Journal of Institute of Science and Technology, 24(2), 49-57 (2019)
ISSN: 2469-9062 (print), 2467-9240 (e)
Doi: http://doi.org/10.3126/jist.v24i2.27257

Research Article

HIGH MORTALITY AND ALTERED DIURNAL ACTIVITY PATTERN OF CAPTIVE BLACKBUCK (*Antilope cervicapra*) IN MRIGASTHALI ENCLOSURE, PASHUPATINATH AREA, KATHMANDU

Rita K.C., Laxman Khanal*

Central Department of Zoology, Institute of Science and Technology, Tribhuvan University, Kathmandu, Nepal
**Corresponding author: lkhanal@cdztu.edu.np*

(***Received**: October 1, 2019; **Revised**: November 15, 2019; **Accepted**: November 26, 2019)*

ABSTRACT

One of the major objectives of keeping the wild animals in captivity is their successful breeding, population growth and future translocation. However, many species have lesser behavioral flexibility and fail to establish a viable population in captive conditions due to poor management, intolerant climatic conditions, competitions with other co-housed species, diseases, etc. Blackbuck (*Antilope cervicapra*) is a nationally endangered and protected mammalian species of Nepal. Blackbucks have been kept under captivity of Mrigasthali enclosure at Pashupatinath Temple area in Kathmandu since 2004 AD and the population has dwindled sharply in recent years. This study was designed to assess the population trend and diurnal activity pattern of the species in the Mrigasthali enclosure. Population census data for the last fifteen years were analyzed and behavioral samplings were done by 'Focal animal sampling' and 'Scan sampling' methods from 5th April to 29th July 2016. The study revealed a sharp decrease of the population since the outbreak of the foot-and-mouth disease in 2014 exposing the remnant population into the risk of extirpation. The surviving individuals have the diurnal activity pattern and the time budgets prominently different than that of the wild populations, especially, they invest lesser time on feeding and more time on resting. Living in open areas despite cooler climate, intense competition for food and space with spotted deer and monkeys, lower behavioral flexibility of the species, anthropogenic disturbances, stochasticity related to the smaller population size, etc. were perceived as the major threats to the Blackbuck in Mrigasthali enclosure.

Keywords: Krishnasar, Mrigasthali, Captivity, Death rate, Behavioral flexibility, Time budgets

INTRODUCTION

Captivity of animals includes their confinement for the purpose of food production or labor, human recreation or education, or domestication as pets (Ross, 2014). Captive environment can be defined in terms of four dimensions potentially affecting animal behaviour: regular presence of large numbers of unfamiliar and behaviourally diverse (passive-active) humans, restricted and unchanging space, forced proximity to other animal species, and human management (Hosey, 2005). Captivity imposes limits on animal behavioural diversity, especially on those with higher mobility and large home ranges, and has been traditionally associated with the appearance of atypical behaviours or stereotyped actions such as moving in circles, pacing, excessive self-cleaning or scratching and, in extreme cases, self-biting and mutilation (Tarano & Lopez, 2015).

Effects of captivity on the behavior and survival vary among animal species depending on their behavioral flexibility, i.e. the ability of animals to modify behaviour in adaptive ways over time and space (Jones, 2005). Flexibility is determined through variation in the expression of different behaviours (such as foraging, mate choice, affiliation, agonism or dispersal). In the wild habitat, animals have a rich social life and often live in large kin groups, whereas, captive animals suffer from isolation, self-harm, developmental deficiencies, and negative health outcomes (Ross, 2014). Captive mammals adjust their behavior to cope with their environment, potentially resulting in genetic and phenotypic divergence between captive and wild populations. Captive individuals can change their behavior to meet an immediate specific need, such as conforming to feeding schedules or conspecific groupings (McPhee & Carlstead, 2010). In some cases, such changes can have strong negative effects on an individual's ability to reproduce successfully, thus affecting the probability of maintaining a sustainable *ex-situ* population. Additionally, captivity can exert directional or relaxed selective pressures on behaviors that will affect the frequencies of those behaviors in future generations. Therefore, as individual behavior shifts, the distribution of traits within a population will also shift over generations. It is important to promote naturalistic and active behaviors in captive animals because such behaviors play vital roles in animal health, successful captive breeding and reintroduction for threatened species and reducing stress-related behaviors or stereotypies (Shyne, 2006).

Ungulates, especially different species of family Cervidae and Bovidae are kept in the zoos and parks because they are beautiful and valuable addition to any captive habitats.

One of the most challenging goals of maintaining such wild animals in captivity is to be able to predict behavioral responses to environmental changes (Thompson, 1989). Ungulates in captivity are under the influence of multiple interdependent factors such as the enclosure, maintenance procedures, keepers, and visitors. In response to those factors, captive animals show alteration in their normal behavior and activity patterns, often the frequency of agonistic behavior increases and affiliative behavior decreases. Captivity has, however, been largely understudied regarding its effect on behavior of the housed animals (Burrell & Altman, 2006).

Blackbuck (*Antilope cervicapra* Linnaeus 1758), known as 'Krishnasar' in Nepali, is the antelope belonging to 'Bovidae' family and is endemic to South Asian region. They were widely distributed in the grasslands of Terai region of Nepal, however, at present, single population is surviving in the wild at Blackbuck Conservation Area (BCA) in Bardiya district. Blackbuck is considered nationally endangered and protected by the National Park and Wildlife Conservation Act 1973 of Nepal (Chalise, 2004). Apart from the wild population in BCA, few captive individuals exist in Central Zoo, Mrigasthali enclosure, Shuklaphanta National Park and Nepalgunj Mini-zoo (KrCA, 2017).

Blackbucks are one of the important animals in the zoo collection which breed very well when they are given proper protection. Upon getting the proper protection, balanced diet and proper medication, the number of the Blackbuck goes up very fast (Rao, 2011). Blackbucks have been kept in Mrigasthali enclosure (Fig. 1), a semi-captive condition with food provisioning by the management of Pashupati Area Development Trust since 2004 AD. They share the enclosure with about 150 Spotted deer (*Axis axis*), few Barking deer (*Muntiacus muntjak*) and more than 400 Rhesus monkeys (*Macaca mulatta*). A total of 20 Blackbucks were introduced in Mrigasthali enclosure in 2004, the population increased above 50 individuals by 2010; however, more than three dozen of them died within few months of 2014. After that, Blackbuck population is struggling to revive back. The reason behind the failure of successful breeding of Blackbuck in Mrigasthali enclosure hasn't been explored yet. Additionally, the behavioral pattern of the surviving captive Blackbuck and their interactions with other co-housed animals are not documented. Therefore, we aimed to explore the population trend and diurnal activity pattern of the Blackbuck in Mrigasthali enclosure. We compared the time budget of the captive Blackbuck with that of the wild populations from previous studies (Mungall, 1978; Chattopadhyay & Bhattacharya, 1983; Khanal, 2006; Ban, 2012) in order to assess the effects of captivity on behavioral patterns. Further, we analyzed their mortality pattern and tested the prevalence of the gastrointestinal parasites. The findings of this research will be helpful for the management of captive mammals in zoos, parks and other enclosures.

MATERIALS AND METHODS

Study site: The Pashupatinath Temple Area

Pashupatinath Area lies in the Kathmandu valley, a flat plain valley located at an altitude of about 1310 m above sea level. Kathmandu consists of many small forest areas in-and-around the valley. Amongst these, the forest patch in Pashupati area bears open grassland, dense and tall trees, temples, stupas and scattered shrines (Fig. 1). Pashupati temple lying on the bank of Bagmati River is about 1700 years old religious place for Hindus. This Hindu temple area is listed on the list of UNESCO World Heritage Sites since 1979 (UNESCO, 2019).

The study area is located in the hilly region. The geological formation of the area is composed of the lacustrine soil formed by the deposited materials in the lake; hence it is fertile (Khanal *et al.*, 2005). The average temperature of the area in summer (May to August) ranges from 19 ºC to 27 ºC and in winter (November to February) ranges between 2 ºC to 20 ºC. Forest in this area is of sub-tropical type. Some of the common flora of the study area are Hade-bayar (*Zizyphus incurve*), Alder (*Alnus nepalensis*) Latte (*Rorippa nasturtium*), Pipal (*Ficus religiosa*), Kuro (*Bidense* sp.), Katus (*Castanopsis tribuloides*), Phirphire (*Acer oblongum*), Chilaune (*Schima wallichi*), Gobre sallo (*Pinus wallichiana*), Sisnu (*Urtica dioica*), Banmasa (*Lantana camara*), Ainshelu (*Rusby sellipticus*), Kapur (*Dryobalanops aromatica*), Kafal (*Myrica esculenta*), Horsetail (*Equisetum* sp.), Bar (*Ficus bengalensis*), etc. Planted trees alternate the forest environment and newly grown species of bushes that is replacing the old and natural species include Titepati (*Artemisia vulgaris*), Chari amilo (*Medicago denticulre*), Banmasa (*Lantana camara*), etc. (Khanal *et al.*, 2005; KC, 2016).

The important fauna of Pashupatinath area are the Rhesus monkeys (*Macaca mulatta*), which are diurnal in habit. Besides Rhesus monkeys, the area is used by Crow (*Corvus splendeus*), House sparrow (*Passer domesticus*), Common maina (*Acridotheres tristis*), Forest rat (*Rattus everetti*), Jungle cat (*Felis chaus*), etc. The Rhesus monkey is the dominant mammal of the area with altogether nine troops consisting of about 430 individuals (Chalise, 2013).

Mrigasthali deer enclosure

Pashupati Area Development Trust (PADT) in collaboration with the National Trust for Nature Conservation (NTNC) Nepal established a deer colony in 2004 within the Mrigasthali forest area by translocating captive bred Barking deer (*Muntiacus muntjak*), Blackbuck (*Antilope cervicapra*) and Spotted deer (*Axis*

axis) from the Central Zoo, Jawalakhel (Khanal *et al.*, 2005). The total area of about 48000 square meter of the forest is fenced with netted metallic fence of about four-meter height (Fig. 1).

The PADT aimed to give reality for the name of the place Mrigasthali (Nepali: *Mriga*-deer, *Sthal*- place) flourishing the religious belief about the area as well as the multiplication of the ungulates in semi-captive habitat. Currently, the enclosure houses about 150 spotted deer, less than half a dozen each of Blackbuck and Barking deer. The area is managed by PADT and the captive animals are supplemented with soaked maize, soybean, gram, choker, etc. mixing with Ayumin-V'. They are also supplied different types of vegetables including cabbage, turnip, carrot, cauliflower, etc. after chopping into smaller pieces.

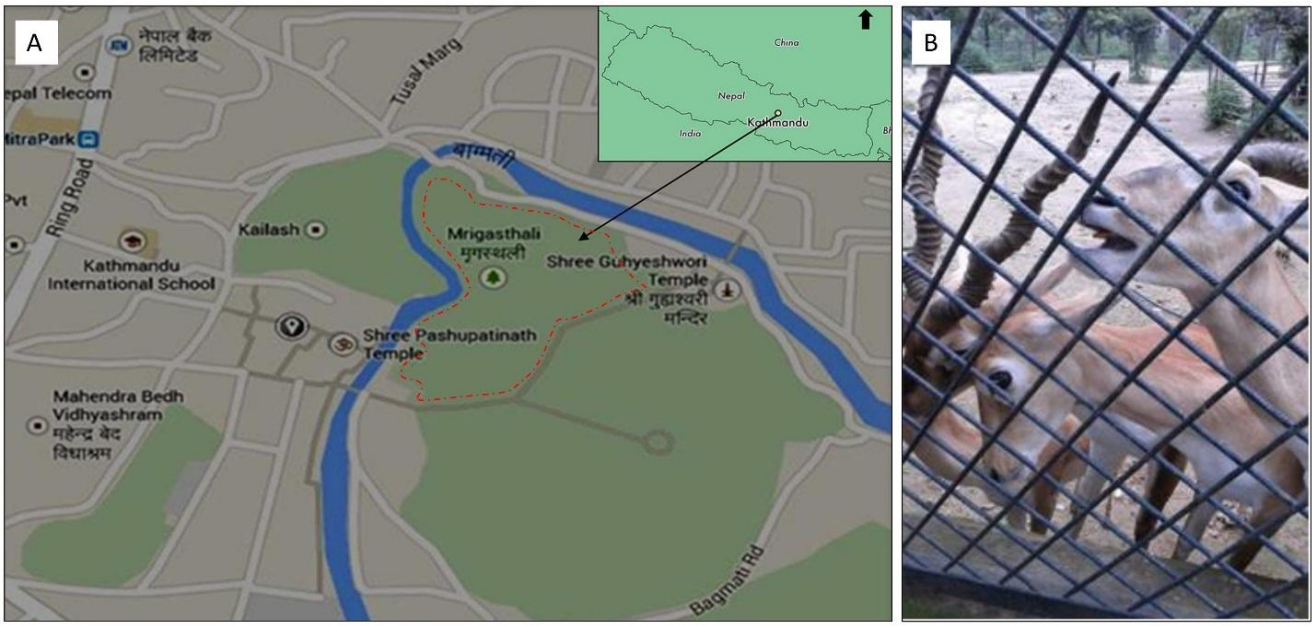

Fig. 1. Map of Pashupatinath area showing Mrigasthali enclosure (represented by red dotted lines, not in scale) (A); Blackbucks inside the enclosure (B)

MATERIALS AND METHODS

Population census

The population of Blackbuck in the Mrigasthali enclosure was censused from the year 2016 by direct observation and age-sex categorization was done according to Jhala (1991). The historical population data were collected from multiple publications including Khanal *et al.* (2005), Ghimire and Shrestha (2009), and the records of Pashupati Area Development Trust.

Diurnal activity pattern

Blackbucks were observed daily from 6:00 AM to 18:00 PM from 5th April to 29th July 2016 for almost four months. The daily observation schedule was divided into four shifts; early morning shift (6:00–9:00 hr), late morning shift (9:00-12:00 hr), afternoon shift (12.00–15:00 hr) and evening shift (15:00-18:00 hr). Direct ocular observation was employed for cataloguing the behavior and monitoring the activities.

Behavioral data were obtained by the 'Focal Animal Sampling' and 'Scan Sampling' methods as described by Altman (1974). The data of event and state behavior were obtained by focal animal sampling. A well identified animal (focal animal) was observed for an observational shift of three hours as mentioned above and all interactions involving that animal were recorded. The quantitative data on the frequency, temporal sequence and duration of behavior was obtained by this method. To obtain the amount or percentage of time used for different behaviors scan sampling of the Blackbuck herd was performed. Blackbuck activities were divided into different state behaviors (Table 1) and at the interval of each 10 minutes, the number of individuals engaged on respective states were noted.

Any remarkable events noticed during the observation were noted. Careful note was made of the activity of the animals, the location of the sighting and any habitat factor affecting their behavior during the field visit. Pattern of movements of the herd was also noted.

Gastro-intestinal parasites investigation

The prevalence of gastro-intestinal parasites in the Blackbuck of Mrigasthali enclosure was assessed by sampling the fresh fecal materials. The fresh fecal samples from different age and sex group of Blackbucks were

collected in sterilized plastic sample tubes and were preserved in 10 % formalin before the samples were examined. Parasite identification was based upon the size and appearance of cysts, eggs and larvae of parasites. The gastro-intestinal parasites were examined in the District Livestock Service Office, Lalitpur by Formalin-Ethyl Acetate concentration (floatation and sedimentation) procedure followed by microscopic observation using 400x to1000x magnifications.

Data analysis

The Blackbuck population and birth rate and death rate were expressed in the bar diagrams. The quantitative data on the frequency, temporal sequence and duration of behavior were converted to percentage and expressed in the pie chart and bar diagrams using Microsoft Excel.

Table 1. Ethogram for monitoring general behavior of the Blackbuck inside the Mrigasthali enclosure

Behavior	Description
Feeding	Grazing, browsing or drinking natural or supplemental materials
Resting	Sitting, lying on the ground, not engaging in other listed behaviors
Standing	Upright position of the animal, not lying on the ground and not engaging in other behaviors
Alert	Scanning the surrounding in head-up position and exhibiting agonistic displays
Moving	Locomotion of different type and purpose such as walking, running, jumping, etc.
Others	Sparring, chasing, courtship, mating, suckling, etc.

RESULTS

Population status of Blackbuck

Current population of Blackbuck in the Mrigasthali enclosure is of only four individuals (two males and two females) by the end of August 2019. Since the introduction of 20 individuals in the year 2004, the population of Blackbuck increased up to 54 individuals by the year 2010 (Fig. 2).

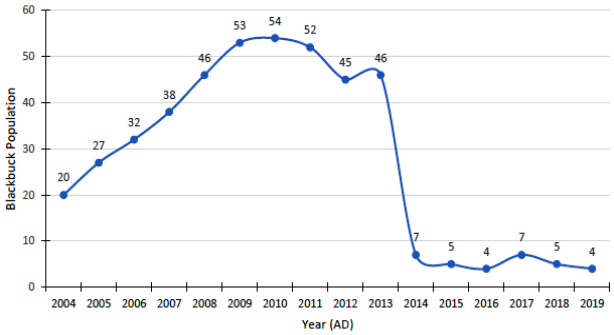

Fig. 2. The population trend of Blackbuck in the Mrigasthali enclosure, Pashupatinath area, Kathmandu

However, it started to decrease and a massive death of the Blackbucks occurred in May and June 2014 due to foot and mouth disease. By the end of the year 2014, only seven individuals of the Blackbuck survived inside the Mrigasthali enclosure. The regular observation since 2016 revealed that the annual death rate has often exceeded the annual birth rate and the population has never gone above seven (Fig. 3).

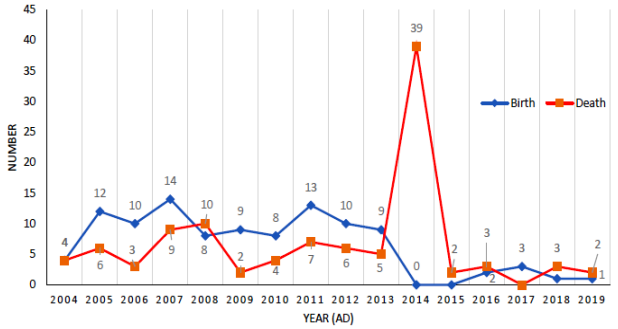

Fig. 3. Birth and death record of Blackbuck in Mrigasthali enclosure, Pashupatinath area, Kathmandu (Source: Khanal *et al.*, 2005; Ghimire & Shrestha, 2009; and field visits 2016-2019)

Diurnal activity pattern and time budget

The total animal contact time for behavioral observation was of 190 hours. A single herd with four individuals (two males and two females) was observed for this study. The herd invested highest percentage of the diurnal time on feeding (40 %) followed by resting (32 %), walking (13 %), standing (9 %), alert (3 %) and others (3 %) of the day time (Fig. 4).

Percentage of time invested on feeding was found to be the highest (75 %) in 6:00 to 9:00 hours observation phase followed by 69 % in 15:00 to 18:00 hours observation phase, 66 % in 09:00 to 12:00 hours observation phase and only 30 % in the observation phase to 12:00 to 15:00 hours (Fig. 5). Resting of Blackbuck was found to be the highest (50 %) in 12:00 to 15:00 hours observation phase followed by 24 % in 09:00 to 12:00 hours observation

phase, 10 % in 06:00 to 09:00 hours observation phase and 9 % in 15:00 to 18:00 hours observation phase. Walking percentage was found to be the highest (16 %) in 15:00 to 18:00 hours followed by 9 % in 12:00 to 15:00 hours, 5 % in 6:00 to 9:00 hours and 4 % in 9:00 to 12:00 hours. Blackbucks were seen mostly alert (6 %) in 12:00 to 15:00 hours followed by 4 % in 6:00 to 9:00 hours, 3 % in 9:00 to 12:00 hours, 3 % in 9:00 to 12:00 hours and 2 % in 15:00 to 18:00 hours observation phase.

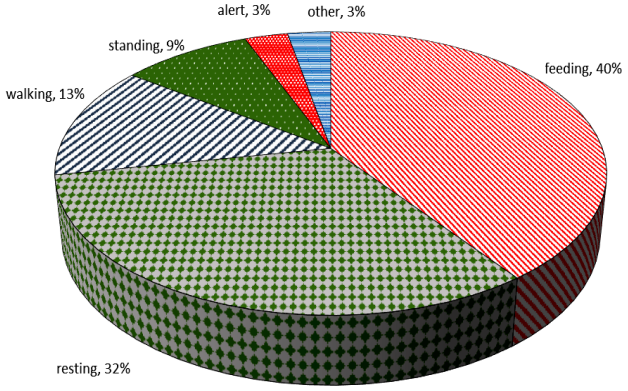

Fig. 4. Diurnal time budgeting of Blackbuck population in Mrigasthali enclosure, Pashupatinath area

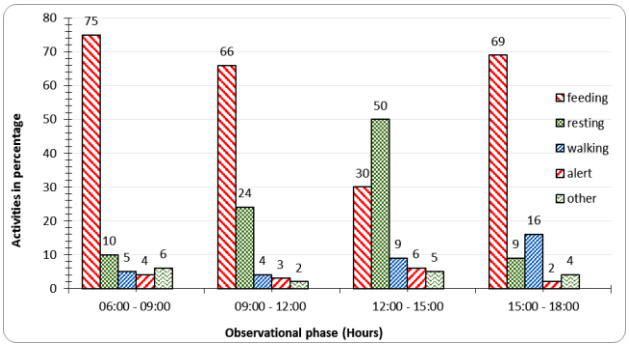

Fig. 5. Activity patterns of Blackbuck at different observational phases in Mrigasthali enclosure, Pashupatinath area

Feeding behavior of Blackbuck

There was a fixed schedule to provide the food in the enclosure. So, feeding population peaked (85 % to 95 %) three times a day around 6 hours, 11 hours and 17 hours (Fig. 6). Less than 50 % of the animals were engaged in feeding between 9:00 to 10:00 hour and then feeding percentage peaked around 11:00 hours to 12:00 hours. Less than 50 % of animals were busy in eating around 2:00 hours and continued to decrease to 16:00 hours. Again 80 % of animals were found to be busy in eating around 17:00 hours. Blackbucks were enclosed along with Spotted deer, so there was competition between them for food. Blackbucks were seen drinking water from the artificial water hole two to three times a day.

Gastro-intestinal parasitic examination

Total four samples of fresh pellets, each from separate Blackbuck of Mrigasthali enclosure were examined microscopically in laboratory to find out gastro-intestinal parasites. None of the four pellets were found infested by the gastro-intestinal parasites. The management of the enclosure administers deworming drugs in every six months to prevent the in-housed animals suffering from parasitic worms. As recommended by the Central Zoo, Jawalakhel animals were supplied with Framindazol mixed with their food for two days in every six months. A vitamin named Groviplex was given to the ungulates for five days after giving Framindazol.

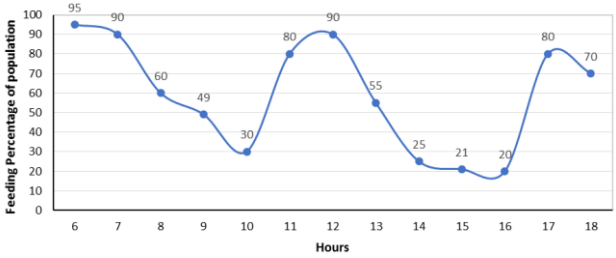

Fig. 6. Feeding Percentage population of Blackbuck between 06:00 and 18:00 hours in Mrigasthali enclosure, Pashupatinath area

DISCUSSION

Population status

A total of 20 Blackbucks were introduced at Mrigasthali enclosure of the Pashupatinath Temple area with the technical assistance of Central Zoo, Kathmandu, Nepal in 2004. The enclosure is managed by Pashupati Area Development Trust (Khanal *et al.*, 2005). The population peaked to 54 individuals by the year 2010 and started to dwindle afterwards. There were 46 Blackbuck in 2013, but the Blackbucks suffered from the chronic infection of foot and mouth disease (FMD) with the onset of summer season in May and June 2014 and 35 Blackbuck died due to the disease itself (KC 2016). Foot-and-mouth disease virtually appeared as the major problem of the Blackbuck. The population of Blackbuck dropped dramatically throughout the year and only seven Blackbucks were counted in 2015. There were seven individuals in February 2015. The population of Blackbuck decreased again to five in June 2016 due to leopard attack and only four individuals were counted in July 2016. Similar incidence of death due to FMD has been reported from the wild habitat of Blackbuck in Khairapur, Bardiya of Nepal (Khanal, 2006). The animal can live normally in captivity, if the near natural conditions are provided. Only limited natural conditions are available in the captivity. The range of tolerance to alternations in environment is variable for different species and individuals with in a species due to which animal becomes uncomfortable and at greater

extremes of stress it may become susceptible to diseases and injury (Khanpara, 2009). Rao (2011) revealed that due to proper environment, protection, balanced diet and proper medication Kanpur Zoological Park had crossed the carrying capacity of the enclosures. The drastic drop of Blackbuck population in Mrigasthali enclosure may be due to environmental conditions which is not suitable for the lowland adapted species. Blackbucks prefer warmer tropical and sub-tropical grasslands; however, they are also thriving in the shades of Central Zoo, Jawalakhel. The cooler and unroofed area of Mrigasthali enclosure may not provide optimum climatic conditions for them to survive.

The smaller the population size, the more vulnerable it is to extinction due to demographic, environmental and genetic stochasticity. The smaller population may become extinct through change fluctuations in fertility and mortality of individuals or a peculiar age structure (Sukumar, 1992; Chapman & Reiss, 2005). The size of group is often considered a fundamental attribute of the social organization of such species (Jarman, 1974; Wilson, 1975). Inbreeding between members of small populations (e.g. in captivity) will result in increased homozygosity and the expression of deleterious recessive alleles, resulting in decreased fecundity, higher mortality and reduced growth rates. In addition, loss of heterozygosity may reduce a population's ability to respond to environmental changes, which could eventually drive a population to extinction (Caro & Laurenson, 1994).

The small population of Blackbuck in Mrigasthali is prone to extinction because of environmental stochasticity that may result from an adverse climate, disease outbreak or predator attack. In a small population, gene frequencies change from one generation to another with the loss of some alleles which is known as genetic drift that leads in to genetic uniformity, such genetic uniformity is not better in evolutionary point of view for the continuity of generation of animals. Sukumar (1992) mentioned that about 500 effective breeding individuals are necessary to counter the genetic drift through natural selection or by gain from mutation, and the population maintaining this effective size can be expected to remain viable from an evolutionary viewpoint. Fragmented, small and isolated populations are at greater risk from demographic (reproductivity and mortality) and environment stochasticity (Purvis *et al.*, 2000). Species with small population, such as the Blackbuck may also suffer from genetic problems (loss of heterozygozity and inbreeding depression).

Altered diurnal activities

Diurnal activities were recorded during April to July 2016. A total of four individuals of both sexes were observed. Most common activity in a characteristic day was feeding (40 %) followed by resting (32 %), walking (13 %), standing (9 %), alert (3 %) and others (3 %). Khanal (2006) accounted more than half of the diurnal time on feeding (~ 57 %) followed by resting (~ 21 %), whereas, Mungall (1978) observed only 40 % of the day time invested on feeding by the introduced population of Blackbuck in Texas, USA. Blackbucks at Ballavpur Wildlife Sanctuary, India spent more than 50 % of the day light on grazing. The higher percentage of resting during this study was due to the easy availability of food. Blackbucks were provided food time to time a day. So, they didn't have to spend more time on searching food. They utilized their time for resting. Their diurnal activities were almost same throughout the study period due to fixed daily schedule.

The animal mostly remained active in the day time except a brief spell around noon when less than 50 % of the population was seen to be active. The activities reached to their peaks once in morning at 06:00 hours. During the peak hours of grazing no individuals were seen resting whereas, during low period of activity and feeding most of them were seen resting on the ground. Standing, resting and alert as static activities, characteristically show just the reverse relation with grazing and walking. Male and female showed similar activity pattern though female showed significantly more feeding than males.

Blackbucks in Mrigasthali enclosure were observed dominated by spotted deer while approaching and using the supplemental food. It may be due to the greater number of large sized spotted deer. Spotted deer grabbed the front position during feeding period; they occupied good resting spot of enclosures. They disturbed to maintain the territory for male bucks. Additionally, it was noticed that visitors used to feed the Blackbucks by biscuits, gram etc. from metal net fence. Such unauthorized feeding might change the food preferences of the animals and might even consume salted polythene pouches of noodles, potato chips, biscuits etc. Similar to this speculation, Khanal *et al.* (2005) reported large amount plastic in the stomach of dead female Blackbucks in Mrigasthali enclosure from their postmortem observations. Children teased them and threw small stones and poked by sticks when Blackbucks came closer to eat biscuits and grams. Pregnant females may abort from such harassment and have serious adverse effects on reproduction (KC, 2016). These activities also disturbed the resting and feeding behaviors of Blackbucks. Similarly, noisy activities of monkeys also disturbed their resting activity. Similarly, monkeys were responsible for the injuries or deaths of many fawns (personal communication from Hom N. Nepal, PADT). This may be the one cause of less population in Mrigasthali.

Blackbucks are almost exclusive grazers (Roberts, 1997; Schaller, 1998) and as most of the ruminants they are non-

selective feeders. They survive well in semi-desert regions as long as there is sufficient scattered vegetation and cultivations (Majupuria & Majupuria, 2006). Therefore, at many places people consider Blackbuck as a problem animal to crops as they damage their crops (Lehmkuhl, 1997; Behera & Mohanta, 2019). The Mrigasthali enclosure has tall trees with dense canopy and barren grounds without the grasses and crop fields. The in-housed animals are supplemented with grains and vegetables including gram, soybean maize corn and wheat chaff called "choker" along with mineral mixture named "Ayumin B". They spent most of the early morning and late afternoon time on feeding and regurgitate their food while resting. Captive conditions like limited foraging space, super abundance of food, protection against natural predators and overlapping territory for bucks during breeding season may greatly alter the time activity budget for the Blackbuck.

Survival threats of Blackbuck in captivity

Parasitic infestations are considered one of the major threats for a small population of the wildlife, it is more pronounced in the captive populations in small enclosure (Khanal & Chalise, 2011). During this study, no gastro-intestinal parasites were recorded from the stool samples of the Blackbuck from the Mrigasthali enclosure which might be due to their recent de-worming campaign by enclosure management. However, there is high chance of parasitic infestations in such enclosures with sharing of limited space among other ungulates and Rhesus monkeys. The common parasites of livestock grazing in the Blackbuck habitat and Blackbucks of BCA were *Paramphistomum*, *Strongyles*, *Ascaris* and *Coccidia* (Khanal & Chalise, 2011). Whereas, Choudhary and Maharjan (2017) identified 12 different species of parasites in Blackbuck at BCA which includes *Entamoeba* and *Eimeria* among protozoans; *Paramphistomum* and *Fasciola* among trematodes; *Moniezia* among cestode; *Trichostrongylus, Ascaris, Haemonchus, Strongyloides, Bunostomum, Trichuris* and *Oxyuris* among nematodes. Although present study showed none of Blackbucks were infested but the chances of transmission of parasites and diseases were seen higher due to close association, dietary and habitat overlap of the Blackbuck with that of Spotted deer and monkeys.

Apart from the parasitic infestations, higher level of competition of Blackbuck with spotted deer and monkeys for the food was observed as one of the major threats to the Blackbuck. Both exploitative and interference type of competitions for the consumption of supplemental food were prominent and Blackbucks were always in the losing sides. Interspecific aggressive interactions are known among a variety of animals including ungulates (Hanzlikova *et al.*, 2014). Even in the wild habitats, high density of competitors such as feral cattle affect the health and survival of the Blackbuck (Khanal, 2006; Khanal & Chalise, 2011; Baskaran *et al.*, 2016; Prashanth *et al.*, 2016). However, we could not quantify the extent of interspecific aggressive interactions between the Blackbuck and Spotted deer enclosed within the same enclosure. That put the limitation on identifying the impacts of such interaction in mortality.

CONCLUSION

This study analyzed the population status and diurnal activity pattern of the Blackbuck in the captive habitat of Mrigasthali enclosure at Pashupatinath Temple area. The population experienced some increments in the past but that collapsed mainly with chronic cases of FMD in the year 2014 and is represented by only four remnant individuals at present. The Blackbucks in Mrigasthali enclosure have very low behavioral flexibility and are highly prone to vanish from any kind of stochasticity. Under the influence of lack of natural forage, dependence to the supplemental foods and competitions (both interference and exploitation) with ecologically superior species like spotted deer and Rhesus monkeys, the Blackbuck population has unusual diurnal activity pattern and time budgets. However, we acknowledge that there may be other variables still to be assessed, and/or multivariable interactions may be contributing to the continued poor breeding success and survival of the Blackbuck in Mrigasthali enclosure.

ACKNOWLEDGEMENTS

We are thankful to the Pashupati Area Development Trust (PADT) for granting permission to carry out this research work at Mrigasthali enclosure. Our sincere thanks are due to Mr. Hom Prasad Nepal, Mr. Hira Lal Pakhrin and Raj Subedi for their valuable information and support during the field work. We appreciate the support of the District Livestock Services, Lalitpur for the facility to identify gastrointestinal parasites of Blackbuck.

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