REVIEW ARTICLE AGROBIOLOGICAL RECORDS
ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

BIOLOGY AND ECOLOGICAL ADAPTATIONS OF BLACKBUCK (*ANTILOPE CERVICAPRA)*: A REVIEW

Rabia Tahir [1], Abdul Ghaffar [1]*, Samra [2], Jaweria Zafar [3], Tanveer Hussain Turabi [4], Xiaoxia Du [5]*, Sangam Khalil [4], Muhammad Safeer [4], Sana Riaz [1], Habiba Jamil [1] and Umair Noor [1]

[1]Department of Zoology, The Islamia University of Bahawalpur, Pakistan;
[2]Department of Zoology, University of Agriculture Faisalabad, Pakistan;
[3]Department of Zoology, Govt. Post Graduate College (W), Satellite Town, Gujranwala, Pakistan;
[4]Department of Forestry and Wildlife, University College of Agriculture and environmental Sciences, The Islamia University of Bahawalpur, Pakistan;
[5]Shandong Vocational Animal Science and Veterinary College, Weifang 261061, China

Corresponding author: dr.abdul.ghaffar@iub.edu.pk (AG); duxiaoxia0931@126.com (XD)

ABSTRACT

Blackbuck is the existing members of genus *Antilope* which is most elegant and graceful among all Antelopes of Asia with distinct sexual dimorphism. Blackbuck show endemism in Pakistan, Nepal and India occupying mainly the semi-arid grassland areas. The name of species attributes towards the dark brownish to blackish coat color of male species. While female and the young ones are tawny or yellow. Chin undersides of legs and chest are white in both male and female individuals. Males have whorled horns with 79cm length with absence in females. The average body length of this animal is 100-150cm with the tail length of 10-17cm. The average body weight for male is 20-57kg and for female 19-33kg. Thin grassy forests, open and semi-desert areas are good habitat for it. Being diurnal and herbivorous, it acts as both grazers and browsers. It is the fastest animal with an average speed of 80km/h. It remains reproductively functional whole year. Reproductive disorders including dystocia and different infectious diseases due to ectoparasites, endoparasites, bacteria and viruses affect these species. Habitat loss, stress, illegal killing and genetic troubles cause the species to be 'Extinct in the Wildlife' in Pakistan so conservation strategies are underway for species protection. It is indispensable for zoologists and conservational biologists to observe the species for its conservation and confronting threats. Review article highlighted necessary information about species, which will clear the way for further research on species.

***Keywords*:** *Antilope cervicapra*, Blackbuck, Herbivorous, Endemic in Pakistan**,** Sexual Dimorphism, Siwaliks, Diurnal, 'Extinct in the Wild' in Pakistan.

Article History (2020-0414) || Received: 21 Apr 2020 || Revised: 05 Aug 2020 || Accepted: 04 Nov 2020 || Published Online: 05 Dec 2020

1. INTRODUCTION

Blackbuck is the single living member of genus *Antilope* endemic to Pakistan, Nepal and India (Long 2003) with some members present in the UAE (Mallon and Kingswood 2001). There are four subspecies of Blackbuck (Csurhes and Fisher 2010) among which two have been recognized (Grubb 2005), which might be independent (Groves and Grubb 2011). Subspecies are as follows: *A. c. cervicapra* (southeastern blackbuck), *A. c. rajputanae* (Pakistan and northwestern blackbuck), *A. c. centralis* (present in central India) and *A. c. rupicapra* (found in Nepal and North India) (Csurhes and Fisher 2010). It is the most gracious and beautiful among all antelopes of Asia (Van der Geer 2008; Saluja et al. 2012).

Although blackbucks have vanished from many regions due to habitat obliteration for anthropocentric development but still their population size is increasing in many protected areas. The data obtained from the Berhampur Forest Division of Ganjam district, India showed that blackbuck population has increased from 1020 to 2325 in about three years. Comparative study of three forest division of Ganjam district revealed that the population growth of blackbuck was highest in Berhampur Forest Division, followed by North Division Gumshur which may be owing to the convenience of virtuous environment and fortification from the local people. Due to increased population in some areas of India the blackbuck is considered to be an irritant animal for agricultural crops (Milind et al. 2016; Behera and Mohanta 2019).

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

Like many other wild animals, blackbuck is also a threatened species which are conserved in many Blackbuck (*Antilope cervicapra*) Conservation Areas (BCA), Khairapur, Bardiya and Shuklaphanta Wildlife Reserve (SWR), Kanchanpur district, Nepal. The current effort was made to report different parasitic infection in blackbuck of BCA by fecal examination using floatation, sedimentation and Stoll's counting techniques (Ballweber et al. 2014; Chakraborty et al. 2016; Alvarado-Villalobos et al. 2017; Pouillevet et al. 2017). An overall, 90% gastro-intestinal parasite while 55 and 89% protozoan and helminthic prevalence was found at study area. The results of our work provided baseline information regarding the presence of parasitic infections in Blackbuck and to design the suitable policies to control parasitic problems (Chaudhary and Mahendra 2017). Another study conducted in Pakistan to find diversity analysis of *Antilope cervicapra* in which fecal samples were collected from different locations and territories. DNA was extracted from fecal samples and Polymerase Chain Reaction (PCR) was executed. Diversity, phylogenetic analysis and Sequencing was performed by different Bioinformatics tools and Big DyeTM Terminator method. Less genomic inconsistency was detected within *Antilope cervicapra* inhabitants through Multi-Dimensional Scaling (MDS) (Abbas et al. 2020).

This review article foregrounds all the aspects of species such as economic importance, taxonomy, evolution, paleontology, morphology, social behavior, breeding, feeding and ecology All these aspects are mention briefly so it will assist in an advance research for conservation of blackbucks in the country.

2. ECONOMIC IMPORTANCE

By taking into account the economic importance and part of nature of Blackbuck attraction of tourists and researchers, its conservation is necessary to maintain the beauty and biodiversity of nature (Amar 2011). For ecotourism, conservational support and sustainable management of species, blackbuck is getting great attention of country level policies (Aryal 2019). Hunting of the species is very much attracting part for some people as species have delicious and nutritious meat. Hunting for amusement is also observed for many cases which is mainly decreasing the blackbuck. High quality meat of species is transferred abroad for subsistence and trade by many agencies. Poaching of offspring to keep the species as a pet is also observed in many cases because of beauty and charm of species liked by privileged sector. In addition, blackbuck have enormous beauty for attracting researchers, biologists and common people due to its morphologically unique features. Moreover, blackbuck feeding habits are necessary to maintain the balance of many wild grasses and shrubs which indirectly playing a role for the ecosystem balance. Blackbuck is important part of food web and food chain of semi-arid grassland (Csurhes and Fisher 2010). Blackbuck play important role in the seed dispersal of many medicinal plants growing in its habitat. Bulk of seeds dispersing by blackbuck through their digestive system, defecated seeds which fall on the ground and growing there naturally (Chandru et al. 2020). Some of the earlier studies reported for the consumption and seed dispersal of *P. juliflora* in grassland habitat by *Antilope cervicapra* (Jadeja et al. 2013; Corlett 2017; Yamato et al. 2020).

3. TAXONOMY AND EVOLUTION

Blackbuck *(Antilope cervicapra),* a lonesome existing individual of genus *Antilope,* were classified under family Bovidae of the order Artiodactyla in the class Mammalia. Carl Linnaeus had given the binomial name of the species in 1758 (Meena et al. 2017). Tribe Antilopini has formed a clade with *Antilope, Eudorcas, Gazella and Nanger.* Furthermore, study of the karyotype of *Antilope* in 1995 and phyletic investigation in 1999 has corroborated that *Antilope* was nearer to *Gazella* group (Vassart 1995; Rebholz 1999). In the recent revision of phylogeny of Antilopini ascertained that *Antilope and Gazella* were sister genera (Considine and Kulik 2008; Bärmann 2013).

4. PALAEONTOLOGY

Siwaliks is a group of southern Himalayan Mountains extending from southwestern Kashmir through India into southeastern Nepal. Fossilized species of genus *Antilope* found in Pakistan are *A. subtorta* from Pliocene in Upper Siwaliks, *A. planicornis* and *A. intermedius* in Middle Siwaliks, *A. cervicapra* from Siwaliks in Pleistocene and *Kobus porrecticornis* from Upper Siwaliks (Khan et al. 2006; Chauhan 2008). Investigations have exhibited that *A. intermedia* intimately colligated to *A. cervicapra* (Khan and Akhtar 2014). *Antilope* genus was recorded at Tatrot and Pinjor sites of Upper Siwaliks, in Africa within omo group and in Gerakarou, Greece during the late Pliocene (Kostopoulos and Koufos 2006).

5. SPECIES DESCRIPTION

5.1. Morphology of Blackbuck

Blackbuck is the most gracious and grandeur among all antelopes of Asia (Van der Geer 2008; Saluja et al. 2012). Species are ungulate with percipient sexual dimorphism (Meena and Saran 2018). The dark brownish to blackish coat color of the male makes attribution towards the name 'Blackbuck' (Sheikh and Molur 2004; Csurhes and Fisher 2010).

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

Eyes are encircled by a white ring. In addition, males have whorled horns with the length of 79cm while absent in female (Csurhes and Fisher 2010). The average body length of species is 100-150cm with the tail length 10-17cm long. The height of shoulders ranges from 60-85cm (Roberts 1997). The average body weight for males is 19.5-56.7kg and for females, it is 19-33kg (Csurhes and Fisher 2010). Morphology of both male and female Blackbuck is clearly depicting that coat color of male is blackish or dark while female is tawny or yellowish. Beauty of horns and intensity of coat color of male species increases with maturity. At first the coat color is yellowish. Then gradually it become darkish with age, a sign that male is getting mature.

5.2. Life Span

Variation in the life span of male and female species was observed as female members of species have high life span as compared to male. Average recorded lifespan in general for blackbuck is ten to fifteen years. The highest recorded age is 12 to 13 years for male and up to 16 years for females. While the average death rate of blackbuck for mature individuals is nearly 8 years (Buckley 2020). Sex ratio of adults is strongly observed to be female biased. Male members of blackbuck reported to show steep decline in survivorship curves as compared to female. Moreover, difference in lifespan of male and female members, high mortality rate in young males thought to be caused by sexual variation in intensity of sexual selection (Meena et al. 2017).

5.3. Social Behavior

Blackbucks are diurnal animal. They mostly live in the form of herd from few to several hundred members (Khanal 2006; Mahato et al. 2010). Three types of social groups exist between species: (1) group with all male members (2) group with all female members (female of all ages and immature male members) and (3) males and females of all ages. Herd size has been strongly influenced by changing seasons and foraging (Jhala and Isvaran 2016). The social behavior of species in the form of grouping of male and female blackbucks to a herd which help them in defense, foraging and in other aspects (Isvaran 2005a; Vats and Bhardwaj 2009; Debata et al. 2017).

5.4. Territory Establishment

Mature male developed the territorial domains in the days of rut development and the size of which varied. Moreover, bucks executed impressions with visual vestiges or bushes and grasses were stained by the odor of pre-orbital gland. Bucks also have laded feces and urine ejected chemicals to pose their social order (Rajagopal et al. 2011). Licking is also perceptible social spectacle in blackbuck and is explicated by the female group size (Isvaran 2000; Isvaran 2005b) and mating strategy. Blackbuck use facial scent gland to mark their territory observed mostly in the days of rut development (Jadeja et al. 2013).

5.5. Predators and Defense: Wolves (*Canis lupus pallipes*) and Cheetah (*Acinonyx jubatus*) are the main predators of species. Predation and bite by the snake also abridge the count of the species. Blackbuck is the quickest animals with the recorded average speed of 80km/h. Swift running and perceptive eyesight are the important defensive factor for species. Furthermore, study has illustrated that superior bucks defend their territory by ostentatiously peculiar postures such as they uplift snout, draw the ears backward, elevate tail, which is curved upward, making a white spot on buttock more discernible. Species position down the head till adjoining the land and insert the peaks of horns to the adversary. In this position, it can withstand the adversary for 15-25min (Kumar and Rahmani 2008; Csurhes and Fisher 2010).

5.6. Breeding and Reproduction

Blackbucks are reproductively functional around the whole year (Buckley 2020). In captivity, there is no breeding apex while in wild blackbuck have highest breeding in mid-August to mid-October. Resource-based territoriality and lek territoriality are the two major type of mating systems observed in blackbuck (Meena et al. 2017). Mating territoriality has shown variation from solitary dispersed to strongly grouped classical leks. In addition, sex ratio of adult members also shown variation as female members have high sex ratio. Preorbital and skin glands of species are reported to have significance for pheromonal communication during breeding season mainly. Pheromone carrying proteins are observed in the preorbital glands of blackbuck which are reported to involved in the territoriality marking and attraction for females airing breeding period (Rajagopal et al. 2011).

Dystocia (difficult birth) was observed in Blackbuck with 75% mothers under study found normal after delivery while 25% was died after obstetric operations (Riaz et al. 2012). Dystocia may have caused by feto-maternal imbalance, cervical dilation (ring womb) non-accomplishment, uterine contortion, uterine inactivity and abnormal postures. Increased amount of epinephrine may have blocked the normal birth process by hindering the hormone release. This serious problem is also contributing for the decline of species (Fraser 2010).

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

5.7. Gestation

Females get sexually matured at the age of two or three years. Gestation is typically six months long after which a single calf is born. Females can mate again after a month of parturition (Schmidly 2004). Juveniles remain active and playful throughout the day. Juvenile males turn black gradually, darkening notably after the third year (Vats and Bhardwaj 2009; Schmidly 2004; Buckley 2020).

6. ECOLOGY AND HABITAT

6.1. Introductory Ecology

Thin forests, grassy plains (Mellon 2007; Deal 2011; Csurhes and Fisher 2010), open areas (Sutherland 1996; Jethva and Jhala 2004) and semi-desert areas are nifty habitat for the species (Mahato et al. 2010). Blackbuck mostly live in the tropical areas due to their daily requisiteness for water (Mallon 2008; Csurhes and Fisher 2010).

6.2. Habitat in Different Regions

Tropical, sub-tropical and hot deserts are the usual habitat of species in Pakistan (Sheikh and Molur 2004). What is more, it is also present in a desert land, coastal areas and mountainous regions. In addition, species are specializing to the short-grass areas with the semiarid environment (Schmidly 2004; Bhatta 2008). Grassland and forest dapples with agricultural areas are the impeccable habitat for Blackbuck (Csurhes and Fisher 2010; Asif and Modse 2016).

6.3. Seasonally Opted Habitat

Semi-arid grassland is the most preferable habitat of species while some variation is there for different seasons (Behera and Mohanta 2019). Blackbuck is bias for grassy areas during monsoon, cropland during summer and winter, while bushy areas are the less bias habitat of species in all seasons (Murmu et al. 2013). Social subordination in male members suppresses the functions of gonads which indirectly affected the habitat selection of these members as they select the less desirable habitats. This selection of habitat due to social dominance by other male members cause the low survival rate and less reproductive potential of these members (Rajagopal et al. 2018).

6.4. Seasonal Effects on Nutritional Ecology

In disparate seasons, species opt for different diets mostly biasing for grasslands (Meena and Saran 2018). Study shows that *Dicanthium annulatum* and *Prosopis juliflora* constitute 35% and 10% respectively to the yearly dry content consumption. Foraging and rate of digestibility are great during monsoon and winter as compared to summer and the dry season (Brashares 2002; Jadeja et al. 2013).

7. FEEDING OF BLACKBUCK

7.1. Diet

Blackbuck being herbivorous acts as both grazer (Isvaran 2005a; Novillo and Ojeda 2008; Mahato et al. 2010; Rajagopal et al. 2011; Jhala and Isvaran 2016) and browser. Blackbuck picks out the sedges, fall witch-grasses (*Digitaria cognate*), berseem *(Trifolium alexandrinum)* as grazer and selects out Mesquite, Acacia trees (in Cholistan Desert) and live oaks as a browser (Pathak et al. 1992). Cereals and pulse crops feed by species in the form of young shoots so they damage the crop. Fruits, pods and flowers have been ingested by species as supplementary diet (Mahato et al. 2010). The crude protein (10.4%) content is optimum for consumption in the diet to exclude the inauspicious aftermaths by consumed diet and on metabolite in the serum of Blackbuck (Das et al. 2012). They consume crops, cereals, grass, fresh tender leaves, vegetables and leaves of shrubs and trees (Meena and Saran 2018).

7.2. Foraging Behavior

Blackbuck shows diurnal foraging behavior (Mahato et al. 2010) but in some instances, they also forage nocturnally (Long 2003; Csurhes and Fisher 2010). Its foraging activity depends upon large number of factors and the sunrise and temperature, food quality and its availability are very important (Meena and Chourasia 2017, Meena and Saran 2018). The size of the group fluctuates during foraging with the handiness of nutrients (Mohammed and Modse 2016). Large herds spend more time on foraging (Isvaran 2007; Meena and Chourasia 2017). A weak and variable tie-up in foraging herd ranges from less than ten members to many hundreds of species (Rajagopal et al. 2011).

8. DISEASES

8.1. Endoparasites

Different endoparasites including *Haemonchus cortortus*, *Trichostrongylus axei*, *Taenia hydatigena* and *Trichuris species* (Fagiolini et al. 2010; Lima et al. 2020) and *Camelostrongylus mentulatus* (Chaudhary and

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

Mahendra 2017). In Cholistan desert of Pakistan, 20% gastrointestinal infections by helminthes were recorded (Farooq et al. 2012). Frequency and prevalence of internal parasites of blackbuck at Bikaner zoo such as *Strongylides* species, *Nematodirus* species, *Trichuris* species, *Balantidium coli*, *Eimeria* species and *Wenyonella* species was recorded as 76.19, 28.57, 38.09, 4.76, 9.52, 7.14 and 2.38%, respectively (Goossens et al. 2005; Cruz-Hernández 2015).

8.2. Ectoparasites

Ectoparasites found in Blackbuck include many parasites (Mertins et al. 1992). Larval Ixodidae and *Tricholipeurus parallelus*; ticks (*Hyalomma anatolicum* and *Boophilus microplus*), Anoplura (sucking lice: *Linognathus cervicaprae*); Mallophaga (chewing louse: *Damalinia cornuta cornuta*); Diptera (louse fly: *Lipoptena mazamae*); Acari (lone star tick: *Amblyomma americanum)* and *Psoroptes cuniculi* are the prominent species (Prakash et al. 2015).

8.3. Bacterial infections

Listeria monocytogenes is the food borne pathogenic bacteria, which gets into the Blackbuck by ensilage herb store in slightly aerobic state inducing listeriosis causing the death of species. Mycobacterium tuberculosis is the bacterial species seriously affecting the *Antilope cervicapra* at the Bardia National Park of Nepal. This bacterial species observed only in captive members of blackbuck while absence of such type of bacteria in wild species. Blackbuck is susceptible to serious infection by this species as it caused death in other species (Peters et al. 2020). *Mycobacterium bovis* isolated from lymph node of thorax and abdomen of blackbuck causing bovine tuberculosis in species leading towards death (Podhade et al. 2013; Akhtar et al. 2019). *Arcanobacterium pyogenes* was reported in blackbuck causing necrotizing pneumonia; mandibular osteomyelitis; peritonitis along with hepatic, pulmonary, renal, and subcutaneous abscessation. Males were observed to get influenced highly as compared to females (Portas and Bryant 2005). In addition, strains of *Escherichia coli* were found in the blackbuck members at the Bikaner Zoo (Rathore et al. 2016). Epizootic hemorrhagic disease virus (EHDV) is a pathogen vectored by Culicoides midges that causes significant economic loss in the cervid farming industry and affects wild deer as well. Despite this, its ecology is poorly understood (Dinh et al. 2020).

8.4. Other infections

Ocular wounds have been detected in Blackbuck, which were caused by *Trypanosoma cruzi*. *Balantidium coli* was also observed in few species of blackbuck at Bikaner zoo (Cruz-Hernández 2015). Contagious ecthyma also called sore mouth is highly contagious viral disease caused by orf virus, which was observed in blackbuck showing the symptoms of thick confluent nodular skin lesions near mouth and dry scaly fissures in the abdominal skin, thigh and shoulder along with subcutaneous hemorrhages (Sharma et al. 2016).

9. CONSERVATION OF SPECIES

Threats like hunting, habitat loss, accidents and pollution (Sheikh and Molur 2004), population explosion (Komers and Curman 2000, Krausman and Bleich 2013), genetic troubles (Jnawali et al. 2011, Purvis et al. 2000), stress and illegal killing have caused the species to be 'Extinct in the Wildlife' in Pakistan (Sheikh and Molur 2004; Nemat et al. 2013). Therefore, different conservation strategies like protection laws (Ali et al. 2011), captive breeding, hormone-mediated conservation, artificial insemination (Sontakke et al. 2009; Sagar and Antoney 2017) and religious affiliation (Kankane 2013; Kankane 2014; Mohapatra 2014) were adopted. Some parasites of livestock and Blackbuck are common and there is a great chance of transference of parasite from the livestock to the blackbuck, which cause hurdle to overcome challenges in its conservation. The index of similarity of parasites between them is 0.67 (Pant and Joshi 2019). Captive breeding in Lal Suhanra National Park, Bahawalpur (Ahmad, 1983), Karachi Zoo and Safari Park, Karachi (Khan et al. 2014) and Kalabagh Game Reserve (IUCN, 1990) breeding centers in Punjab (Mallon and Kingswood 2001) and private farms in Sindh are the main centers where these animals are kept for conservation (Amar 2011).

Conclusion: Blackbuck has mesmerizing beauty with its unique black color, which attracts tourists, researchers and zoologists to observe the species. Darker color coat of male and yellowish coat of female exhibits the unusual sexual dimorphism. The swiftness with an average speed of 80km/h and perceptive eyesight are the unique features of species, which helps for its defense. A species with its endemism adds uniqueness in Mammalian biodiversity of Pakistan. It is concluded by the review that species count is curtailed by different threats like stress, hunting, genetic problems and diseases which should be eradicated by adopting disparate conservation strategies. Among all conservation strategies, captive breeding is the most effective one at present for increasing the count of Blackbucks.

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

Summarized data covering all aspects of species given in an article will be helpful for further research on species, which is required at that time for conservation of species. Therefore, there will be an emendation in the Mammalian biodiversity of Pakistan.

ORCID

Rabia Tahir https://orcid.org/0000-0003-3693-3956
Abdul Ghaffar https://orcid.org/0000-0002-5608-785X
Samra https://orcid.org/0000-0002-9517-6599
Jaweria Zafar https://orcid.org/0000-0002-2186-3521
Tanveer Hussain Turabi https://orcid.org/0000-0002-0053-7284
Xiaoxia Du https://orcid.org/0000-0002-6245-9138
Sangam Khalil https://orcid.org/0000-0002-9386-8540
Muhammad Safeer https://orcid.org/0000-0002-9642-6676
Sana Riaz https://orcid.org/0000-0003-1986-8785
Habiba Jamil https://orcid.org/0000-0002-5605-0432
Umair Noor https://orcid.org/0000-0001-7203-606X

REFERENCES

Abbas G, Nadeem A, Javed M, Ali MM, Aqeel M, Babar ME, Tahir MS, Tabassum S and Shehzad W, 2020. Mitochondrial *cytochrome-b, cytochrome-c* and *d-loop* region based phylogenetic and diversity analysis in blackbuck (*Antilope cervicapra*). Kafkas Universitesi Veteriner Fakultesi Dergisi 26: 25-31. https://doi.org/10.9775/kvfd.2019.22108

Ahmad A, 1983. A note relating to some problems with the re-introduced blackbuck [*Antelope cervicapra*] at Lal Suhanra in Bahawalpur [Pakistan]. Pakistan Journal of Forestry 33: 87-90.

Akhtar R, Sadiqa M, Tipu MY, Khan MR, Aslam A, Ijaz M, Mustafa G and Zahid B, 2019. Use of molecular probes for presumptive diagnosis of tuberculosis associated with Mycobacterium tuberculosis and Mycobacterium bovis infection in antelopes in Pakistan. Pakistan Veterinary Journal 39: 316-319. http://dx.doi.org/10.29261/pakvetj/2019.067

Ali Z, Bibi F, Mahel AQ, Firdous F and Zamaan SU, 2011. Captive Breeding Practices in Pakistan: A Review. Journal of Animal and Plant Sciences 21: 368-371.

Alvarado-Villalobos MA, Giuseppe C, Maria PM, Aurelie C, Laura R, Barbachano-Guerrero A, Roger G, Colin AC and Serio-Silva JC, 2017. Flotation techniques (FLOTAC and mini-FLOTAC) for detecting gastrointestinal parasites in Howler monkeys. Parasites & Vectors 10: 586. https://doi.org/10.1186/s13071-017-2532-7

Amar G, 2011. Blackbucks: a dying breed in Kirthar? Available at: http://www.pakistantoday.com.pk/2011/07/11/blackbucks-a-dying-breed-in-kirthar. Accessed April 04, 2017.

Aryal C, Ghimire B, Niraula N, 2019. Tourism in protected areas and appraisal of ecotourism in Nepalese policies. Journal of Tourism and Hospitality Education 9: 40-73. https://doi.org/10.3126/jthe.v9i0.23680

Asif M and SR Modse, 2016. The Distribution Pattern and Population of Blackbuck *Antilope cervicapra* Linnaeus in Bidar, Karnataka. Indian Forester 142: 965-970.

Ballweber LR, Beugnet F, Marchiondo AA, Payne PA, 2014. American Association of Veterinary Parasitologists'review of veterinary fecal flotation methods and factors influencing their accuracy and use – is there really one best technique? Veterinary Parasitology 204: 73-80. https://doi.org/10.1016/j.vetpar.2014.05.009

Bärmann EV, Rössner GE and Wörheide G, 2013. A revised phylogeny of Antilopini (Bovidae, Artiodactyla) using combined mitochondrial and nuclear genes. Molecular Phylogenetics and Evolution 67: 484-493. https://doi.org/10.1016/j.ympev.2013.02.015

Behera SK and Mohanta RK 2019. A survey of the abundance, population structure, and distribution of blackbuck (Antilope Cervicapra) using day ground surveys in Berhampur Forest Division, Area, Odisha. Annals of Ecology and Environmental Science 3: 1-4

Bhatta S, 2008. People and Blackbuck: Current management challenges and opportunities. The Initiation 2: 17-21. https://doi.org/10.3126/init.v2i1.2514

Brashares JS and Arcese P, 2002. Role of forage, habitat and predation in the behavioural plasticity of a small African antelope. Journal of Animal Ecology 71: 626–638.

Buckley G, 2020. Blackbuck. Biology Dictionary. https://biologydictionary.net/blackbuck/. Accessed on July 12, 2020.

Chakraborty, Tiwari S, Reddy DM and Umapathy G, 2016. Prevalence of gastrointestinal parasites in civets of fragmented rainforest patches in Anamalai Hills, Western Ghats, India. Journal of Parasitology 102: 463-467. https://doi.org/10.1645/15-834

Chandru G, Pandiyan J, Durga V, Govindarajan M, Alharbi NS, Kadaikunnan S, Khaled JM, Panneerselvam C, Krishnappa K, 2020. Seed dispersal by ungulates in the point calimere wildlife sanctuary: A scientific and perspective analysis. Saudi Journal of Biological Sciences 27: 2790-2797. https://doi.org/10.1016/j.sjbs.2020.06.042

Chaudhary RB and Mahendra M 2017. Parasitic infection in blackbuck (*Antilope cervicapra* Linnaeus, 1758) of Blackbuck Conservation Area, Bardiya and Shuklaphanta Wildlife Reserve, Kanchanpur, Western Nepal. Nepal Journal of Environmental Science 5: 9-17. https://doi.org/10.3126/njes.v5i0.22710

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

Chauhan PR, 2008. Large mammal fossil occurrences and associated archaeological evidence in Pleistocene contexts of peninsular India and Sri Lanka. Quaternary International 192: 20-42. https://doi.org/10.1016/j.quaint.2007.06.034

Considine GD and Kulik PH 2008. Van Nostrand's Scientific Encyclopedia (10thed). Wiley-Interscience. Hoboken, New Jersey, USA; pp: 183.

Corlett RT, 2017. Frugivory and seed dispersal by vertebrates in tropical and subtropical Asia: An update. Global Ecology and Conservation 11: 1-22. https://doi.org/10.1016/j.gecco.2017.04.007

Cruz-Hernández NDL, Edgar López-Acevedo E, Torres-Rodríguez L, Gabriel Aguirre-Guzmán G 2015. Fatal parasitosis in blackbucks (*Antilope cervicapra*): a possible factor risk in hunting units. Revista MVZ Córdoba 20: 5046-5052

Csurhes S and Fisher P, 2010 (Updated 2016). Blackbuck, *Antilope cervicapra*. Pest Risk Assessment. Department of Agriculture and Fisheries. Biosecurity Queensland pp. 1-13.

Das AS, Katole A, Kumar SP and Gupta MS, 2012. Feed consumption, nutrient utilization and serum metabolite profile of captive blackbucks (*Antelope cervicapra*) fed diets varying in crude protein content. Journal of Animal Physiology and Animal Nutrition 96: 442–449. https://doi.org/10.1111/j.1439-0396.2011.01162.x

Deal KH, 2011. Wildlife and Natural Resource Management, 3rd Ed. Delmar Cengage Learning. Clifton Park, New York, USA; pp: 156.

Debata S, 2017. Population size, herd structure and sex ratio of the Blackbuck *Antilope cervicapra* (Mammalia: Cetartiodactyla: Bovidae) in a human dominated area in Odisha, India. Journal of Threatened Taxa 9: 10953-10955. https://doi.org/10.11609/jott.2658.9.11.10953-10955

Dinh ETN, Cauvin A, Orange JP, Shuman RM, Samantha M. Wisely SM and Blackburn JK, 2020. Living la Vida T-LoCoH: site fidelity of Florida ranched and wild white-tailed deer (*Odocoileus virginianus*) during the epizootic hemorrhagic disease virus (EHDV) transmission period. Movement Ecology 8: 14 (2020). https://doi.org/10.1186/s40462-020-00200-2

Fagiolini M, Lia RP, Laricchiuta P, Cavicchio P, Mannella R, Cafarchia C, Otranto D, Finotello R and Perrucci S, 2010. Gastrointestinal parasites in mammals of two Italian zoological gardens. Journal of Zoo and Wildlife Medicine 41: 662-670. https://doi.org/10.1638/2010-0049.1

Farooq ZS, Mushtaq ZI and Akhtar S, 2012. Parasitic helminths of domesticated and wild ruminants in Cholistan desert of Pakistan. International Journal of Agriculture and Biology 14: 63-68.

Fraser AF, 2010. The behavior and welfare of the horse. 2nd Ed, Cambridge University Press, Cambridge, UK; pp: 140.

Goossens E, Dorny P, Boomker J, Vercammen F, and Vercruysse J, 2005. A 12-month survey of the gastro-intestinal helminths of antelopes, gazelles and giraffids kept at two zoos in Belgium. Veterinary Parasitology 127: 303-312. https://doi.org/10.1016/j.vetpar.2004.10.013

Groves C and Grubb P, 2011. Ungulate Taxonomy. Johns Hopkins University Press. Baltimore, Maryland, USA; pp: 317.

Grubb P, 2005. Order Artiodactyla. In: Mammal Species of the World: A Taxonomic and Geographic Reference (3rd ed.), Wilson, D.E. and D.M. Reeder, (eds). Johns Hopkins University Press. Baltimore, Maryland (US). pp: 637-688.

Isvaran K and Jhala Y, 2000. Variation in lekking costs in blackbuck (*Antilope cervicapra*): relationship to lek-territory location and female mating patterns. Behaviour 137: 547–563. https://doi.org/10.1163/156853900502204

Isvaran, K. 2005a. Variation in male mating behaviour within ungulate populations: Patterns and processes. Current Science 89: 1192-1199

Isvaran K, 2005b. Female grouping best predicts lekking in blackbuck (*Antilope cervicapra*). Behavioral Ecology and Sociobiology 57: 283-294. https://doi.org/10.1007/s00265-004-0844-z

Isvaran K, 2007. Intraspecific variation in group size in the blackbuck antelope: the roles of habitat structure and forage at different spatial scales. Oecologia 154: 435-444. https://doi.org/10.1007/s00442-007-0840-x

IUCN, 1990. IUCN directory of South Asian protected areas. International Union for Conservation of Nature (IUCN), Gland, Switzerland and Cambridge, UK; pp: 294.

Jadeja SS, Prasad S, Quaderand K and Isvaran, 2013. Antelope mating strategies facilitate invasion of grasslands by a woody weed. Oikos 122: 1441-1452. https://doi.org/10.1111/j.1600-0706.2013.00320.x

Jethva BD and Jhala YV, 2004. Foraging ecology, economics and conservation of Indian wolves in the Bhal region of Gujarat, Western India. Biological Conservation 116: 351-357. https://doi.org/10.1016/S0006-3207(03)00218-0

Jhala YV and Isvaran K, 2016. Behavioural Ecology of a Grassland Antelope, the Blackbuck *Antilope cervicapra*: Linking Habitat, Ecology and Behaviour. In: Ecology of Large Herbivores in South and Southeast Asia. Springer, Dordrecht pp: 151-176.

Jnawali SR, Baral HS, Lee S, Acharya KP and Upadhyay GP, 2011. The Status of Nepal Mammals: The National Red List Series, Department of National Parks and Wildlife Conservation Kathmandu, Nepal; pp: 4.

Kankane PL, 2013. The Revival Model for Common Property Reserves in the Thar Desert of Rajasthan with Special Reference to their Faunal Components. In: Faunal Heritage of Rajasthan, India. Springer, Cham, pp: 299-307.

Kankane PL, 2014. Human being as one of the factor for survival of larger mammals in the Thar desert of Rajasthan. Traditional Knowledge 241: 241-248.

Khan MA and Akhtar M, 2014. Antelopes (Mammalia, Ruminantia, Bovidae) from the Upper Siwaliks of Tatrot, Pakistan, with description of a new species. Paleontological Journal 48: 79-89.

Khan MA, Ghaffar A, Farooq U and Akhtar M, 2006. Ruminant fauna from the Tertiary hills (Neogene) of the Siwaliks of Pakistan. Journal of Applied Sciences 6: 131-137. https://doi.org/10.3923/jas.2006.131.137

Khan MZ, Samreen N, Ghalib SA, Zehra A and Hussain B, 2014. Biology and behaviour study of Chinkara, Cheetal, Nilgai, Blackbuck and Hog Deer in captivity in Karachi zoo and Safari Park. International Journal of Biology and Biotechnology 11: 341-349.

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

Khanal L, 2006. Population Status, General Behaviour and Conservation Practices of Blackbuck (Antilope cervicapra) at Khairapur, Bardiya, Nepal. A Dissertation Submitted to Central Department of Zoology, Tribhuvan University, Kathmandu

Komers PE and Curman GP, 2000. The effect of demographic characteristics on the success of ungulate re-introductions. Biological Conservation 93: 187-193. https://doi.org/10.1016/S0006-3207(99)00141-X

Kostopoulos DS and Koufos G, 2006. Pheraios chryssomallos, gen. et sp. nov. (Mammalia, Bovidae, Tragelaphini), from the Late Miocene of Thessaly (Greece): Implications for tragelaphin biogeography. Journal of Vertebrate Paleontology 26: 436-445.

Krausman PR and Bleich VC, 2013. Conservation and management of ungulates in North America. International Journal of Environmental Studies 70: 372-382. https://doi.org/10.1080/00207233.2013.804748

Kumar S and Rahmani AR, 2008. Predation by Wolves (*Canis lupus pallipes*) on Blackbuck (*Antilope cervicapra*) in the Great Indian Bustard Sanctuary, Nannaj, Maharashtra, India. International Journal of Ecology and Environmental Sciences 34: 99-112.

Lima TA, Salgado PAB, Chagas CRF, Ramos PL, Adriano EA and Gonzalez IHL, 2020. Feral cats: Parasitic reservoirs in our zoos? Open Journal of Veterinary Medicine 10: 126-138. https://doi.org/10.4236/ojvm.2020.108011

Long JL, 2003. Introduced mammals of the world: their history, distribution and influence. CSIRO Publishing, Collingwood, Australia; pp: 486-487.

Mahato AKR, Ramakrishna M and Raziuddin, 2010. Status, ecology and behaviour of *Antilope cervicapra* (Linnaeus, 1758) in Proposed Community Reserve for Blackbuck, Ganjam District, Orissa, India. Zoological Survey of India; pp: 1-160.

Mallon DP and Kingswood SC (compilers), 2001. Antelopes. Part 4: North Africa, the Middle East, and Asia. Global Survey and Regional Action Plans. SSC Antelope Specialist Group. International Union for Conservation of Nature (IUCN). Gland, Switzerland and Cambridge, UK; pp: 7-249.

Mallon DP, 2008. *Antilope cervicapra*. IUCN Red List of Threatened Species. IUCN. Version 2017-1. Available at: www.iucnredlist.org. Accessed 18 February 2017.

Meena R and Saran RP, 2018. Distribution, ecology and conservation status of blackbuck (*Antilope cervicapra*): An update. International Journal of Biology Research 3: 79-86.

Meena R and Chourasia V, 2017. Forage availability and feeding preferences of Blackbuck *Antelope Cervicapra* Linn in Sorsan, Rajasthan, India. International Journal of Current Advanced Research 6: 7370-7373.

Meena R, Saran RP and Chourasia V, 2017. Population characteristics, habitat availability, forage preferences and threats to the blackbuck *Antilope cervicapra* (Linn) in the Sorsan Region of Baran, Rajasthan. World Journal of Zoology 12: 53-59.

Mellon D, 2007. *Antilope cervicapra*. IUCN red list of threatened species. Available at: www.iucnredlist.org. Accessed 15 February 2017

Mertins JW, Schlater JL and Corn JL, 1992. Ectoparasites of the Blackbuck Antelope (*Antilope cervicapra*). Journal of Wildlife Diseases 28: 481-484.

Milind W, Kajol P, Abhijeet B and Pramod P, 2016. A theoretical model of community operated compensation scheme for crop damage by wild herbivores. Global Ecology and Conservation 6: 58-70. https://doi.org/10.1016/j.gecco.2015.11.012

Mohammed A and Modse S, 2016. The distribution pattern and population of Blackbuck *Antilope cervicapra* Linnaeus in Bidar, Karnataka. The Indian Forester 142: 965-970.

Mohapatra A, 2014. Concept of Biodiversity Conservation in Indian Religion. Traditional Knowledge Social Practices pp. 161-168.

Murmu A, Mahato AKR, Guha S and Saren PC, 2013. Status of Blackbuck, *Antilope cervicapra* in Orissa. Status Survey Report; pp: 1-20.

Nemat A, Ali Z, Ahmad S, Sikander SK and Hussain Z, 2013. Study of disease records of zoo animals in Lahore Zoo, Pakistan. The Journal of Animal and Plant Sciences 25: 483-492.

Novillo A and Ojeda RA, 2008. The exotic mammals of Argentina. Biological Invasions 10: 1333–1344. https://doi.org/10.1007/s10530-007-9208-8

Pant L and Joshi PS 2019. Conservation threats of re-introduced blackbuck (antilope cervicapra) in hirapurphanta of Shuklaphanta National Park, Kanchanpur, Nepal. International Journal of Progressive Sciences and Technologies 5: 24-41.

Pathak NN, Kewalramani N and Kamra DN, 1992. Intake and digestibility of oats (*Avena sativa*) and berseem (*Trifolium alexandrinum*) in adult blackbuck (*Antilope cervicapra*). Small Ruminant Research 8: 265–268. https://doi.org/10.1016/0921-4488(92)90047-8

Peters H, Sadaula A, Masters N and Sainsbury A, 2020. Risks from disease caused by *Mycobacterium orygis* as a consequence of Greater one-horned Rhinoceros (*Rhinoceros unicornis*) translocation in Nepal. Transboundary and Emerging Diseases 67: 711-723. https://doi.org/10.1111/tbed.13389

Podhade DN, Jasutkar RK, Vivek K and Ajay D, 2013. Bovine tuberculosis in a black buck (*Antilope cervicapra*)-a case report. Veterinary Practitioner 14: 71-2.

Portas TJ and Bryant BR, 2005. Morbidity and mortality associated with *Arcanobacterium pyogenes* in a group of captive blackbuck (*Antilope cervicapra*). Journal of Zoo and Wildlife Medicine 36: 286-289. https://doi.org/10.1638/04-058.1

Pouillevet H, Serge-Ely D, Ngoubangoye B, Poirotte C, Marie JE and Charpentier, 2017. A Comparative study of four methods for the detection of nematode eggs and large protozoan cysts in Mandrill Faecal Material. Folia Primatologica 88: 344–357. https://doi.org/10.1159/000480233

Prakash MM, Sahu P, and Gaherwal S, 2015. Hard ticks induced hematological changes in blackbuck (*Antilope cervicapra*). Indian Streams Research Journal 4: 8. https://doi.org/10.6084/m9.figshare.1362161.v1

Purvis A, Agapow PM, Gittleman JL and Mace G, 2000. Nonrandom extinction and the loss of evolutionary history. Science 288 (5464): 328-330. https://doi.org/10.1126/science.288.5464.328

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

Rajagopal T, Archunan G and Sekar M, 2011. Impact of zoo visitors on the fecal cortisol levels and behavior of an endangered species: Indian blackbuck (*Antelope cervicapra* L.). Journal of Applied Animal Welfare Science 14: 18-32. https://doi.org/10.1080/10888705.2011.527598

Rajagopal T, Archunan G, Geraldine P and Balasundaram C, 2010. Assessment of dominance hierarchy through urine scent marking and its chemical constituents in male blackbuck *Antelope cervicapra*, a critically endangered species. Behavioural Processes 85: 58-67. https://doi.org/10.1016/j.beproc.2010.06.007

Rajagopal T, Ponmanickam P, Chinnathambi A, Padmanabhan P, Gulyas B and Archunan G, 2018. Inter-relationship of behaviour, faecal testosterone levels and glandular volatiles in determination of dominance in male Blackbuck. NISCAIR-CSIR, India 56: 781-794. http://nopr.niscair.res.in/handle/123456789/45347

Rathore P, Choudhary S, Meena D, Boyal PK, Kumari P, Singh P and Kataria AK, 2016. Determination of antibiogram pattern in Escherichia coli strains isolated from black buck (*Antilope cervicapra*) faeces of Bikaner Zoo. Veterinary Practitioner 17: 13-14.

Rebholz W and Harley E, 1999. Phylogenetic relationships in the bovid subfamily Antilopinae based on mitochondrial DNA sequences. Molecular Phylogenetics and Evolution 12: 87–94. https://doi.org/10.1006/mpev.1998.0586

Riaz H, Ahmad N and Aleem M, 2012. Dystocia in blackbucks (*Antilope cervicapra*). Pakistan Veterinary Journal 32: 301-302.

Roberts TJ, 1997. The Mammals of Pakistan. Oxford University Press, Walton Street, New York, USA; pp: 525.

Sagar HSS and Antoney PU 2017. Measuring Indian Blackbuck *Antilope cervicapra* Mammalia: Cetartiodactyla: Bovidae abundance at Basur Amruth Mahal Kaval Conservation Reserve, Chikkamagaluru, southern India. Journal of Threatened Taxa. 9: 10468-10472.

Saluja G, Capoor A and Gupta DP, 2012. Studies on the feeding behaviour of Indian Blackbuck, *Antilope cervicapra* L. in semi-wild habitat of Sikandra at Agra, India. World Journal of Applied Science and Research 2: 32-35.

Schmidly DJ, 2004. Mammals of Texas (Revised ed). University of Texas Press. Austin, Texas, USA; pp: 293.

Sharma AK, Venkatesan G, Mathesh K, Ram H, Ramakrishnan MA and Pandey AB, 2016. Occurrence and identification of contagious ecthyma in blackbuck. Virus Disease 27: 198-202. https://doi.org/10.1007/s13337-016-0316-x

Sheikh KM and Molur S, 2004. Status and Red List of Pakistan's Mammals. Based on the Conservation Assessment and Management Plan. International Union for Conservation of Nature (IUCN), Pakistan; pp: 312.

Sontakke SD, Patil MS, Umapathy G, Rao KR and Shivaji S, 2009. Ejaculate characteristics, short-term semen storage and successful artificial insemination following synchronisation of oestrus in the Indian blackbuck antelope (*Antilope cervicapra*). Reproduction, Fertility and Development 21: 749-756. https://doi.org/10.1071/RD08291

Sutherland WJ, 1996. Mammals. In: Ecological census techniques: a handbook, Southerland WJ (ed); Cambridge University Press, Cambridge, UK; pp: 260-278.

Van Der Geer AAE, 2008. Animals in stone: Indian mammals sculptured through time. Brill Publishers, JC Leiden, The Netherlands 21: 55-63.

Vassart M, Seguela A and Hayes H, 1995. Chromosomal evolution in gazelles. Journal of Heredity 86: 216-227. https://doi.org/10.1093/oxfordjournals.jhered.a111565

Vats R, and Bhardwaj CS, 2009. A Study of the behaviour of the old male and female indian black buck (*Antilope cervicapra*) Linn. (*Mammalia Artodactyla*) in the context of herd size at M.C. Zoological Park, Chattbir (Pb). Biomedical and Pharmacology Journal 2: 133-136.

Yamato T, Ahimsa CA, Soumya P, Shumpei K; McConkey, Kim RM, 2020. Intraspecific differences in seed dispersal caused by differences in social rank and mediated by food availability. Scientific Reports 10: 1532. https://doi.org/10.1038/s41598-020-58381-0