sparring, mating, aggression, defense, alarm and other diurnal activities.
- Management practices like fencing, diet provided, etc. of spotted deer.

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

3.2.5 Interview and Discussion

Formal and general interviews were conducted among park authorities such as Officer, Administrative assistant and caretaker and discussed who have been directly involved for the management of spotted deer for several years. Similarly, general interviews and discussions were made with the officials of PADT who are locally working in collaboration with the park for the wildlife management.

4. RESULTS

4.1 General Behaviour and Diurnal Activity Pattern

4.1.1 General Behaviour

4.1.1.1 Social Behaviour

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. The herd used to travel in queue especially in the narrower trail, and generally leading by an elder female.

The single isolated male and isolated females were occasionally seen traveling and foraging within the park during afternoon of April between 12.00 to 15.00 hours. The doe started well feeding only after mixing with the larger herd. The fawns had frequently been observed playing during 9.00 to 12.00 hours in the late morning and 15.00 to 18.00 hours in the evening of April. Playing was in the form of leaping back and forth, random and zigzag run. Sometimes they were seen playing with head butting fights.

They like the company of others of their own kind. In the park we seen association of Spotted deer along with Barking deer and Blackbuck. 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 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 spotted deer were seen resting in small groups under the tree-shed after feeding at afternoon 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.

4.1.1.2 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. 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. 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 afternoon of 10th April at 13.10 hours a matured buck at the cemented pool side 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 2-3 times. Then he scraped the ground alternately with each front foot many times, and then brushed his antlers through the twig again. Mostly signpost scraps were found around the resting areas.

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. They produced low hisses with each breath. 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 feeding. Except this, no other aggressive behaviour was observed among females.

4.1.1.3 Feeding Behaviour

Spotted deer are completely herbivores. Herbivores have long been known preference to a variety of plant species. Spotted deer from the beginning have been following ancestral foraging pattern and are pure herbivore. Though Spotted deer are grazers they are given ready made food in the park, served in a cement basin. From the observation it is found that the Spotted deer enjoy food given by its caretaker. By feeding well served ready make food has totally changed their wild habit of browsing. The food is provided at 9.00 am and 3.00 pm respectively. The semi-captive Spotted deer are provided with balanced diet everyday by the Mrigasthali park authorities keeping in view the food preference, balanced diet and availability of the food items in the market the park authorities have very well managed the daily diet of the Spotted deer. Four caretakers are involved to provide the balanced diet for Spotted deer as shown below in Table 1.

Table 1. Daily Routine of Diet Provided to Spotted Deer in Mrigasthali.

S.N.	List of diet provided	Quantity
1	Gram	6.4 Kg
2	Corn	9.6 Kg
3	Soyabin	6.4 Kg
4	Wheat Flour	30 Kg
5	Green grasses	64 Kg

(Source: PADT- 2014).

According to caretaker Om Ghimire, 5 kg salt along with other minerals mixture is provided for Spotted deer weekly. Spotted deer actively feed on supplemented food. They sometimes come towards the human crowd and open their mouth asking for food. Human feeding is prohibited in the Mrigasthali. A troop of *Rhesus* monkey was seen frequently together with the herd of spotted deer. The fresh buds and leaves of *Schima wallichii*, *Castonopsis indica* etc fallen during the feeding of monkeys were fed by the spotted deer. The spotted deer were seen drinking water from the artificial source of water in the Mrigasthali 2-3 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 but, they were not seen drinking muddy water of the surface.

4.1.1.4 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 its 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.

4.1.1.5 Anti-predatory Behaviour

The spotted deer 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 spotted deer were vigilance about the possibility of attack from their predator (such as leopard, Snakes etc) while in the park. The common anti-predatory behaviours of spotted deer observed during the field visit in Mrigasthali were as follows:

4.1.1.5.1 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.

4.1.1.5.2 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 led by the does but not by the bucks.

4.1.1.5.3 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. During the park 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 50m to 100m distance from the place of disturbance and looked back towards the danger to confirm whether the danger still existed or not.

4.1.2 Diurnal Activity Pattern

Diurnal activities of Spotted deer were recorded from the April to July 2014 and in September 2014 during the second field visit. The total park time was 250 hours and animal contact time was 180 hours. The observation period was divided into three shifts; 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 9 hours continuous observation was made by manipulating data of three successive days with identical climatic conditions. The direct observation method was employed. Scan Sampling Method and Focal Animal Sampling Method as explained by Altman (1974) 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:

4.1.2.1 Late Morning Activities of Mixed Herds

A total population of 25 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 (37%) followed by walking (21%), resting (24%), alert (11%) and others (7%) of the late morning. The activities like antler brushing by spiked bucks and sparring by adult bucks were remarkable events during this period (Figure 7).

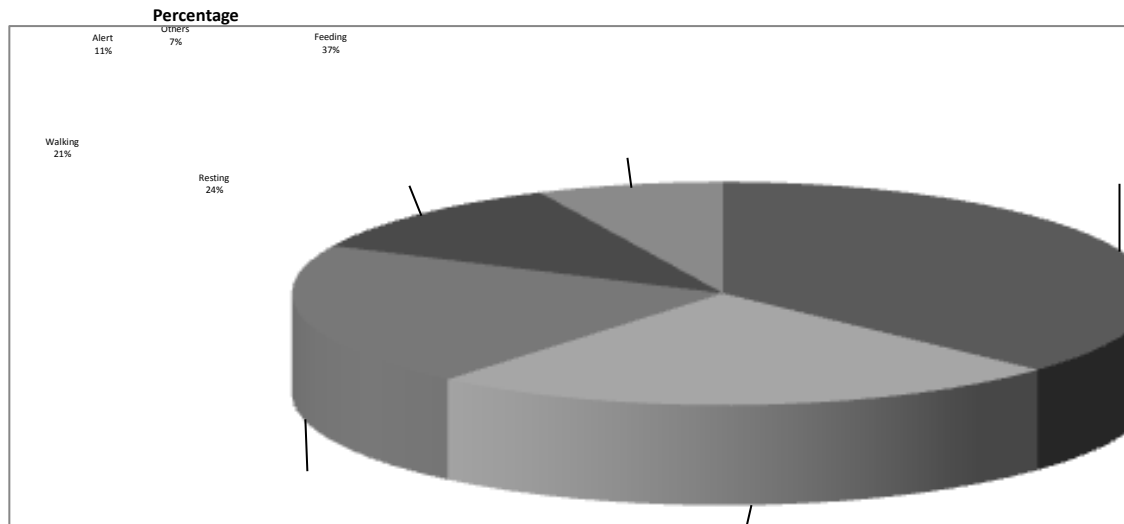


Figure 7: Late Morning activities of mixed herds of Spotted deer in Mrigasthali.

4.1.2.2. Afternoon Activities of Mixed Herds

A total population of 21 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 (31%) followed by resting (28%), walking (23%), alert (15%) and others (3%) of the afternoon (Figure 8).

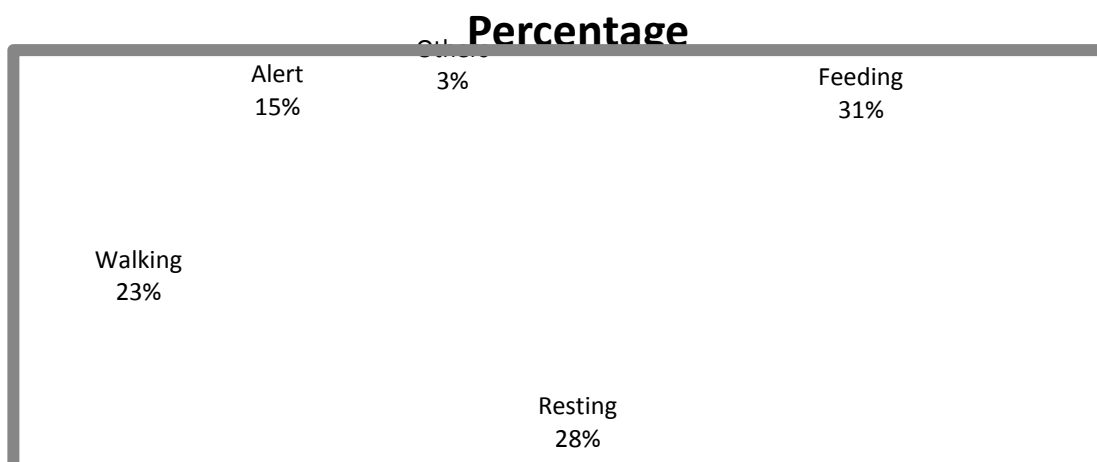


Figure 8: Afternoon activities of mixed herds of Spotted deer in Mrigasthali.

4.1.2.3 Evening Activities of Mixed Herds

A total of 27 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 (56%)

followed by walking (24%), resting (14%), alert (4%) and others (2%) of the evening time (Figure 9).

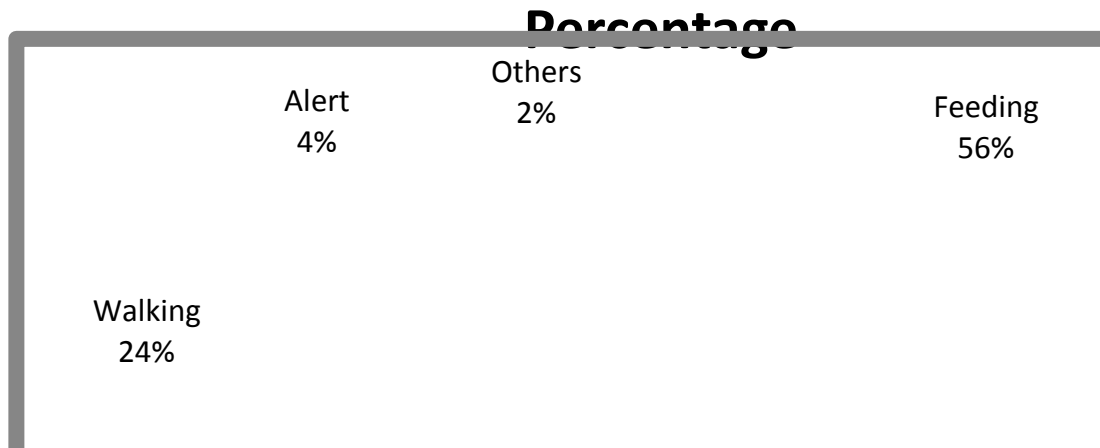


Figure 9: Evening activities of mixed herds of Spotted deer in Mrigasthali.

4.1.2.4 Average diurnal activities of Spotted deer in Mrigasthali

A total of 75 individuals of mixed herds of spotted deer were observed during the whole observation period from 9.00 hours late morning to 18.00 hours in the evening. Out of 75 individuals, almost 31 individuals (41.33%) were engaged on feeding followed by 17 individuals (32.67%) on walking, 16 individuals (22%) at rest and 8 individuals (10%) on alert posture. Similarly 3 individuals (4%) were engaged in other activities of the day (Figure 10).

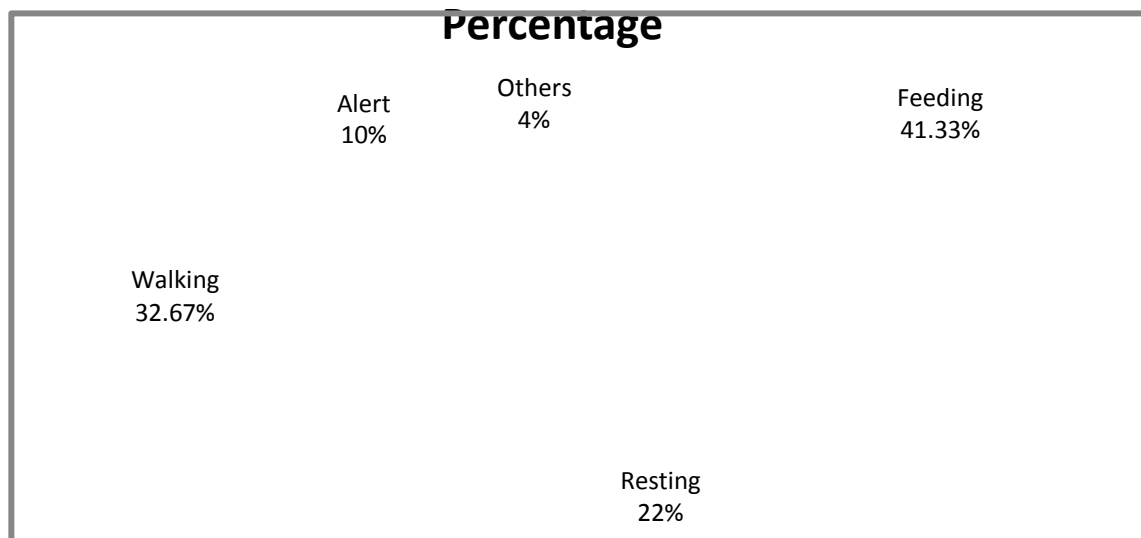


Figure 10: Average diurnal activities of mixed herds of spotted deer in Mrigasthali.

Feeding was the most common activity of spotted deer in Mrigasthali. They spent maximum time on feeding during evening shift of 15.00 hours to 18.00 hours followed by

56% in the evening shift and the lowest 31% 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 (24%) on resting during evening shift from 15.00 hours to 18.00 hours followed by 23% on afternoon shift from 12.00 hours to 15.00 hours and 21% on late morning shift of 09.00 hours to 12.00 hours. The spotted deer were seen alert frequently when stimulated by minor or violent auditory or visual signals. They spent almost 15% time on alert during afternoon shift from 12.00 hours to 15.00 hours followed by 11% on late morning shift and 4% on the evening shift of the day. The deer were seen resting mostly (28%) during the afternoon shift followed by 24% on late morning shift and 14% 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.

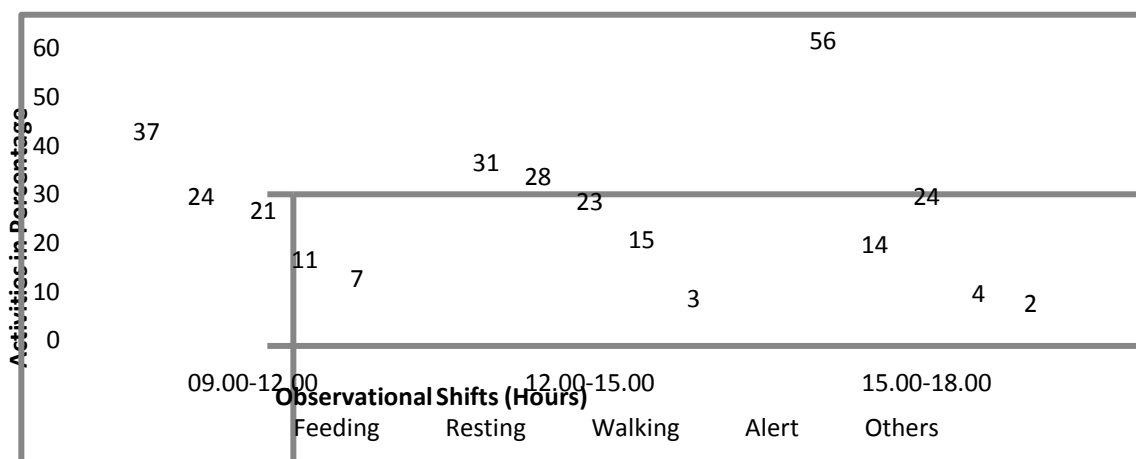


Figure 11: Average percentage of diurnal activities of Spotted deer in Mrigasthali.

4.2 Management Practices

A number of management practices were observed in the Mrigasthali at Kathmandu with the involvement of PADT, NTNC, non-governmental organization and local people. Guri Parajuli, officials at the PADT office, said about Rs.30,00,000 has been allocated for Mrigasthali this year (2014/2015). The different management practices done at Mrigasthali are:

4.2.1 Habitat Manipulation

Some of the methods of manipulating the Mrigasthali in the favour of Spotted deer were practiced as:

4.2.1.1 Fencing

To the east there is forested hill of Mrigasthali which is 1.28km length, 4.8 ha area is fenced with the metallic net, border with Bagmati river in South. There was 4 main entrance gate with security guards only gate is for visitor entrance. Recently Mrigasthali area is double fenced which splits half of Mrigasthali area for well management of Spotted Deer inside Mrigasthali to maintain peace and greenery. The trees and shrubs species inside the park is protected through metallic fencing.

4.2.1.2 Water Holes Construction

Four water holes were constructed and water was supplied with underground plastic pipes. Out of four water holes one is cemented. Only two of such water spouts were seen working during the observation period. Spotted Deer used such spouts for drinking in all season. Fresh water is limited in Mrigasthali they drink from a water holes.

4.2.1.3 Plantation and Ploughing

Under the financial support of PADT, in Mrigasthali about 1-2 ha area was planted and ploughing twice a year in different area inside the Mrigasthali. The seasonal trees, shrubs, herbs and grasses are planted or ploughed. In rainy season mostly grass species were ploughed and in summer tree species were planted. In June/July 2014, Mrigasthali area was ploughed and grass seeds were sown to provide supplement diet of the Spotted deer. The planted trees and shrubs were giving protection by fencing it to prevent feeding on bark of the tree species and young shrubs plant.

4.2.1.4 Non-Palatable Species Removal

Non-palatable species like Pirrhe (*Cymbopogon cirtatus*), Besharma (*Ipomoea fistula*) etc. that were invading in many area of Mrigasthali were removed. The *Cymbopogon* and *Ipomoea* is dug out from their root; they were dried and burnt on fire.

4.2.2 Management committees:

There are 6 members employed for management of Mrigasthali area. Among them 1-officer, 1-Administrative assistant and 4-caretakers according to PADT. There are 21-22 helpers for bringing green grasses to deer. The members of the working committees of Mrigasthali area used to have regular monthly meeting. Various discussions, interaction and training programmes were also organized in the coordination with NTNC.

4.2.3 Involvement of Local Trust

PADT and NTNC were the trust directly involved in the Spotted deer management Programme. PADT in the past conducted many training programmes, mobilized the local people and PADT officials in management. PADT conducted non-formal education programme to visitors in Mrigasthali. NTNC is working in the field of biodiversity conservation and local development in Kathmandu district. NTNC regularly conducted the awareness raising programmes in Kathmandu district by means of training and seminars in management of Spotted deer. NTNC provided fund and manpower for the fencing in the Mrigasthali area, treatment for Spotted deer and helps in translocation process etc. were some of the mentionable events carried out under NTNC programme in Mrigasthali.

4.2.4 Perception of Local People



Figure 12. Perception of Local People for the Institutional Involvement in Spotted deer management in Mrigasthali (Source: Field Survey, 2015).

Most of the respondents expressed importance of Spotted deer for its religious, tourism and ecological value. 100% of the respondents said that the Spotted deer should be well managed and 94.14% of the respondents said that the Mrigasthali area should be declared as "Deer Sanctuary" by the government. 48% of the 76 respondents expressed that Spotted deer should be managed by local communities themselves with technical assistance from government and NGOs / INGOs; 24.7% expressed that Kathmandu Meteropolitican should managed it. 22.3% recommended the role of PADT and remaining 5% recommended for some other institution (Figure 12).

5. DISCUSSION

5.1 General Behaviour and Diurnal Activity Pattern

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 Mrigasthali during this study. The rest position of the male, female and fawns were found to be variable and disorganized. The mixed herds and female-fawn herds were most commonly seen social groups of spotted deer in Mrigasthali. The largest herd of 25 individuals of Spotted deer was observed during evening of June at Mrigasthali. The frequent large herd were found during feeding, walking or any other disturbance. They like the company of others of their own kind. In the park we have seen good association of Spotted deer along with Barking deer and Blackbuck.

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. From the observation it is found that the Spotted deer enjoy food given by its caretaker. By feeding well served ready made food has totally changed their wild habit of browsing. The food is provided at 9.00 am and 3.00 pm respectively twice a day. The Spotted deer are provided with balanced diet everyday by the Mrigasthali caretaker in view the food preference, balanced diet and availability of the food items in the market. The Mrigasthali park authorities have very well managed the daily diet of the Spotted deer. Spotted deer feed mainly on fallen leaves and fruits of trees, as grass and edible shrubs are scarce (Raman *et.al.* 1996). In the study area the fallen leaves and fruits by Rhesus is mainly feed by Spotted deer. Axis deer drink appears to depend on season and availability of water (Waring, 1966). The spotted deer were seen drinking 2-4 times in the hot of April in Mrigasthali.

Butting of fawns each other and with 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. 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 territorial male raised his tail vertically and approached to the opponent by which the later was slightly stepped back. Out of 180 hrs 10 % shows the alertness during anti-predatory behavior in the park. In the case of danger they flew away with high speed and dispersed towards different directions. When a group of spotted deer felt threatened, a short and sharp 'Yowp!' sound was uttered.

Rutting males are known to join groups of females to form mixed group more frequently during the rut (Schaller, 1967; Khan and Vohra 1992). 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). Out of 180 hrs 4% sexual behavior like courtship, suckling, mating etc. seen in the study area during observation period. During the April, mostly males were with rutting females and successful mountings were observed in Mrigasthali. 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 12 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 barking deer were noticed in Mrigasthali park 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 born which seen walking and feeding with single mother.

The diurnal activities patterns of spotted deer were observed during April to July and September, 2014. A total of 75 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 (41.33%), followed by walking (32.67%), resting (22%), alert (10%) and others (4%). 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, 1990). 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 56%, followed by 37% in the late morning, and least as 31% in the afternoon. Spotted deer rests twice daily- the hours before the daybreak and from mid morning to mid afternoon (Mitra, 1990). 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 (24%) and least in the evening (14%). It is because of hot season in which they spend most of the daylight hours in the tree-shade.

5.2 Management Practices of Spotted deer

Khanal, (2006) reported conservation practices of Blackbuck at Khairapur, Bardia. Mrigasthali (4.8 ha) is the sacred area of Sleshmantak forest of Pashupati where deer are kept and the entire area is fenced with steel bars and gabion wires. PADT in 2004 where 2 Barking deer, 10 Spotted deer and 20 Blackbuck were introduced with the technical assistance of NTNC which are bought from central zoo. Unpolluted water is limited in Mrigasthali they drink water from a water holes which is supplied by underground water. About 1-2 hectare of the Mrigasthali area was planted and ploughed twice a year in different locations alternately were grown. The fence was seen of total use for Spotted deer protection, but some cases of Spotted deer death after striking on the fence while escaping from the chase of other animal were reported by the local people and PADT officials. Non-palatable plant species like *Ipomoea fistulata*, *Cymbopogon cirtatus* etc. were dug out, dried and burnt.

Local peoples of Kathmandu Meteropolitans were involved in the management of Spotted deer at Mrigasthali. Management Committees of PADT and NTNC members were engaged in management programmes with active participation in various discussions, interactions and training programmes organized by the local NGOs involved in Spotted deer management. Most of the local people said that the government should initiate the effective measures to manage Spotte deer at Mrigasthali. They pointed the management of Spotted deer at Mrigasthali for religious, tourism, economic and ecological importance. Almost all the local people said that the Mrigasthali area should be declared as the “Deer Sanctuary” with legislative measures as soon as possible.

6. CONCLUSION

Season, food, habitat and human interaction appear to have major influence on behaviour of Spotted deer in Mrigasthali. The seasonal changes were accompanied by changes in behaviour notably in Feeding, Walking, Resting, Alert etc. Even with the frequent anthropogenic disturbance they exhibit their characteristic social, feeding, aggressive, anti-predatory and sexual behaviour. The social groups were mainly mixed herds, breeding herds, buck herds and isolated males; the aggregations were loose which could be changed by climatic and disturbance factors. The adult bucks were mostly aggressive during rut seasons. They are calm and not aggressive towards the number of visitors daily. The "signpost" habit and sparring were common territorial behaviour of the bucks. Sharp eye sight, long range of vision in flat land and high speed are the natural defence measures of Spotted deer against predators. The mother Spotted Deer licked the neonate thoroughly while nursing, making it odourless as the means of defence. Sparring was observed mostly among the individuals of the same age group in which two males jerked their head down, locked horns with crash and then pushed and twisted their head until one turned aside. The winner often followed the loser in head up display. Out of 180 hrs only 4% sexual behavior like courtship, suckling, mating etc. recorded. The dominant male exhibited similar head up display for dominance and for courtship. Out of 180 hrs 10 % alertness during anti-predatory behavior recorded. In the case of danger they flew away with high speed and dispersed towards different directions. When a group of spotted deer felt threatened, a short and sharp 'Yowp!' sound was uttered.

They have adapted to taking supplemented food served by their caretakers and their caretaker as a part of their association. The feeding reached to the peak (56%) at 17:00 hrs in the evening and least (31%) at 12:00 hrs in the afternoon and again peaked (37%) at 9:00 hrs in the late morning. Less than 50% of Spotted deer were engaged in feeding from 12.00 to 15.00 hours; that again peaked up and continued till the evening. Drinking of water in artificial water holes was observed 2 to 3 times a day in April and May. Most common activity in day time was feeding (41.33%) followed by walking (32.67%), resting (12.44%), alert (10%) and others (4%) (Sparring, chasing, courtship, mating, etc).

In contrast to the habitat situation of Mrigasthali, there is more crowded in space. Though the staff in Mrigasthali has said that the management practices are satisfactory but i think

the area is not enough for the Spotted deer. Management of water system is much easier and good in Mrigasthali there should be made additional water holes. I found the workers very generous, experienced and punctual in case of feeding food to Spotted deer. The dead deers are buried under the soil and for the prevention from microbes, germs and bad smell, sprays and different chemicals are spread. No any complaints and suggestion were received from Mrigasthali. The climate and temperature in Mrigasthali is feasible for the spotted deer and their breeding but the area don't have enough space to move for natural food which has turned the ground into a desert type land and even they use to eat the bark of trees. For the translocation of the spotted deer, the PADT should put their words to the head office and from their decision they are moved. It would be better to improve environmental hygiene inside the park premises and expand facilities provided by the Mrigasthali. Greenery, peace, addition of animals, and availability of sufficient resting places are other major sectors for improvement. Government should pay more attention towards its better management so that we shouldn't have to hear about its extinction in near future. Fencing 1.28 km of western boundary, supplying water in artificial water holes, plantation and ploughing of tree, shrubs, grasses etc and the removal of non-palatable invasive species *Ipomoea* and *Cymbopogon* are some of the habitat manipulation practices done at Mrigasthali which are not satisfactory. 'Deers Management Committees' of local people, and NTNC work in the field of Spotted deer management. Respondents said that Mrigasthali area should be declared as 'Deer Sanctuary' and management of Spotted deer should be done by the local people. So, in the continuity of present situation, the long-term survival and population flourish of the Spotted deer at Mrigasthali does not seem to be expected.

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. Easier availability of spotted deer in the park has made the behaviorists convenient to detect wilderness behaviour of large mammal *ex-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 decorated 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 Mrigasthali:

1. For healthy environment the area should be increased or some Spotted deer should be translocated to the next suitable area with detailed ecological study.
2. Spotted deer are sprout feeders which prefer the fresh low growing grasses, herbs and forbs, so alternate ploughing of grass species on the different blocks of park.
3. Non-palatable and invasive species like Besharma (*Ipomoea fistula*), Pirrhe (*Cymbopogon cirtatus*) etc should be dug out, dried and burnt on fire before their flowering for their control and eradication.
4. Unpolluted water supply is needed in Mrigasthali. Existing artificial water holes were not much useful and not sufficient too. So, two to three other water holes should be made in Mrigasthali.
5. Captive breeding of the Spotted deer and farming for the population boost up should be done.
6. Mrigasthali should be declared as the 'Deer Sanctuary' with the essential legislative measures from the government.
7. Detailed study on ecological, behavioural and genetic aspects of Spotted deer should be given higher priority.

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APPENDIX-I

[Questionnaire Survey with PADT Authorities and Visitors of Mrigasthali]

Date... ..

1. Name of Respondent Age.....
 - a. Sex..... Place: Occupation.....
 - b. Working experiences in Mrigasthali: Years
2. Which animal is frequently observed in Mrigasthali?
 - a. Spotted deer
 - b. Barking deer
 - c. Blackbuck
 - d. Other
3. In which time do you see the animals feeding in large numbers in Park?
 - a. Early in the morning
 - b. Late morning
 - c. Afternoon
 - d. Evening
4. Which plant leaves do they prefer for browsing?
 - a. Please specify
5. In which time deer are seen drinking water?
 - a. Please specify the time
6. Have you ever seen soil licking of spotted deer?
 - a. If yes, Please specify the place
7. Are they aggressive towards other animals?
 - a. a. Yes
 - b. No
8. In which seasons do the deer fight?
 - a. Please specify the season
9. Which animals are main threats for spotted deer in Mrigasthali?
 - a. Please specify:
10. What type of relation is seen between spotted deer and monkeys
 - a. ?
11. Do local people have any kind of belief or some interesting saying about spotted deer?
 - a. Yes
 - b. No
12. Do local people interested in managing spotted deer?

Appendix-II

[Maximum and Minimum Temperature of Mrigasthali, 2010-2014 AD.]

Year Months	Maximum Temperature (⁰ C)					
	2010 AD	2011 AD	2012 AD	2013 AD	2014 AD	Average
January	22.3	19.6	17.5	18.9	18.6	19.38
February	23.2	23.8	22.8	23.8	20.9	22.9
March	29.2	27.0	26.6	28.1	25.8	27.34
April	31.9	28.7	28.7	29.3	29.6	29.64
May	30.3	28.9	31.4	30.0	29.7	30.06
June	31.1	29.4	31.2	30.0	30.6	30.46
July	29.5	28.6	28.8	29.4	29.6	29.18
August	29.2	29.5	29.5	29.6	29.3	29.42
September	28.6	28.4	29.4	29.8	28.4	28.92
October	28.0	28.1	27.3	26.6	26.5	27.3
November	24.8	22.4	22.5	22.6	21.9	22.84
December	20.8	18.9	19.3	18.8	20.2	19.6

Year Months	Minimum Temperature (⁰ C)					
	2010 AD	2011 AD	2012 AD	2013 AD	2014 AD	Average
January	3.1	2.4	2.7	1.6	3.9	2.74
February	4.8	5.3	5.2	6.1	5.6	5.4
March	10.9	8.8	8.4	10.1	9.1	9.46
April	13.9	11.9	13.0	12.4	11.9	12.62
May	16.8	16.2	16.0	17.1	16.4	16.5
June	19.5	19.0	20.1	20.1	20.0	19.74
July	20.6	20.5	20.6	20.4	20.9	20.6
August	20.6	20.0	20.2	20.2	20.6	20.32
September	19.2	19.1	19.0	18.9	19.0	19.04
October	14.9	14.2	12.7	15.9	13.6	14.26
November	9.9	9.5	6.5	7.7	10.1	8.74
December	2.9	4.1	4.0	4.8	4.8	4.12

APPENDIX-III

[Some photoplates of the study area]



Photo 1. Practice to note the behavioural data in the field.



Photo 2. Rhesus-spotted deer association Seen in the study area



Photo 3. Female-fawn herd heading towards the water holes.



Photo 4. Spotted deer utilizing the tree shade in hot-dry season.



Photo 5. Adult Male spotted deer foraging on the tree leaves.



Photo 6. A mixed heard group seen in cool dry season.



Photo 9. Enclouser for wounded and treatment of deer in Mrigasthali.



Photo10. Schima-Castonopsis forest and heavily grazed bare area in Mrigasthali.



Photo 11. Shelter and resting place for Spotted deer inside Mrigasthali.



Photo 12. Discussion and taking interviews with the PADT officials.



Photo 13. Protection of Trees through metallic fencing inside Mrigasthali.



Photo 14. Water holes and Cemented pools inside Mrigasthali.

