

Population Status, Distribution, Threats and Conservation of Blackbuck *Antilope cervicapra* in South Asia: An Updated Literature Review

Rabia Tahir,¹ Fozia Afzal,² Samra,³ Anabat Bin Sohail,⁴

Sobia Abid² and Muhammad Wasim Tasleem^{2*}

¹College of Animal Science and Technology, Sichuan Agricultural University, Ya'an, China

²Department of Zoology, The Islamia University of Bahawalpur, Bahawalpur, Pakistan

³Department of Zoology, University of Agriculture Faisalabad, Faisalabad, Pakistan

⁴College of Resources, Sichuan Agricultural University, Ya'an, China

ABSTRACT

Blackbuck, *Antilope cervicapra*, is a diurnal ungulate species with distinct sexual dimorphism and spellbinding beauty. Male blackbuck has mesmerizing beauty with its unique darker coat, showing the increased intensity of color with age. Blackbuck is endemic to Pakistan, Nepal, India and Bangladesh but now its population is reduced to a few areas. Threats such as hunting, stress, habitat loss, diseases, poaching, road accidents, habitat fragmentation, interspecific competition, predation pressure etc., have reduced the population size of blackbuck to a threatened level. Therefore, different conservation strategies are underway to increment its count for improvement of faunal diversity, tourism development and dispersal of the local culture in South Asia. Captive breeding of species is the most efficacious conservation strategy in South Asia so far. Furthermore, various rules and regulations along with strategies like hormone-mediated conservation by injections of prostaglandin and artificial insemination are assisting the species by increasing its birth rate. Genetic studies, introduction to non-endemic but suitable habitat and religious affiliation of communities also contributed to blackbuck conservation. Current conservation practices are helping to conserve the blackbuck but are associated with a few concerns also, thereby proper management, planning, monitoring of conservation practices is required. Population size, distribution range, threats confronted by species, conservation practices and recommendations have been discussed in this article, which will help in advancement of work in this area.

KEY WORDS: BLACKBUCK, CAPTIVE BREEDING, CONSERVATION STRATEGIES, CONSERVATION STATUS, DISTRIBUTION RANGE.

INTRODUCTION

Blackbuck, (*Antilope cervicapra*) (Linnaeus, 1758) is native to Pakistan, India, Nepal and Bangladesh with presence of some individuals in UAE, Argentina, USA and Texas (Wright and Glaze 1988; Mallon and Kingswood 2001; Long 2003). It is the single existing member of genus *Antilope* (Ranjitsinh, 1989). Fossils of species are found in the Siwaliks Hills of Pakistan (Lydekker 1878; Pilgrim 1937; Pilgrim 1939; Khan et al. 2006; Chauhan 2008). Species are diurnal ungulate with distinct sexual dimorphism and spellbinding beauty (Van der Geer 2008; Mahato et al. 2010; Saluja et al. 2012; Sheikh and Molur 2014). Males

have whorled horns up to 79cm which are absent in females. The color of male progressively turns into darkish with age, tawny to intense brown or black. Female and young ones are yellow at their front and rear. Chin and undersides of legs and chest are white in both sexes. Eyes encircled by a white ring (Sheikh and Molur 2004). The body length of species ranged from 100-150cm with the tail length 10-17cm and body weight for the male ranged between 20-57kg and of female 19-33kg (Roberts 1997b; Sheikh and Molur 2004). From a biological point of view, Blackbuck is part of nature so we require conserving it to maintain the beauty and biodiversity of nature. In addition, it helps in tourism development in the country. Tourists, researchers and animal lovers may have an interest in it so it will aid the dissemination of culture. Humans have interest in its hunting due to its delicious meat, which is exported for subsistence, and trade (Woodford 1995; Nocon 1999; Sheikh and Molur

Article Information:*Corresponding Author: wasimape@gmail.com

Received 15/10/2021 Accepted after revision 10/02/2022

Published: 31st March 2022 Pp- 00-00

This is an open access article under Creative Commons License,

<https://creativecommons.org/licenses/by/4.0/>.

Available at: <https://bbrc.in/> DOI: <http://dx.doi.org/10.21786/bbrc/15.1.1>

2004). Species performs a negative role by damaging the crops, mainly sorghum and millet that induce the farmers to kill them (Jhala 1993; Nocon 1999; Behera and Mohanta 2019; Meena et al. 2020).

Open grassland, dry thorn scrub, scrubland, and sparsely forested area, as well as agricultural edges, where it is sometimes spotted feeding in fields, are all habitats for this

species as indicated in table 1. Because blackbuck require water on a daily basis, distribution is limited to locations where surface water is available for the most of the year. Blackbuck are grazers by nature, but they browse when grasses are few, forcing them to rely more on leaf litter, flowers, and fruits. They are mostly sedentary, however during the summer they may travel greater distances in search of water and food (Tahir et al. 2021).

Table 1. Habitat preferences of Blackbuck (IUCN, 2017)

| Habitat | Season | Suitability | Major Importance |
|--|----------|-------------|------------------|
| Forest (Subtropical/ Tropical Dry) | Resident | Marginal | - |
| Grassland (Subtropical/ Tropical Dry) | Resident | Suitable | Yes |
| Desert (Desert – Hot) | Resident | Marginal | - |
| Artificial / Terrestrial (Arable Land) | Resident | Suitable | No |
| Artificial / Terrestrial (Pastureland) | Resident | Suitable | No |

Blackbuck's spatial detectability and density distribution rise significantly with grassland size, habitat openness, and grass biomass, but drop significantly with *Prosopis* cover, shrub cover, proportion of woodland, and distance to water, demonstrating their negative effect on the blackbuck. Furthermore, *Prosopis* cover reduces the area of grassland, habitat openness and grass productivity, all of which are important positive predictors of blackbuck density distribution. Thus, alien invasive species has a deleterious impact on the native blackbuck population. This highlights the importance of eradicating or regulating invasive species like *Prosopis juliflora* in order to save the endemic blackbuck in the long run (Rathore 2017; Rajput et al. 2019; Arandhara et al. 2021). Constant monitoring of blackbuck sociality will aid in understanding of population distribution, formulation and implementation of successful conservation strategies for this rare species (Jyoti 2021).

As case study of Hisar region of India, where 1715 blackbucks observed the mean group size of 13.19 and 29.66 mean crowding value during 2017-2019 (Jyoti 2021). Likewise, 7134 blackbucks observed at Odisha, India with herd size of 19.49 varying with seasons and mean group size for blackbuck was 13.84 with crowding value of 31.31 at Haryana, India for 941 blackbuck members (Debata 2017; Rai 2019). Although blackbuck have vanished from many regions due to habitat loss from agricultural usage and hunting, they are reappearing in several protected areas in South Asia and Vishnoi-dominated areas in Rajasthan and Haryana at India (Rahmani 2001; Jyoti 2021).

Converting dense scrub and woodland to grassland and agriculture expands the amount of appropriate habitat available. Due to excessive hunting, blackbuck numbers reduced over the twentieth century, and while they are now protected, some blackbucks are still shot illegally (Mallon and Kingswood 2001). In South Asian countries, blackbuck is legally protected and can be found in a number of protected places. Likewise, species is also protected by different laws established in different south Asian countries (Sheikh and Molur 2004; Jyoti 2021).

Threats such as hunting, stress, habitat loss, diseases, poaching, road accidents, habitat fragmentation, interspecific competition, predation pressure etc., have reduced the population size of blackbuck to threatened level. Hormone-mediated conservation, genetic studies and introduction to non-endemic but suitable habitat also contributed to blackbuck conservation. Current conservation practices are helping to conserve the blackbuck but associated with few concerns also, thereby proper management, planning, monitoring of conservation practices is required. Thereby, distribution range, population size, conservation status, threats to blackbuck, conservation struggles and recommendations are accounted in the text. Review article will act as limelight for taking further steps for conservation of blackbuck and focus over research lack as identified.

Distribution of Blackbuck: Previously, Blackbuck could be found practically everywhere on the Indian subcontinent at south of the Himalayas. But now, their range shrank, and they are now observed to get extinct in Bangladesh and Pakistan. Blackbuck has been introduced to Texas and Argentina and found extant there currently as indicated in Figure 1 (IUCN 2017). Blackbuck have been found in the Terai and adjacent areas of foothills in Nepal (Wegge 1997). Species also found at single small, isolated location of Blackbuck Conservation Area (BCA), Nepal at grassy areas having semi-arid environment (Mallon and Kingswood 2001; Bashistha et al. 2012).

Other protected areas enlisted in text where blackbuck is existing according to literature studied. Pakistan is occupying almost 195 species of mammals from 10 orders (Roberts 1997; Roberts 2005). 44 mammalian species recognized as Critically Endangered or Near Threatened. While others found extinct in region and data deficient (Khattak et al. 2021). Among recorded species of Antelopes in Pakistan are Nilgai, Blackbuck, Chinkara or Indian Gazelle and Goitered Gazelle (Roberts 1977a). In Pakistan, Blackbuck has existed at an altitude of 100-200 m (Sheikh and Molur 2004). Species was found in Bahawalpur and Fort Abbas at the northern area of the Cholistan Desert, Punjab at the

border with India (Roberts 1977a). Blackbuck was found under captive breeding at the Lal Suhanra National Park, Bahawalpur; Manglot Wildlife Park, Nowshera and Togh Mangara Safari Park, Kohat (Khattak et al. 2021) (Figure 2). But species get regionally extinct in its native distribution now and only found in captive conditions. Protected areas occupying blackbuck in Pakistan are enlisted in text (Sheikh and Molur 2004; Khattak et al. 2021).

Figure 1: Distribution range of *Antelope cervicapra* in South Asia (Source: IUCN, 2017 and modified by authors according to recent literature).

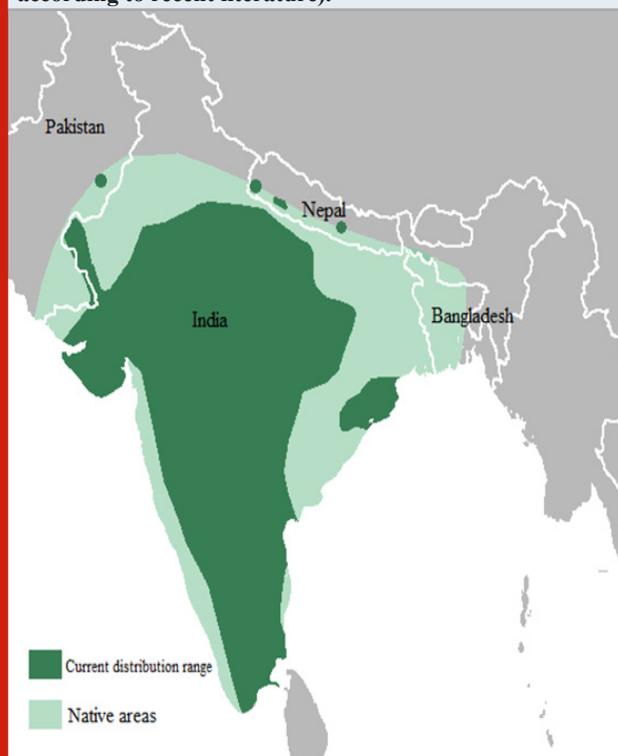


Figure 2: Male Blackbuck at Togh Mangara Safari Park, Kohat (Khattak et al. 2021)



Blackbuck population found once at forest regions, grassy sites and agricultural lands of the Bangladesh. But species now reckoned as 'Extinct' as there has been no site found in

the country where antelopes were introduced again (Akonda 1997; IUCN 2017). Recent data indicated the no blackbuck population at Bangladesh which need to be focused for reintroduction of species at its possible breeding sites. Six species of antelopes including Blackbuck observed in India (Mallon and Kingswood 2001). During 1970's and 1980's, there has an increment in count of species due to many rehabilitation projects (Ranjitsinh 1982; Rahmani 1989; Rahmani 1991; Rahmani and Sankaran 1991).

Many sites where blackbuck conserved was observed such as Thar Desert National Park, sites at ganjivaripall, Velavadar National Park, Gujarat, Great Indian Bustard Wildlife Sanctuary, Maharashtra and a lot of other sites listed in article. Blackbuck is found in 15 states of India including 19 districts of Rajasthan, where more than 30,000 blackbucks observed in 2016 (Rahmani 1991; Srinivasulu and Nagulu 2002; Sharma et al. 2003; Saran and Meena 2018). Blackbuck evidenced to exist at the grassy plains, forest areas and agricultural land of India (IUCN 2017; Meena and Chourasia 2017; Meena et al. 2020). At the Sir Bani Yas, location of UAE, major assemblage of freely moving antelopes including Blackbuck was noticed at semi-arid regions. UAE was not included in native distribution of species but maybe possible site for species living (Mallon and Kingswood 2001; Meena et al. 2020).

Conservation Status of Blackbuck: Conservation status of Blackbuck at a global level was assessed as "Vulnerable (VU)" during 1994-1996. While from 2003-2008, conservation status found as 'Near Threatened (NT)' (Prater 1971; Suwal and Verheugt 1995; Khanal et al. 2002; Ernest 2003; Wiegler 2005; Baral and Shah 2008; Bhatta 2008; Mallon 2008). But according to last recent assessment carried out during 2016, conservation status of Blackbuck at a global level was ascertained as "Least concern (LC)" under category of ver 3.1 (IUCN 2017). On the basis of Conservation Assessment and Management Plan Workshop 2003, Blackbuck has been given the status of 'Extinct in the wild' in Pakistan (Sheikh and Molur 2004). But according to last recent assessment carried out during 2016, conservation status of Blackbuck in Pakistan was ascertained as "Extinct (EX)". Now many members of Blackbuck species are observed at the Lal Suhanra National Park (LSNP) which are being flourished successfully at their breeding center (Meena et al. 2020).

But species found regionally extinct in its distribution area at Pakistan. Population size need to be focused by the researcher to assess the recent population of Blackbuck in Pakistan within protected areas (IUCN 2017). Status of Blackbuck in Nepal was ascertained as 'Critically Endangered' few years ago (Jnawali et al. 2011). But according to last recent assessment carried out during 2016, species is found extant in Nepal. Likewise, conservation status of Blackbuck in India has figured out as 'Near Threatened' few years back but now status of Blackbuck in India was ascertained as extent (Asif and Modse 2016; IUCN 2017). Conservation status of Blackbuck at Bangladesh found "Extinct" according to estimation during 2016. There seems to be no site in Bangladesh where

Blackbuck could be reintroduced under captivity since most of the potential habitat has been deteriorated (Mallon and Kingswood 2001; IUCN 2017; Meena et al. 2020).

Population Size of Blackbuck: Population trend assessed as “unknown” according to study in 2016 given by IUCN. While 35000 mature individuals of Blackbuck counted during this assessment at global level. Blackbuck are still widespread and prolific in certain locations at South Asia, are increasing in many protected areas, and are becoming an agricultural pest in others, despite their range and numbers declining over the last century (IUCN 2017; Behera and Mohanta 2019; Meena et al. 2020). Another recent study of 2021 has shown about 50,000 individuals of Blackbuck at global level (Zhongming et al. 2021). General range of Blackbuck has shrunk as a result of habitat loss, but this has been partially offset by the conversion of dense scrub and woodland to agriculture, which has resulted in the creation of more appropriate, open habitats. In spite of adaptability to many geographic areas, Blackbucks are increasingly under threat by growth of human population, domestic cattle expansion and economic development (Tahir et al. 2021). No quantitative statistics identified for population trends of Blackbuck currently, however even if species is reducing in general, there is little evidence that it is declining over nineteen years for three generations of species, which is near to threshold for Vulnerable under criterion A (IUCN 2017; Zhongming et al. 2021).

Four million members of Blackbuck speculated to exist a century ago but in 1947, that number reduced upto the 80,000 members. Blackbuck in India observed to increase from 24,000 to 50, 000 members of Blackbuck with 35000 mature blackbucks during 2000. Maximum count of species

observed at Rajasthan state in Punjab, Madhya Pradesh, Gujarat and Maharashtra then (Rahmani 2001). At Nepal, 200 Blackbucks were observed during 2012 (Bashistha et al. 2012). Blackbuck were introduced in South America and Argentina. members observed were 8600 at Argentina while at USA, there were 35000 individuals of blackbuck (Mallon and Kingswood 2001). Blackbuck still found extant at both of these sites (IUCN 2017; Zhongming et al. 2021).

There has been no systematic census, hence there are no reliable population estimates for the present population size. It is, nevertheless, still common and numerous in many areas. The species has evolved to the edges of agricultural land, and data suggests that clearing scrub and woodland benefits it by providing adequate habitat. In some locations, the Blackbuck population has grown to the point where it has become an agricultural nuisance, though not on the same magnitude as Nilgai (Tahir et al. 2021). So current population size needs to be estimated.

Threats To Blackbuck: For the most part, threats to Blackbuck are anthropogenic in nature. Of import, threats to the species are as what is listed next:

Hunting: Hunting for subsistence and trade by humans outside and in protected areas has threatened the species (Schaller 1967; Macdonald 1984; Sheikh and Molur 2004). Earlier, 4 million blackbucks were present in India and were hunted by Maharajas using tamed Cheetah (*Acinonyx jubatus venaticus*). The decision of the government in 1996 to allow shooting of Nilgai as crop pest has led to increase in illegal hunting of Blackbuck in areas where both species have common habitat (Mallon and Kingswood 2001). This threat is also indicated by the IUCN (2017) as indicated in table 2 (Isvaran 2007; Tahir et al. 2021).

Table 2. Threats faced by the Blackbuck under different regions (IUCN, 2017)

| Threat | Timing | Scope | Severity | Impact Score |
|---|---------|-------------------|----------------------------|------------------|
| Agriculture and aquaculture (Livestock farming and ranching-Small-holder grazing, ranching or farming) | Ongoing | Majority (50-90%) | Slow, Significant declines | Medium Impact: 6 |
| Biological resource use (Hunting & trapping terrestrial animals-International use, Persecution/control) | Ongoing | Minority (50%) | No decline | Low Impact: 4 |
| Stresses: Ecosystem stress by ecosystem change and degradation | | | | |
| Stresses: Species mortality | | | | |

Diseases: Various disorders are affecting the blackbuck. Among these diseases, dystocia is the main disease, which is disorder in female confronting the difficulty in giving birth maybe due to increase in level of epinephrine hormone (Roberts 1971; Fraser 2010; Riaz and Aleem 2012). Parasitic infestations are one of the most serious hazards to a small population of wildlife, and it is especially prevalent in captive populations in small enclosures (Khanal and Chalise 2011a; Tahir et al. 2021).

Endoparasites like *Haemonchus cortortus*, *Trichostrongylus axei* etc and ectoparasites like *Hyalomma anatolicum*,

Psoroptes cuniculi, *Amblyomma americanum* have affected the species, with extreme cases leading to death (Kreis 1935; Rewell 1948; Rewell 1951; Jansen 1959; Singh and Pande 1963; Patnaik 1964; Wetzel and Fortmeyer 1965; Thornton et al. 1973; Cole et al. 1984; Flach and Sewell 1987; Wright and Glaze 1988; Mertins et al. 1992; Prakash et al. 2015). *Listeria monocytogenes* the main bacteria that bear on the species (Krüger 1963; Webb and Rebar 1987). Protozoas like *Trypanosoma cruzi* has also impacted over the population of Blackbuck species (Schmidt et al. 1981; Tahir et al. 2021).

Paramphistomum, *Strongyles*, *Ascaris* and *Coccidia* were most prevalent parasites of animals grazing in Blackbuck habitat and protected areas (Khanal and Chalise 2011). Chaudhary and Maharjan (2017) found *Entamoeba* and *Eimeria* among protozoans, *Paramphistomum* and *Fasciola* among trematodes, *Moniezia* among cestodes, and *Trichostrongylus*, *Ascaris*, *Haemonchus*, *Strongyloides*, *Bunostomum*, *Trichuris* and *Oxyuris* among nematodes in Blackbuck. Although no Blackbucks were found to be infested in study by Rita and Khanal (2019). But chances of parasite and disease transmission were seen to be higher due to the Blackbuck's strong relationship, nutritional and habitat overlap with that of Spotted deer and Monkeys. Study by Pant and Joshi (2019) indicated the *Eimeria*, *Strongyloides* sp. and *Strongyle* sp in blackbuck owing to the parasite transference from livestock, (Chaudhary and Maharjan 2017; Rita and Khanal 2019; Pant and Joshi 2019; Tahir et al. 2021).

Fracture is a leading cause of death in free-ranging ruminants when it comes to non-infectious diseases. Tibial fracture is the most common long bone fracture in small ruminants. After femur, radius and ulna, tibial fractures are third most common form of long bone fracture, accounting for 21% of all long bone fractures. Tibial diaphyseal fractures are responsible for 75-81% of all tibial fractures. Treatment of severe injuries and fractures in non-domestic animals is difficult due to difficulties in restraint and wound dressing. It's also tough to keep an animal under control during an examination (Tahir et al. 2021). Study by Singh et al. (2019) shown that blackbuck was stabilised with use of analgesics and hydration treatment. Pre-anaesthetic agent xylazene 0.2 mg/ kg body weight I/m and local anaesthetic agent inj Xylocaine epidurally were used in next day to perform amputation.

Immobilization and surgical intervention should be carefully monitored and conducted under strict veterinarian supervision, since they can result in dangerous and short-term behavioural changes (Singh et al. 2019). Treatment of traumatic injuries in non-domestic animals is also difficult because to difficulties in restraint and wound dressing. Antibiotic sensitivity test showed that ciprofloxacin had the highest sensitivity, followed by amoxicillin + Salabactam, amoxycillin, amoxicillin and cefotaxime (Kumari et al. 2017; Singh et al. 2019; Tahir et al. 2021).

Competitive behavior: Apart from parasite infestations and diseases, competitive behavior among different species in wild and captive conditions also impact over species. Increased competition for food by Blackbuck with spotted deer and monkeys has been identified as one of the Blackbuck's significant concerns at Mrigasthali Enclosure at Pashupatinath Area of Nepal. Blackbucks were consistently on the losing end of both exploitative and interference type competitions for the ingestion of supplemental food. Various animals, particularly ungulates, have been observed to engage in interspecific aggressive interactions (Hanzlikova et al. 2014; Rita and Khanal 2019). Also in wild habitats, excessive densities of competition such as feral cattle have an impact on the Blackbuck's health and survival (Khanal 2006; Khanal and Chalise 2011b; Baskaran et al. 2016;

Prashanth et al. 2016; Rita and Khanal 2019; Tahir et al. 2021).

Stress: Stress hormones as glucocorticoids produced by stimuli as new environment, vehicles, social stress and aggressiveness, human interference, and predators, as observed in study by Terio et al. (1999) and Wielebnowski et al. (2002). Stress induced by captivity, which led to health and behavioral alterations (Nemat et al. 2013). A large number of zoo visitors have affected the behavior and adrenocortical secretions in Blackbuck (Rajagopal et al. 2011). To forbid the crop damage; Blackbucks have been trammelled in their habitat in India (Haryana district) as a captive condition. Species have confronted stress there owing to chase by farmers and killing assail by predatory dogs outside the fence, which has abridged its breeding rate (Chauhan 1990; Joseph 2011).

Small and isolated populations of Blackbuck mainly in captivity has confronted the genetic troubles like stress caused by inbreeding, homozygosity and environment (Purvis et al. 2000; Jnawali 2011). Fecal cortisol was observed in range of 0.18-2.62 ng/mg in blackbuck residing at the Rajiv Gandhi Zoological Park, Pune at India. Number of visitors and temperature humidity index (THI) impacted over the cortisol amount mainly during winter season but not in October heat. Whereas, stress level was not linked to the sex category of blackbuck. Management of Blackbuck population under captive condition will be aided by studying stress response of blackbuck to design the captive facilitation for effective conservation (Nikhil 2020).

Figure 3: Blackbuck resting under shady area at Lal Suhanra National Park, Breeding centre for Blackbucks, Pakistan (Imran, 2011)



Habitat loss: Human interference for agricultural intentions by livestock and farming are deteriorating the habitat of species (Schaller 1967; Macdonald 1984; Oza 1988; Sheikh and Molur 2004; Mahato et al. 2010; Jnawali 2011). Threat level by agricultural practices is indicated in table 2. Agricultural uses, human interruptions in habitat, deforestation and economic melioration have imperiled the species by deterioration of its habitat (Macdonald 1984; Sheikh and Molur 2004; Mahato et al. 2010). Population increments in South Asian country like Pakistan (at a rate of around 3%) has coerced the policy makers to orient the attention towards the feeding of an ever-growing population, which has deteriorated the blackbuck' habitat

(Cade 1988; Rahbeck 1993; Snyder et al. 1996; Komers and Curman 2000). Eco transformation and accelerating count of livestock have also pressurized the species (Mahato et al. 2010; Nikhil 2020).

Predation Pressure: Predation to blackbuck observed as threat to endangered blackbuck at many places like case reported at Marwar region of India where feral dogs cause decline in blackbuck population in rainy season (Meena and Jaipal 2020). Soft and slippery surface by rainy season cause difficult run by Blackbuck so making easy capture of infants and adults as well. Feral dogs prey heavily on calves, particularly during the breeding season. Wolf (*Canis lupus pallipes*) and golden jackal (*Canis aureus*) are also observed as main predators of infants (Meena et al. 2017). Leopard predation, hyena attacks, and stray dog attacks were also the main threats to Blackbuck inside BCA, Nepal (Gyawali et al. 2020).

Other factors: Human blackbuck conflict cause the significant threat to survival of blackbuck. Thereby, illegal use of naked electric wires with 220V current by farmers around the crop area has also impelled death of blackbuck (Chauhan 1990). Accidents and pollution are also affecting the blackbuck population size (Schaller 1967; Macdonald 1984; Sheikh and Molur 2004; Meena and Chourasia 2018). Habitat degradation, illegal poaching, road accidents, cattle overgrazing, and wildlife crime has already reduced the blackbuck population to limited site at its endemic area as case study observed at Marwar region. Another major threat is habitat fragmentation by roads construction. Road accident cause great mortality mainly to infants (Meena et al. 2017; Meena and Jaipal 2020).

Blackbuck Conservation Struggles

Rules and regulations: Different rules and regulations were designed to implement for protection of blackbuck in different countries of South Asia. Blackbucks have dislodged from Schedule III of Protected animals and birds to Schedule II by Punjab Parks and Wildlife Department, Pakistan, which has countenanced the private sectors to raise them (Ali et al. 2011). The species have given highest protection status under National Park and Wildlife Conservation Act 2029-1973 in Nepal (Jnawali 2011). Blackbuck protected in India under Schedule-I of the Indian Wildlife Protection Act WLP, 1972. All these regulations help in conservation of blackbuck (Kankane 2014).

Captive breeding: Captive breeding has become an important aspect of conservation around the world as a result of increasing human pressure on the environment. Extinction rates are rising 100-1000 times faster than natural rates as a result of manmade activity, wiping out 150 species in a single day (Ahmed 2007). Humans have shortened, taken over and modified natural ecosystems to the point where many species' survival is now dependent on captive breeding. Captive breeding is a broad word that refers to a variety of situations ranging from the laboratory to animals kept in close confinement (such as a zoo's indoor enclosure) to semi-free wandering (outdoor enclosures).

Successful breeding, population increase and potential translocation are all significant goals of keeping wild animals in captivity. However, due to inadequate management, inhospitable climatic conditions, competition with other co-housed species, illnesses and other factors, many species have less behavioral flexibility and fail to maintain a healthy population in captivity (Rita and Khanal 2019). One study by Rao (2011) indicated that Blackbucks are one of the most significant creatures in the zoo's collection, and they breed well when provided good care. When given sufficient protection, a well-balanced diet, and treatment, the Blackbuck population explodes as seen at Kanpur Zoological Park, India. Thereby, Blackbuck also conserved by captive breeding at different areas as listed (Rao 2011; Khattak et al. 2021).

Lal Suhanra National Park, Pakistan: Lal Suhanra National Park (LSNP), 35km east of Bahawalpur, Punjab, includes desert, forest and wetland. Area of LSNP was suggested firstly in 1966 as a good place for breeding Blackbuck and important wetland area (Mountfort and Poore 1967). By the groovy plan for LSNP, a system of partition has been proposed, by which the entire Cholistan Desert has been integrated within the wild zone in which exploitation has not permitted. Enclosures have established for the Blackbuck breeding program to which entrance is prohibited (Masud 1980). Blackbuck shown at Lal Suhanra National Park in Figure 3 (Khattak et al. 2021).

Blackbuck reintroduction programme: It has commenced in April 1970 with an initial consignment of ten animals (seven females and three males) from a Texas ranch to small enclosure of Lal Suhanra Sanctuary, Pakistan under the aegis of the Worldwide Fund for Nature (WWF) and Government of Punjab and more species have anticipated to be introduced into the vicinal larger fenced enclosure of 518.4 ha (Mirza and Waiz 1973; Schaller 1975; Aleem 1978; Sheikh 1982; Ahmad 1983; Ranjitsinh 1989; Mallon and Kingswood 2001). Survival of young has turned out to be depleted so in 1980 five more females and one male have added to the collection by Copenhagen Zoo. By that time, number of species has increased to 48 by 1982. Another breeding center has launched in a separate area in 1982 with Blackbucks from Copenhagen Zoo and Western Plains Zoo, New South Wales (Aleem 1978; Sheikh 1982; Ahmad 1983). Captive breeding plan at LSNP proved successful at that time but there is lack of data about the recent population of Blackbuck at Lal Suhanra National Park so it needs to be measured by wildlife researcher (Khattak et al. 2021).

Karachi Zoo and Safari Park, Karachi, Pakistan: Species have thrived successfully in captivity as reckoning delineated: in Karachi Zoo, 14 in 2009, 16 in 2010, 17 in 2011 and 18 in 2012; in the Safari Park, 44 in 2009, 48 in 2010, 57 in 2011 and 65 in 2012 (Khan et al. 2014). Estimation for current population at this site is still noy available thereby it needs to be calculated through proper research design along with factors impacting over the population of Blackbuck so it can be conserved properly (Khattak et al. 2021).

Kalabagh Game Reserve, Pakistan: Species have introduced in Kalabagh Game Reserve as a part of national endeavors for the conservation of species in Pakistan. But there is lack of last and current population size of blackbuck at this site (Khattak et al. 2021).

Kirthar National Park, Pakistan: It is in Southwest Sindh in the Kirthar Mountain range near Karachi. Fifteen Blackbucks from the USA have been introduced in Khar Wildlife Breeding Centre of Kirthar National Park, in October 1984. It has contrived to get the species to the park, but the most preferred habitat of species has overdriven by the human beings (Mirza 1973; Mallon and Kingswood 2001). Increment in count of species in this national park as an aftermath has engendered the enclosure to be deficient for the species. Therefore, an earlier king of the UAE, late Sheikh Zayed Bin Sultan Al Nahyan, has donated the large enclosure of 700 acres confining the Hub Dam and mountainous terrain (Khattak et al. 2021).

Other protected areas for Blackbuck in Pakistan: Thirteen breeding centers in Punjab, Pakistan have established to maintain the count of species under captivity (Mallon and Kingswood 2001). Species have conserved at the private farms by conservationists in Sindh province, including the Tando Muhammad Khan, Nawabshah, Khangharah, Ghotki and New Jatoi (Amar 2011). Blackbuck was found under captive breeding at the Manglot Wildlife Park, Nowshera and Togh Mangara Safari Park, Kohat at KPK (Mallon and Kingswood 2001; Khattak et al. 2021).

Blackbuck Conservation Area, Nepal: Blackbucks have placed in a single isolated and small size location (16km²) of Blackbuck Conservation Area at Bardiya district of Nepal which has left them jeopardize to different threats. Action Plan for Conservation (2016-2020) for blackbuck in Shuklaphanta Reserve, Nepal has referred by the Department of National Parks and Wildlife Conservation (Prater 1971; Suwal and Verheught 1995; Mallon and Kingswood 2001; Khanal et al. 2002; Ernst 2003; Weigal 2005; Mallon 2008; Baral and Shah 2008; Bhatta 2008; DNPWC 2016; Khattak et al. 2021).

Mrigasthali Enclosure, Pashupatinath Area, Nepal: Since 2004, Blackbucks have been kept in Mrigasthali enclosure near Pashupatinath Temple in Kathmandu, in a semi-captive situation with food provided by the Pashupati Area Development Trust management. Total of 20 Blackbucks were put into the Mrigasthali enclosure. About 150 Spotted deer (*Axis axis*), some Barking deer (*Muntiacus muntjak*), and about 400 Rhesus monkeys (*Macaca mulatta*) occupy the enclosure with blackbucks. But their population has dropped dramatically according to study in 2016. Population size was checked in 2016 for previous 15 years whereas behavioral pattern was also analyzed from April to July, 2016. By 2010, the population had grown to over 54 animals, but then unfortunately, more than a third of them died within a few months of 2014. Following that, Blackbuck population tried to recover and in 2016 only four individuals was found.

This study found that the population has dropped dramatically since the emergence of foot-and-mouth disease in 2014, putting the remaining species at risk of extinction. The diurnal activity pattern and time budgets of the surviving individuals are markedly different from those of wild populations; in particular, they spend less time feeding and more time sleeping. Despite the cooler climate in open areas, fierce competition for food and space with spotted deer and monkeys, lesser behavioral flexibility among species, anthropogenic disturbances, stochasticity due to the small population size, and other factors were seen as major threats to Blackbuck in enclosure (Rita and Khanal 2019; Khattak et al. 2021).

Other protected areas at Nepal: By 10 September 2020, once-extinct Blackbuck *Antelope cervicapra* recovered to population of 9 to 234 in Krishnasaar Conservation Area, Khairapur and 28 to 115 in Shuklaphanta National Park, Hirapur Phanta. Government of Nepal designated the Krishnasaar Conservation Area in Khairapur as a special protected area with electric fencing to ensure the survival of the introduced population. To develop a free-roaming wild population, a second colony was established in Hirapur Phanta in Shuklaphanta National Park. Effective management interventions (population, habitat, and health) combined with active stakeholder participation, institutionalization and extension of specific protected area dedicated to blackbuck conservation marked the growth of the species' last remaining population in Nepal's seminatural habitat (BK and Awasthi 2018; Bist et al. 2021).

Protected areas for Blackbuck in India: Vallanad Blackbuck Sanctuary, India has isolated small natural hill having scrub forest, a place for Blackbuck habitation (Joseph 2011). Other noteworthy protected areas for Blackbuck are Velavadar National Park, Gujarat; Point Calimere Wildlife Sanctuary, Tamil Nadu; Ranabennur Wildlife Sanctuary, Karnataka; Great Indian Bustard Wildlife Sanctuary, Maharashtra; Kanpur Zoological Park, Uttar Pradesh; Nehru Zoological Park, Hyderabad; Guda-Vishnonian and Taal Chhappar Blackbuck Sanctuary, Rajasthan; Rajiv Gandhi Zoological Park and Wildlife Research Centre, Pune; Balipadar- Bhetnoi blackbuck reserve, Ganjam; Conservation and Breeding Centre of Arignar Anna Zoological Park, Tamil Nadu; Sathyamangalam tiger reserve, Tamil Nadu; Basur Amruth Mahal Kaval Conservation Reserve, Chikamagaluru and Guindy National Park, Chennai (Rahmani 1991; Bagchi et al. 2003; Sontakke et al. 2009; Rao 2011; Joseph 2011; Sagar and Antoney 2017; Das et al. 2018; Rajagopal et al. 2018; Rajput et al. 2019). It has hinted that pilot projects on translocation of Blackbuck to sites of earlier habitat, culling, and evaluation of threat of a sport-hunting programme should be carried out (Mallon and Kingswood 2001; Khatri et al. 2021).

Hormone-mediated conservation: Hormonal level conservation by oestrus synchronisation and non-surgical AI technology studied to be successful for the conservation and population management of blackbuck. Evaluation of blackbuck ejaculates and testosterone concentrations, as well as the possibility of short-term semen storage at cold,

suggested that AI technology could be used to improve genetic breeding and conservation of blackbuck. Two of five inseminated blackbuck females achieved successful pregnancies after receiving Norgestomet ear implants and i.m. administration of pregnant mare's serum gonadotropin (PMSG), although both had twin pregnancies that were delivered prematurely. However, two doses of prostaglandin 11 days apart found efficient for synchronizing oestrus in blackbuck. In oestrous-synchronised animals, transcervical AI resulted in successful pregnancies in four of six inseminated females (67 percent) and delivery of three live fawns following the second prostaglandin injection after 72-96 hour. This research show how AI technology could be used to help save endangered ungulates (Sontakke et al. 2009; Khatri et al. 2021).

Genetic analysis: Distribution and patterns of intraspecies genetic variation are critical for developing effective conservation measures (Awise 2000). Thereby, genetic diversity measurement was carried out for blackbuck along-with phylogenetic analysis at South India. Sequencing of mitochondrial DNA of cytochrome b for 120, cytochrome c oxidase subunit-1 (COI) for 137, and control region for 137 fecal pellets from eleven different locations in southern India for phylogenetic and genetic diversity analyses of blackbuck populations among different distribution ranges in southern India. The genetic structure of three mitochondrial markers, control region, cytochrome b, control region and COI area, was investigated separately and in combination. Control region had a larger haplotype diversity and nucleotide diversity than cytochrome b and COI, with 0.969 and 0.047, respectively (Bhaskar et al. 2021).

Several unique haplotype groups were detected within blackbuck using Bayesian phylogeny and a MJ network based on the control region and combined dataset (105 sequences), however no clusters were identified using the cytochrome b and COI phylogenetic analyses. The combined data set's molecular variance analysis found 52% genetic variation within the population. With examination of the combined dataset in each population and study of each marker separately in the overall population, mismatch distribution analysis revealed that blackbuck populations underwent extensive alterations. These findings show that due to habitat fragmentation, blackbuck populations in different geographic regions have diverse population structures. These findings give preliminary genetic data for monitoring, maintaining, and reintroducing wild blackbuck populations in their natural habitat in Southern India (Bhaskar et al. 2021).

Another similar study reported by Kumar et al. (2017) for assessment DNA barcoding for blackbuck using COI region. Likewise genetic study for blackbuck was done by De et al. (2021) at Kaimoor Wildlife Sanctuary of India. In this study, panel of five microsatellite markers was suggested for blackbuck identification and monitoring of its population. Along with it seven additional markers given for genetics studies for blackbuck conservation. Few other genetic studies observed by Jana and Karanth (2019) and Abbas et al. (2020). Further studies also required at other areas

endemic for blackbucks so it can be reintroduced into its natural habitats (De et al. 2021).

Introduction in non-endemic but suitable habitat: Blackbucks have brought to Texas (Willard 1995) during 1932, where count in 1974 estimated a population of 7,339 Blackbuck (Ranjitsinh 1989). So, by introduction in Texas Blackbuck show increment in number (Mirza and Waiz 1973). These Blackbucks are the posterity of 35 Blackbucks gifted to Texas in 1940 by the late amir of Bahawalpur (Aleem 1978; Sheikh 1982; Ahmad 1983). Blackbuck were also introduced in Argentina and United states. Members observed were 8600 at Argentina while at USA, there were 35000 individuals of blackbuck (Mallon and Kingswood 2001). Blackbuck still found extant at both of these sites (IUCN 2017; De et al. 2021).

Religious association: Blackbuck in Thar Desert of India has given protection owing to religious affiliation so their intervention in human vicinage and agricultural locality has granted. Vishnoi Community also sets up in Rajasthan has given protection to Blackbuck under their precepts (Rahmani 1990a; Rahmani 1990b; Rahmani 1991; Mohapatra 2014; Kankane 2014; Sinha and Singh 2020). The protected status of species has gained ground at public level publicity by the case of Salman Khan (India's leading film star) to which he was sentenced imprisonment of five years for the killing of two black bucks and several endangered Chinkara. Actuation for arrest has done by extreme protests on behalf of the Vishnoi ethnic group (on whose area the hunting had occurred), which consider the animals and trees sacred as reported by the Times of India in January 2017. Orans have created by native communities in Thar desert of Rajasthan for conservation of blackbuck as it is propitious habitat for species (Kankane 2013). Survey was carried out from March to December, 2017 at Dhansu and Dobhi village of Haryana district, India. As an agricultural pest, Blackbuck found to reduce in number by 46% at Dhansu village and 51% at Dobhi village. But at Dhansu village, 59% people of Vishnoi community involved in survey agreed for protection of Blackbuck. While at Dobhi village, 18% agreed to protect the blackbuck (Rai 2018; De et al. 2021).

Recommendations: Recommended suggestions to fructify the conservation program are as follows: blackbuck demands a great deal of research on survival, breeding, behavioral aspects, selection, and availability of food, which is under continuance (Mirza and Waiz 1973; Sheikh and Molur 2004). Blackbucks are capable of subsisting in mixed agricultural areas, so the transition of scrubland and forest into grassland and cropland may do well to Blackbuck (Mallon and Kingswood 2001). For meliorated conditions in protected areas proffers are given as: to observe the animal behavior in captivity to contrive an ideal enclosure. Data of the behavior and biology of the animals in the form of pamphlets and guidebooks, etc. should be circularized to the visitors and students.

A guidance map should be available at the entry point. Safari and Zoo came to grip by linking its management with

conservation organizations. Animal conservation programs should be organized which will invigorate visitants and educates to take part in such endeavors. Among the observed reasons of deaths, major is the consumption of scraps and shopping bags etc. thrown by visitants. Some visitors present unhealthy food to the animals causing the flu, tuberculosis and lung infection, etc. so it should be averted. Green area should be created to boost the oxygen level in Safari. Species should be placed in couplet form to generate natural and social behavior among them. The pond should be accessible to animals for cleanliness (De et al. 2021).

Increased numbers of visitors induce stress in species, which should be grappled. High rainfall drives lots of water in the enclosures. Therefore, there should be few high ground terrains where animals may take shelter (Khan et al. 2014). Breeding sites at zoological park should be modified for blackbuck by creating hidden watching sites so the stress created by visitor's contact will not impact over the population of blackbuck. Impacts created by visitors like movement, mocking, sounds or any physical harm should be reduced by the taking effective measures in the zoo. Continuous health assessment and physiological studies should be carried out for checking the reproductive potential of blackbuck under captivity. Effective husbandry practices along with blackbuck conservation plans should be created for safety of blackbuck (Nikhil 2020).

Eradication of *Prosopis juliflora*, appropriate management for improvement of a blackbuck habitat and indigenous floral species have favorable consequences on high density blackbuck populations. Removal of *Prosopis* has allowed for more canopy opening, which has resulted in increased grass growth as shown by Rajput et al. (2019). Good habitat state of open land for blackbuck has been ensured by moderate cover and grass density. To combat the *Prosopis juliflora* invasion, robust modern controlling measures such as mechanical eradication, prescribed burning, and chemical control are being recommended. Furthermore, sustainable management to guarantee ecological balance and livelihood enhancement of local people will be community-based *Prosopis juliflora* eradication within protected areas. Thereby, *Prosopis Juliflora* eradication has a favorable impact on blackbuck population and will provide as a baseline data foundation for invasive habitat management through appropriate management plan within protected areas (Rajput et al. 2019). Constant monitoring of blackbuck sociality will aid in understanding of population distribution, formulation and implementation of successful conservation strategies for this rare species (Jyoti 2021).

CONCLUSION

The findings of the present review has shown that animals are resplendence of nature and Blackbuck is a wondrous example of it, discoursed in the text. Unique darker coat of species gives it hypnotic beauty and attraction. Species are confronting different threats by the hand of human beings. Imperilments encountered by species include stress, hunting, poaching, diseases, habitat loss, habitat fragmentation, agricultural practices, illegal killing, human

population explosion, road accidents, noise and pollution. Because of all these threats, various conservation strategies were planned and, on the way, to conserve blackbuck. Rules and regulations, captive breeding, hormone mediated conservation, artificial insemination and religious affiliation are the efforts being carried out for its conservation. Captive breeding is concluded as most expedient one in contemporary circumstances, owing to the fact that its natural habitat is being deteriorated by man in most of the places.

Captive breeding is underway in various sites of Pakistan like in Lal Suhanra National Park, Bahawalpur; Karachi Zoo and Safari Park, Karachi; Kalabagh Game Reserve; Kirthar National Park etc. Lal Suhanra National Park, Bahawalpur, Pakistan renders the peachy habitat for species with desert, forest and wetland as its part. So, it is suggested as a groovy site for conservation by captive breeding of Blackbuck to emendate its count as Cholistan is the native place for species. Karachi Zoo and Safari Park, Karachi, Pakistan is also good site for breeding of species. Likewise, protected areas at Nepal and India are also enlisted in article. In addition to all of these practices, further maneuvers and plans are necessitated for the conservation of species. Recommendations are also given in text for blackbuck conservation in its endemic area and protected sites. Research lack was also identified at each level which should be focused for the proper management and monitoring of population size, distribution and conservation of species.

Conflict of Interest: Authors declare no conflicts of interests to disclose.

Data Availability Statement: The database generated and /or analysed during the current study are not publicly available due to privacy, but are available from the corresponding author on reasonable request.

REFERENCES

- Abbas, G., Nadeem, A., Javed, M., et al. (2020). Mitochondrial Cytochrome-b, Cytochrome-c and d-loop Region Based Phylogenetic and Diversity Analysis in Blackbuck (*Antelope cervicapra*). Kafkas Üniversitesi Veteriner Fakültesi Dergisi, 26(1). DOI: 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]. Pak. J. Forest., 33: 87-90.
- Ahmed, D., (2007). Convention on biological diversity, United Nations Environment Programme. [https:// www.cbd.int/doc/speech/2007/sp-2007-05-22-esen](https://www.cbd.int/doc/speech/2007/sp-2007-05-22-esen)
- Akonda AW (1997). Bangladesh. In: Shackleton, D.M. (editor). Wild sheep and goats and their relatives. Status survey and conservation action plan for Caprinae. IUCN, Gland, Switzerland and Cambridge, UK, pp. 264–266.
- Aleem A (1978). Re-introduction of blackbuck in Pakistan. Pak. J. Forest., 28:11-115.

- Ali Z, Bibi F, Mahel AQ, et al. (2011). Captive Breeding Practices in Pakistan: A Review. *J. Anim. Plant Sci.* 21:368-71.
- ALIC., (1981). Draft environmental profile. The Islamic Republic of Pakistan. USAID/US National Parks Service/US Man and the Biosphere Secretariat. Arid Lands Information Center, Office of Arid Lands Studies, University of Arizona, Tucson.
- Arandhara, S., Sathishkumar, S., Gupta, S., et al. (2021). Influence of invasive *Prosopis juliflora* on the distribution and ecology of native blackbuck in protected areas of Tamil Nadu, India. *European Journal of Wildlife Research*, 67(3), 1-16.
- Avise JC (2000). *Phylogeography: the history and formation of species*. Harvard University Press, Cambridge, MA.
- Bagchi S, Goyal SP and Sankar K (2003). Habitat separation among ungulates in dry tropical forests of Ranthambhore national park, Rajasthan. *Tropical Ecology*. 44(2):175-82.
- Baral HS and Shah KB (2008). *Wild mammals of Nepal*. Himalayan Nature, Kathmandu. pp. 72-77.
- Bashistha, M., Neupane, B. K. and Khanal, S. N. (2012). *Antilope cervicapra* Blackbuck in Nepal: Population Status, Conservation and Translocation Issues of Blackbuck in the Blackbuck Conservation Area, Bardiya, Nepal. LAP Lambert Academic Publishing, Saarbrücken.
- Baskaran, N., Ramkumaran, K., and Karthikeyan, G. (2016). Spatial and dietary overlap between blackbuck (*Antilope cervicapra*) and feral horse (*Equus caballus*) at Point Calimere Wildlife Sanctuary, Southern India: Competition between native versus introduced species. *Mammalian Biology*, 81(3), 295-302.
- Behera, S. K., and Mohanta, R. K. (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(3), 1-4.
- Bhaskar, R., Kanaparthi, P., and Sakthivel, R. (2021). Genetic diversity and phylogenetic analysis of blackbuck (*Antilope cervicapra*) in southern India. *Molecular Biology Reports*, 48(2), 1255-1268.
- Bhatta S, (2008). *People and Blackbuck: Current Management Challenges and Opportunities*. The Initiation., 2(1):17-21.
- Bist, B. S., Ghimire, P., Poudyal, L. P., et al. (2021). From extinction to recovery: the case of blackbuck *Antilope cervicapra* from Nepal. *Mammal Research*, 1-5.
- BK, D. B. B., and Awasthi, B. (2018). Seasonal Feeding Ecology of Re-Introduced Blackbuck (*Antilope cervicapra*) in Hirapur Phanta of Suklaphanta National Park, Nepal. *The Journal of University Grants Commission*, 7(1), 48-60.
- Cade TJ (1988). Using science and technology to reestablish species lost in nature. *Roy. Soc. Ch.*, pp.279-288.
- Chaudhary, R. B., and Maharjan, 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.
- Chauhan NP and Singh R (1990). Crop damage by overabundant populations of nilgai and blackbuck in Haryana (India) and its management.
- Chauhan PR (2008). Large mammal fossil occurrences and associated archaeological evidence in Pleistocene contexts of peninsular India and Sri Lanka. *Quatern. Int.*, 192(1):20-42.
- Cole NA, Guillot FS and Purdy CW (1984). Influence of *Psoroptes ovis* (Hering) (Acari: Psoroptidae) on the performance of beef steers. *Journal of economic entomology*. Apr 1;77(2):390-3.
- Das, U. K., Kar, S., and Pattnaik, S. K. (2018). Forage and feeding ecology of Indian antelope or blackbuck (*Antilope cervicapra*. Linn 1780) in Ganjam district, South Odisha, eastern India. *International Educational Applied Research Journal*, 2(11), 1-8.
- De, R., Kumar, V., Ankit, K., et al. (2021). Cross-amplification of ungulate microsatellite markers in the endemic Indian antelope or blackbuck (*Antilope cervicapra*) for population monitoring and conservation genetics studies in south Asia. *Molecular Biology Reports*, 48(6), pp.5151-5160.
- 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(11), 10953-10955.
- Department of National Parks and Wildlife Conservation (DNPWC) (2016). *Site Specific Conservation Action Plan for Blackbuck in Shuklaphanta Wildlife Reserve, Nepal (2016–2020)*. Government of Nepal, Ministry of Forest and Soil Conservation, Department of National Parks and Wildlife Conservation, Kathmandu, Nepal., pp. 1-31. Available at: <http://www.dnpwc.gov.np>.
- Ernest SM (2003). Life history characteristics of placental nonvolant mammals: ecological archives E084-093. *Ecology*. 84(12):3402-.
- Flach EJ and Sewell MM (1987). Gastrointestinal nematodiasis in blackbuck (*Antilope cervicapra*) at Edinburgh Zoo. *The Journal of Zoo Animal Medicine*. Jun 1:56-61.
- Fraser AF, (2010). *The behavior and welfare of the horse*. Cambridge University Press, Cambridge, UK. (2) pp. 140.
- Guriro A, (2011). Blackbucks: a dying breed in Kirthar? Available at: <http://www.pakistantoday.com>.

- pk/2011/07/11/blackbucks-a-dying-breed-in-kirthar. (Accessed March 01, 2021).
- Gyawali, U., Mandal, R. A., Mathema, A. B., et al. (2020). Assessing the Population Dynamics of Blackbuck, Its Habitat Condition and Peoples Interaction in Blackbuck Conservation Area, Khairapur Nepal. *Annals of Archaeology*, 3(1), 1-8.
- Imran A (2011). Black Buck Wildlife Centre Bahawalpur. *Paki Mag*. Available at: <https://www.pakimag.com/tourism/black-buck-wildlife-centre-bahawalpur.html>
- Isvaran K (2007). Intraspecific variation in group size in the blackbuck antelope: the roles of habitat structure and forage at different spatial scales. *Oecologia*. 1;154(2):435-44.
- IUCN (International Union for Conservation of Nature) (2017). *Antilope cervicapra*. The IUCN Red List of Threatened Species. Version 2021-2. <http://www.iucnredlist.org>. Downloaded on 20 October 2021.
- IUCN SSC Antelope Specialist Group. (2017). *Antilope cervicapra*. The IUCN Red List of Threatened Species 2017: e.T1681A50181949. <https://dx.doi.org/10.2305/IUCN.UK.2017-2.RLTS.T1681A50181949.en>. Downloaded on 20 October 2021
- Jansen J, (1959). *Auchenia glama* and *Antilope cervicapra*, new hosts for some Trichostrongylidae. *J. Parasitol.*, 45: 509.
- Jhala YV, (1993). Damage to Sorghum crop by Blackbuck. *Int. J. Pest. Manage.*, 39: 23-27.
- Jnawali SR, Baral H, Lee S, et al. (2011). The status of Nepal mammals: the national red list series, department of national Parks and wildlife conservation Kathmandu, Nepal. Preface by Simon M. Stuart Chair IUCN Species Survival Commission The Status of Nepal's Mammals: The National Red List Series.4.
- Joseph PP, (2011). Steps taken to save blackbucks. *The Hindu*. Available at: <http://www.thehindu.com/todays-paper/tp-national/tp-tamilnadu/steps-taken-to-save-blackbucks/article1037275.ece> (Accessed 18 January 2021).
- 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.*, pp. 299-307.
- Kankane PL. (2014). Human being as one of the factors for survival of larger mammals in the Thar desert of Rajasthan. *Proc. Nat. Sem. Trad. Knowl. & Soc. Prac.*, pp.241-248.
- KC, R., and Khanal, L. (2019). High Mortality and Altered Diurnal Activity Pattern of Captive Blackbuck (*Antilope cervicapra*) in Mrigasthali Enclosure, Pashupatinath Area, Kathmandu. *Journal of Institute of Science and Technology*, 24(2), 49–57. <https://doi.org/10.3126/jist.v24i2.27257>
- Khan AM, Ghaffar A, Farooq U, et al. (2006). Ruminant fauna from the Tertiary Hills (Neogene) of the Siwaliks of Pakistan. *Journal of Applied Sciences*.6(1):131-7.
- Khan MZ, Samreen N, Ghalib SA, et al. (2014). Biology and behaviour study of chinkara, cheetal, nilgai, blackbuck and hog deer in captivity in Karachi zoo and safari park. *Int. J. Biol. Biotech*.11(2-3):341-9.
- Khanal P, Khanal SN, Jnawali SR, et al. (2002). Study on the land use of proposed Blackbuck conservation area, Khairapur, Bardia district, and habitat options for translocation of Blackbuck (*Antilope cervicapra*) at Royal Suklaphant Wildlife Reserve in Kanchanpur district, Nepal. Local Governance Programme United Nations Development Programme, Nepal.
- Khanal, L. (2006). Population status, general behaviors and conservation practices of blackbuck (*Antilope cervicapra*, Linnaeus, 1758) at Khairapur, Bardia, Nepal (MSc Thesis). Central Department of Zoology, Tribhuvan University, Kathmandu, Nepal.
- Khanal, L., and Chalise, M. K. (2011a). Population status of blackbuck (*Antilope cervicapra*) at Khairapur, Bardiya, Nepal. *Journal of Natural History Museum, Tribhuvan University*, 25, 266-275.
- Khanal, L., and Chalise, M. K. (2011b). Impacts of livestock grazing on blackbuck at BCA, Bardiya, Nepal. Special issue published on the occasion of 16th Wildlife Week, 2068; Department of National Parks and Wildlife Conservation (DNPWC), Kathmandu, Nepal. pp. 14-22.
- Khattri, K., Mohite, J., Pandit, P., et al. (2021). Isolation, Description and Genome Analysis of a Putative Novel *Methylobacter* Species ("Ca. *Methylobacter coli*") Isolated from the Faeces of a Blackbuck (Indian Antelope). *Microbiology Research*, 12(2), 513-523.
- Khattak, R. H., Liu, Z., and Teng, L. (2021). Ex-Situ Conservation of Wild Ungulates in Khyber Pakhtunkhwa Province, Pakistan.
- Komers, P.E. and G.P. Curman, (2000). The effect of demographic characteristics on the success of ungulate re-introductions. *Biol. Conserv.*, 93(2):187-193.
- Kreis HA, (1935). Beitrage zur Kenntnis parasitischer Nematoden. L. Ein neuer parasitischer Nematode aus der Hirschziegen-antilope, *Antilope cervicapra* L.: *Trichuris cervicapra*, n. sp. *Verhandl. Naturf. Gesell. Basel.*, 46: 59-65.
- Krüger W, (1963). Das Vorkommen von *Listeria monocytogenes* in den Verschiedenen Silagen und dessen ätiologische Bedeutung. *Archiv für Experimentelle Veterinärmedizin.*, 17(1):181-203.
- Kumar, V., Sharma, N., and Sharma, A. (2017). DNA barcoding of the Indian blackbuck (*Antilope cervicapra*) and their correlation with other closely related species. *Egyptian Journal of Forensic Sciences*, 7(1), 1-7.
- Kumari, A., Tiwary, R., Kumar, M., et al. (2017). Management of wound in black Buck. *Journal of*

- Pharmacognosy and Phytochemistry SP1: 507-508
- Long JL, (2003). Introduced mammals of the world: their history, distribution and influence. CSIRO Publishing, Collingwood, Australia. pp. 486-487.
- Lydekker R, (1878). Indian Tertiary and post Tertiary Vertebrata:3. Crania of ruminants, Palaeontol. Ind., 10:88-181.
- Macdonald DW, (1984). The Encyclopedia of Mammals. New York. Facts on File., 895.
- Mahato, A.K.R., and M. Ramakrishna 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, (2008). *Antilope cervicapra*. IUCN Red List of Threatened Species. International Union for Conservation of Nature (IUCN). Version 2016.2. Available at: www.iucnredlist.org Accessed 18 February 2021.
- Mallon DP, Kingswood SC and Antelopes (2004). Part 4: North Africa, the Middle East, and Asia. Global Survey and Regional Action Plans. SSC Antelope Specialist Group, IUCN, Gland, Switzerland and Cambridge, England (4).
- Masud RM, (1980). Master plan for Lal Suhanra National Park, Bahawalpur-Pakistan 1980 to 1985. National Council for Conservation of Wildlife in Pakistan (NCCW), Islamabad., pp. 55.
- Meena, M., and Jaipal, A. K. (2020). A perspective study on seasonal threats of blackbuck, *Antilope cervicapra* in Marwar region of Rajasthan, India. J. Exp. Zool. India, 23(2), 1957-1963.
- Meena, M., Jaipal, A. K., and Garg, K. (2020). Crop Damage by the Blackbuck (*Antilope cervicapra*) and other Ungulates in Around Rohat Region, Rajasthan, India. Alochana Chakra Journal, 5, 2866-2875.
- Meena, R., and Chourasia, V. (2017). Activity Pattern of Blackbuck *Antilope cervicapra* (Linn) in the Sorsan Grassland. International Journal of Research in Applied Science and Engineering Technology, 5(12), 1560-1564.
- Meena, R., and Chourasia, V. (2018). Influence of Anthropogenic Activities on Blackbuck Population at Sorsan Region of Baran District, Rajasthan. International Journal of Advance Research in Science and Engineering, 7(2), 463-469.
- Meena, R., Saran, R. P., 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(3), 53-59.
- Mertins JW, Schlater JL and Corn JL (1992). Ectoparasites of the blackbuck antelope (*Antilope cervicapra*). Journal of Wildlife Diseases. 28(3):481-4.
- Mirza ZB and Waiz A, (1973). Food availability for blackbuck (*Antilope cervicapra*) at Lal Suhanra Sanctuary, Pakistan. Biological Conservation.1;5(2):119-22.
- Mirza ZB, (1973). Availability of Food for Black Buck *Antilope cervicapra* at Lal Suhanra Wildlife sanctuary Bahawalpur, Pakistan. Biol. Conserv., 5(2):120-146.
- Mohammed A and Modse SR (2016). The distribution pattern and population of Blackbuck *Antilope cervicapra* Linnaeus in Bidar, Karnataka. Indian Forester. 142(10):965-70.
- Mohapatra A, (2014). Concept of Biodiversity Conservation in Indian Religion. Proc. Nat. Sem. Trad. Knowl. & Soc. Prac., pp. 161-168.
- Mountfort G and Poore D (1968). Report on the second World Wildlife Fund expedition to Pakistan. World Wildlife Fund.
- Nemat A, Ali Z, Ahmad S, et al. (2013). Study of Disease Records of Zoo Animals in Lahore Zoo, Pakistan. The Journal of Animal and Plant Sciences.25(3):483-92.
- Nikhil, S. B. (2020). Faecal Cortisol Metabolites as an Indicator of Stress in Captive Spotted Deer (*Axis Axis*) and Blackbuck (*Antilope cervicapra*) in India (Doctoral dissertation, University of Nairobi).
- Nocon W, (1999). *Antilope cervicapra* (On-line), Animal Diversity Web. Available at: http://animaldiversity.org/accounts/Antilope_cervicapra/. Accessed April 27, 2021.
- Oza GM, (1988). An Indian Conservational Success: Saving Habitat for the Endangered Blackbuck. Environ. Conserv., 15(2):167-169.
- Pant, L., and Joshi, S. P. (2019). Conservation Threats of Re-introduced Blackbuck (*Antilope cervicapra*) in Hiranpurphanta of Shuklaphanta National Park, Kanchanpur, Nepal. International Journal of Progressive Sciences and Technologies, 15(2), 24-41.
- Patnaik MM, (1964). A note on the helminth parasites of blackbuck (*Antilope cervicapra*). Current Sc., 33:180.
- Pilgrim GE, (1937). Siwalik antelopes and oxen. American Museum of Natural History, Bull., 72:729-874.
- Pilgrim GE, (1939). The fossil Bovidae of India, Palaeontol. Ind. N. S., 26(1):1-356.
- Prakash MM et al., (2015). Hard Ticks Induced Hematological Changes in Blackbuck (*Antilope cervicapra*). Indian Streams Research Journal (ISRJ), 4.
- Prashanth, M. B., Saravanan, A., Mathivanan, M., et al. (2016). Conservation of a fragmented population of blackbuck (*Antilope cervicapra*). Current Science, 111(03), 543-549.
- Prater SH, (1971). The Book of Indian Animals. Third (Revised) Edition, Bombay Natural History Society, Bombay Society and Oxford University Press, India. (3), pp. 324.
- Purvis A, Agapow PM, Gittleman JL, et al. (2000). Nonrandom extinction and the loss of evolutionary history. Science. 14;288(5464):328-30.

- Rahbeck C, (1993). Captive breeding – A useful tool in the preservation of biodiversity? *Biodivers. Conserv.*, 2:426–437.
- Rahmani AR and Sankaran R (1991). Blackbuck and Chinkara in the Thar Desert: a changing scenario. *Journal of arid environments*. 1;21(3):379-91.
- Rahmani AR, (1989). The uncertain future of the Desert National Park in Rajasthan, India. *Environ. Conserv.*, 16:237–244.
- Rahmani AR, (1990a). Distribution, density, group size and conservation of the Indian gazelle or chinkara *Gazella bennetti* (Sykes 1831) in Rajasthan, India. *Biol. Conserv.*, 51:177–189.
- Rahmani AR, (1990b). Distribution of the Indian gazelle or chinkara *Gazella bennetti* (Sykes) in India. *Mammalia.*, 54:605–619.
- Rahmani AR, (1991). Present distribution of the blackbuck *Antelope cervicapra* Linn.in India, with special emphasis on the lesser-known populations. *J. Bombay Nat. Hist. Soc.*, 88(1):35–46.
- Rai, D. (2018). Status and ecological aspects of blackbuck, *Antelope cervicapra* (Linnaeus, 1758) through opinion surveys in and around Hisar, Haryana (India). *Journal of Experimental Zoology, India*, 21(2), 1195-1201.
- Rai, D. (2019). Crowding, group size and population structure of the Blackbuck *Antelope cervicapra* (Linnaeus, 1758) (Mammalia: Cetartiodactyla: Bovidae) in the semi-arid habitat of Haryana, India. *Journal of Threatened Taxa*, 11(9), 14194-14203.
- Rai, JD (2021). Measures of Sociality, Social Organization and Population Structure in Blackbuck, *Antelope cervicapra* (Linnaeus, 1758). *Proc Zool Soc* 74, 268–279 (2021). <https://doi.org/10.1007/s12595-021-00371-9>
- 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*. 1;14(1):18-32.
- Rajagopal, T., Ponmanickam, P., Chinnathambi, A., et al. (2018). Inter-relationship of behaviour, faecal testosterone levels and glandular volatiles in determination of dominance in male Blackbuck. *Indian Journal of Experimental Biology*, 56, 781-794.
- Rajput, N., Baranidharan, K., Vijayabhama, M., et al. (2019). Ecological impact of *Prosopis juliflora* on the habitat conditions of blackbuck in Sathyamangalam tiger reserve, Tamil Nadu, India. *Journal of Entomology and Zoology Studies* 7(3): 610-615.
- Rangitsinh MK. (1982). Territorial behavior of the Indian blackbuck (*Antelope cervicapra* Linnaeus, 1758) in the Velavadar National Park, Gujrat. *J. Bombay Nat. Hist. Soc.*, 79(2):241-246.
- Ranjitsinh MK, (1989). The Indian blackbuck. Natraj Publishers, Dehradun, India., pp. 1-155.
- Rao, K. P. (2011). Population control by segregation of Blackbucks at Kanpur Zoo. *ZOO's PRINT*, 26(3), 18-19.
- Rathore, D. (2017). Blackbuck occupancy in Moyar valley, Tamil Nadu. M. Sc. Environmental studies and resource management. Submitted to Department of Natural Resource. TERI University.
- Rewell RE, (1948). Diseases of tropical origin in captive animals. *Tr. Roy. Soc. Trop. Med. Hyg.*, 42: 17-25.
- Riaz H, N Ahmad and M Aleem, (2012). Dystocia in blackbucks (*Antelope cervicapra*). *Pak Vet J*, 32(2): 301-302.
- Rita, K. C., and Khanal, L. (2019). High Mortality and Altered Diurnal Activity Pattern of Captive Blackbuck (*Antelope cervicapra*) in Mrigasthali Enclosure, Pashupatinath Area, Kathmandu. *Journal of Institute of Science and Technology*, 24(2), 49-57.
- Roberts SJ, (1971). *Veterinary Obstetrics and Genital Diseases*. Edwards Bros, Ann Arbor, MI, USA. (2), pp. 247-261.
- Roberts TJ, (1977a). *The Mammals of Pakistan*. Ernest Benn Ltd., London. *J. Mammal.*, 59(2):455-456.
- Roberts TJ, (1997b). *The Mammals of Pakistan*. Oxford University Press, Walton Street, New York. pp. 525.
- Roberts, T.J., (1997). *The mammals of Pakistan*. Oxford University Press, New York.
- Roberts, T.J., (2005). *Small mammals of Pakistan*. Oxford University Press, Karachi.
- Sagar, H. S. C., and Antoney, P. U. (2017). Measuring Indian Blackbuck *Antelope cervicapra* (Mammalia: Cetartiodactyla: Bovidae) abundance at Basur Amruth Mahal Kaval Conservation Reserve, Chikkamagaluru, southern India. *Journal of Threatened Taxa*, 9(7), 10468-10472.
- Saran, R. P., and Meena, R. (2018). Near Threatened to Least Concern: Blackbuck Conservation Efforts from Rajasthan, India. *International Journal of Zoology and Applied Biosciences* 3 (1): 71-76.
- Schaller GB, (1967). *The deer and the tiger: a study of wildlife in India*. The University of Chicago Press, Chicago, Illinois, USA. pp. 370.
- Schaller GB, (1975). *Pakistan: Status of Wildlife and Research Needs*. Ecological Guidelines for the use of Natural Resources in the Middle East and South West Asia., 133.
- Schmidt RE and Toft JD, (1981). Ophthalmic lesions in animals from a zoologic collection. *Journal of Wildlife Diseases*.17(2):267-75.
- Shackleton DM, (1997). Wild sheep and goats and their relatives-status survey and conservation action plan for caprinae. IUCN, Gland (Suiza). Species Survival Commission.

- Sharma S, Sharma SK and Sharma S, (2003). Notes on mammalian fauna of Rajasthan. *Zoos' Print Journal*. 2003;18(4):1085-8.
- Sheikh KH, (1982). Lal Suhanra National Park. *World Wildlife Fund Pakistan (WWF-Pakistan) Newsletter*, pp. 4-6.
- Sheikh KM and Molur S, (2004). Status and red list of Pakistan's mammals. In *Based on the Conservation Assessment and Management Plan Workshop*. IUCN Pakistan
- Shrestha TK, (1997). *Mammals of Nepal*. Publisher: Mrs. Bimala Shrestha, Kathmandu, Nepal., pp. 190-19.
- Singh PP and Pande BP (1963). Helminths collected from the Indian Antelope, *Antilope cervicapra*. *Annales de parasitologie humaine et comparée*.38(3):439-57.
- Singh, M., Kumar, R., Kalaiselvan, E., et al. (2019). Management of septic compound tibial fracture in black buck. *Journal of Entomology and Zoology Studies* 7(4): 1166-1168
- Sinha, B. L., and Singh, A. (2020). Embodying a Preparedness to Die: Why Bishnois of Western Rajasthan Rise in Defence of the Blackbuck and the Chinkara? *Sociological Bulletin*, 69(1), 34-50.
- Sloan JEN, (1951). A note on the occurrence of *Trichostrongylus retortaeformis* in the blackbuck (*Antilope cervicapra*). *Proc. Zool. Soc. London.*, 121:723-725.
- Snyder NF, Derrickson SR, Beissinger SR, et al. (1996). Limitations of captive breeding in endangered species recovery. *Conservation biology*.10(2):338-48.
- Sontakke SD, Patil MS, Umapathy G, et al. (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*. 22;21(6):749-56.
- Srinivasulu C and Nagulu V, (2002). Mammalian and avian diversity of the Nallamala Hills, Andhra Pradesh. *Zoos' print J*. 17(1):675-84.
- Suwal RN and Verheugt, WJM, (1995). Enumeration of the mammals of Nepal. *Biodiversity Profiles Project Technical Publication No. 6*. Department of National Parks and Wildlife Conservation, Ministry of Forests and Soil Conservation, His Majesty's Government of Nepal, Kathmandu., pp. 151.
- Tahir R, Ghaffar A, Zafar SJ, et al. (2021). Biology and ecological adaptations of blackbuck (*Antilope cervicapra*): a review. *Agrobiological Records* 4: 23-31. <https://doi.org/10.47278/journal.abr/2020.023>
- Terio KA, Citino SB and Brown JL (1999). Fecal cortisol metabolite analysis for noninvasive monitoring of adrenocortical function in the cheetah (*Acinonyx jubatus*). *Journal of Zoo and Wildlife Medicine*. 1:484-91.
- Thornton JE, Galvin TJ, Bell RR, et al. (1973). Parasites of the blackbuck antelope (*Antilope cervicapra*) in Texas. *Journal of wildlife diseases*.9(2):160-2.
- Van der Geer AAE, (2008). *Animals in stone: Indian mammals sculptured through time*. Brill., 2:55-63.
- Webb DM and Rebar AH, (1987). Listeriosis in an immature black buck antelope (*Antilope cervicapra*). *Journal of wildlife diseases*.23(2):318-20.
- Wegge P and Oli MK (1997). *Nepal. Wild Sheep and Goats and Their Relatives: Status Survey and Conservation Action Plan for Caprinae*.231-9.
- Wetzel R and Fortmeyer HP, (1965). Zur Nematodenfauna der Hirschzie genantilope (*Antilope cervicapra*) und ihrer Wirtsspezifität. *Zeitschrift für Parasitenkunde*.25(4):342-9.
- Wiegl R, (2005). Longevity of Mammals in Captivity; from the Living Collections of the World. [Kleine Senckenberg-Reihe 48]. E. Schweizerbart'sche Verlagsbuchhandlung (Nägele und Obermiller), Stuttgart., pp. 214.
- Wielebnowski NC, Fletchall N, Carlstead K, et al. (2002). Noninvasive assessment of adrenal activity associated with husbandry and behavioral factors in the North American clouded leopard population. *Zoo Biology: Published in affiliation with the American Zoo and Aquarium Association*.21(1):77-98.
- Willard ST, Carroll JA, Randel RD, et al. (1995). *In vitro* cell culture and adrenocorticotropin secretion by Indian blackbuck antelope (*Antilope cervicapra*) anterior pituitary glands collected under field conditions. *Journal of Zoo and Wildlife Medicine*. 1:252-9.
- Woodford K, (1995). The production characteristics of farmed Blackbuck Antelope. *Rural Industries Research and Development Corporation. Research Report No. 95/11*.
- Wright FC and Glaze RL, (1988). Blackbuck antelope (*Antilope cervicapra*), a new host for *Psoroptes cuniculi* (Acari: Psoroptidae). *Journal of wildlife diseases*.24(1):168-9.
- Zhongming, Z., Linong, L., Wangqiang, Z., et al. (2021). Blackbuck population increasing in Nepal. <http://119.78.100.173/C666/handle/2XK7JSWQ/311780>