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Cover Page Footnote

Conservation and management of Captive Blackbucks

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FEEDING ECOLOGY OF REINTRODUCED BLACKBUCKS IN LAL SUHANRA NATIONAL PARK, BAHAWALPUR

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ABSTRACT

The study was conducted in Lal Suhanra National Park, Bahawalpur, in June 2021. This study aimed to explore the food habits and dry matter intake of reintroduced blackbuck in Lal Suhanra. The critical methods employed in this study were the direct observation of food, bite rate, and fecal output of blackbuck aided with binoculars (8 × 50). A total of 3840 bites in the RD 65 enclosure and 3929 edges in the RD 65 enclosure were recorded, accounting for the average bite rates of 43.5 bites/min in RD 25 and 44.03 bites/min in RD 65. The average dry weight of the bite was 0.067 g in the enclosure RD 25 and 0.081g in RD 65. Total dry matter intake for an adult blackbuck was 1.07 kg/day in RD 25 and 1.09 kg/day in RD 65. The average daily defecation rate was 7.34 times and 7.89 times in both enclosures. Daily fecal output in average dry weight was 362g for RD 25 and 340 g for RD 65. Dry matter digestibility was, on average, 66.32 % for RD 25 and 68.97 % for RD 65. The blackbuck at RD 65 are more healthy, with a high birth rate and less mortality. The blackbuck preferred 8 plant species and 10 plant species for feeding at RD 25 and RD 65 respectively. For their long-term survival in LSNP, control of diseases, cultivation of seasonal food, plantation of edible plants, habitat extension, and proper management should be considered.

Keywords: Bite count, blackbuck, feeding preference, lal suhanra national park.

INTRODUCTION

Lal Suhanra National Park, located in the Bahawalpur District of Punjab, is one of Pakistan's most important and oldest national parks. In 1972, it was officially designated as a National Park. The park was established to protect current wildlife and plants, reintroduce extinct species, restore wildlife habitat, build education/research facilities for local and foreign tourists, and provide recreational opportunities for the local populace. (Rafay et al., 2013).

Antilope cervicapra (blackbuck antelope) is native to parts of India, Pakistan, and Nepal. Hunting and habitat change have reduced their numbers across India. A sharp decline in the blackbuck population during the 20th century caused local extinctions at the range extremities, i.e., Pakistan and Bangladesh, resulting in fragmented populations in India and Nepal and a small population in Pakistan reintroduced from Texas, U.S.A. (Khanal and Chalise, 2010; Mirza and Waiz, 1973; Saran and Meena, 2018).

The IUCN Red List categorizes the Blackbuck as "Least Concern" and lists it in CITES Appendix III. (IUCN, 2017). Cholistan and Thar, Pakistani semi-deserts, are home to the Blackbuck. The Blackbuck occasionally wanders the eastern desert border areas of the country. Pakistan has no permanent residents. Pakistan began reintroducing Blackbuck from Texas in the late 1970s and early 1980s.

Three or four locations, primarily Kirthar and Lal Sohanra National Parks,

now have tiny captive Blackbuck populations thanks to these projects. There were 413 births at Lal Sohanra (Aleem, 1978) and many Black Bucks were donated by Kirthar to prominent conservationists for use in their own private reserves. The exceptions to this are the specimens housed in zoos, wildlife centers, and private collections. There are currently around 1500 captive-bred Black Bucks in Pakistan's Punjab and Sindh provinces. They're about to be unleashed into the wild.

Being herbivorous, blackbuck can be seen in both grazing and browsing roles (Jadeja et al., 2013; Rajagopal et al., 2011). As a grazer, blackbuck prefers sedges and fall witch-grasses (Digitaria species), whereas as a browser, blackbuck prefer Mesquite and Acacia trees (in the Cholistan Desert), as well as live oaks (Pathak et al., 1992). These pests feed on the developing seedlings of cereals and pulses, wreaking havoc on agricultural production. Fruits, pods, and flowers have been used as food sources by a variety of animals (Mahato and Raziuddin, 2010). Understanding how diet selection of a species changes with differing nutritional constraints could aid in conservation of those species by informing management decisions to target the easing of nutritional constraints (Jacob et al., 2020). Keeping in view the current study aims to explore the feeding habits of reintroduced blackbuck for their better managemnet and conservation. It is also tried here to acccess, estimate the dry matter intake using direct observation, bite rates, and fecal output, and the threats faced by the blackbucks at LSNP.

METHODOLOGY

Study Area

The research was conducted in Bahawalpur's Lal Suhanra National Park (LSNP). Located 32 kilometers east of Bahawalpur on the main Bahawalpur-Bahawalnagar highway, Lal Suhanra National Park (LSNP) covers an area of 65790.36 hectares at an altitude of 125 to 140 meters between 29°12' and 29°28' north latitude and 71°48' and 72°08' east longitude in the south-eastern part of the Punjab Province.

Geology and Climate

The area's geology and climate are typical of a subtropical continental climate, which features low and erratic precipitation, high temperatures, low relative humidity, a rapid rate of evaporation, and strong summer winds. The hottest months are May and June, with average highs of 50 degrees Celsius and lows of -2 degrees Celsius. Average annual rainfall ranges from 90 to 200 mm, and relative humidity hovers around 60 percent (Hameed et al., 2002).

Floristic Survey and Identification

Two selected sites namely blackbuck enclosure at RD 25 and blackbuck enclosure at RD 65 were explored for the botanical survey in the LSNP. These two habitats were visited frequently for the collection of plant specimens and relevant data for a week. The plant species present in and outside of both blackbuck enclosures were studied keenly. Sample specimens were collected and some plants were also photographed for identification purposes. The collected specimens were pressed, dried, and mounted on standard herbarium specimens and identified using available floristic literature and also sent to the taxonomic experts in the Institute of Botany of the University of Punjab for the proper identification of plant species.

Study of Food Preference

Methods used in the study of food preference were as under:

After 24 hours of last offered food to animals under study, 15 species of diffeent plants were randomly picked from the area around the enclosure. These food samples were piled equally in small rows and study animals were allowed to feed. The food preference of blackbucks was observed from a hidden place. We accepted as reliable indicators of dietary preferences the sequence in which the various plant species were consumed. The frequency with which each pile was visited, and the total time spent there was obsereved.

Study Sites

Blackbuck enclosure RD 25 & 65

The study was carried out in the blackbuck enclosures RD 25 and RD 65 of the LSNP in June 2021 for two weeks there was a population of 324 blackbucks in the RD 25 enclosure. In this enclosure, the blackbucks were totally in a captive condition. This enclosure was open for visitors for recreation purposes. The RD 65 was the other study site of where 183 blackbucks were present at that time. In this enclosure, the blackbucks were kept nearly in wild conditions. They were allowed to self-graze outside the enclosure along with the food provided similarly to blackbucks housed in enclosure RD 25.

Focal Animals

A total of 16 adults blackbucks were selected from both enclosures. Eight adults from every enclosure were sampled as focal animals with four males and four females following Altmann (1974) from each enclosure. These animals were sprayed with colored paint without any disturbance, so that they could be identified and observed easily while feeding with the other animals in the enclosure. These focal animals were observed twice a day for total seven days. Once at 11:00 in the morning when the feed was first provided in the enclosure RD 25 until the 1:00 pm. The second time of observation was 5:00-7:00 pm at that time the focal animals were provided with feed again. Observation was done from a distance of about 10 m just to avoid any disturbance in feeding of animals under observation.

Data Collection in RD 25

The study was based on both primary and secondary data. The primary data was collected through direct observations with the help of binoculars (8 × 50) when blackbucks were grazing and field surveys. During the field visit, food, bite rates, and fecal output of blackbuck were recorded inside the enclosure. The secondary data was collected from concerned departments, workers, and nearby communities.

Bite Count

The focal animals were observed from a distance of about 10 m while they were feeding. The no.of bites they take in a particular time was counted. The bite count events lasted for about 2 to 5 minutes based on the duration of the feeding bout. Once the bite count events were over the blackbuck's tracks were followed and the bites were mimicked by hand stimulations. Bites of each food species were collected separately in polybags with ID (Shrestha and Wegge, 2006).

Weighing the Collected Bites

The weight of the freshly collected bites was done by using a Shimadzu AX 200 weighing electric machine. After the weighing fresh bites were sun-dried for a week. When the samples were fully dried, they were weighed again using the same weighing machine.

Dry Matter Intake (DMI)

Dry matter intake for the focal animals of RD 25& 65 was calculated by multiplying the number of bites on a species by focal animals in RD 25 with the dry bite weight of the collected bites of that specific species (BK and Awasthi, 2018).

Fecal Output and Defecation Rate

For recording the defecation rate and fecal output a pair of animals from both enclosure from were selected as focal animals in RD 25 & 65 enclosure. Sampled blackbuck (1 male and 1 female) was followed for 3 days continuously from dawn to dusk. During this observation time six fresh fecal samples of focal animals were collected each day in separate polybags with ID from both cages. The fresh weight of every defecates were recorded and the average defecation rate for each cage was then obtained. The total fecal output (TFO) was estimated by weighing the fresh fecal matter of the focal animal during the continuous monitoring period. The pellet samples were then dried at 40-50˚C for 48 h in incubator and then dry weight of all fecal was measured for all samples.

Estimation of Dry Matter Digestibility (DMD)

Dry matter digestibility (DMD) was estimated by the formula described by Robbins (1993).

DMD = (DMI-TFO)/DMI (1)

For calculating DMI following values were also calculated:

Bite rate per min (X), Dry weight (g) per bite (Y)

The proportion of time spent feeding (min) on a species while obtaining 100 bites from the particular core habitat:

% bites on a species (A)=

$$\frac{\textit{Total number of bites on a species}}{\textit{Total number of bites on the core habitat}} \textit{ X 100} \quad \textbf{(2)}$$

Habitat (B) = % bites / bite rate **(3)**

$$\mathbf{B} = \frac{A}{X}$$

Total time spent (h) on a particular species in a day (D) = **Time grazing in a species**

Habitat (C) =

B × Total time spent feeding in the core habitat / Total time for 100 bites

$$C = B \times \sum C / \sum B \qquad (4)$$

(C) × bite rate (X) ×60.

D = C×X×60 (5)

Dry matter intake (DMI) in g per day from a species (E) = Number of bites on a species in a season (D) × Dry bite weight (Y).

$$E = D \times Y \qquad (6)$$

Birth and Mortality Record

The data regarding the birth and mortality of the blackbucks was collected from the health records of the LSNP management. Also, the data regarding the causes for mortalities in blackbuck was collected. The informations regarding most prevailing dieases were also collected.

Estimation of Threats to the Blackbuck Population in LSNP

For the estimation of threats faced by the blackbucks at both study sites surveys were conducted. In these surveys, the informations regarding the different threats to of blackbuck population were collected by direct observations, interviews with staff and wildlife officers of the park and meeting with local communities were also arranged.

RESULTS

The following results were generated after surveys, meetings, and food preferences analysis of blackbucks.

Flora in and around the Blackbuck Enclosures

After the botanical surveys of the blackbuck enclosures both in RD 25 and RD 65 in LSNP almost 98 species of plant were observed out of these species 15 species were eaten by blackbucks. These 15 species of plants were are *Calotropis procera (aak), Acacia nilotica, Prosopis cineraria, Lasiurus hirsutus, (Gorkha), Prosopis glandulosa, Cymbopogon jwarancusa, Cynodon dactylon, Tamarix aphylla, Zyziphus sp., Cenchrus pennisetiformis, Sesbania bispinosa(jantar), Sorghum bicolor (jwar), Cicer arietinum (chany), Cymbopogon martinii (katran),* and *Dalbergia sisso.* All these species were provided to the antlopes in RD 65. But in RD 25 the major food items given to the blackbucks were *Sesbania bispinosa (jantar), Sorghum bicolor (jwar)* and *Cicer arietinum (chany)* along with little amounts of legumes of the *Acacia nilotica (kikar)* and green leaves of the *Zyziphus sp.(ber).* Table (1) gives the insight of the plants species given in both enclosures.

Table 1: Plant species eaten by Blackbuck in Enclosure RD 25 and RD 65

SN	Plant Species	Eaten in RD25 enclosur	Eaten in RD 65 enclosure
1	*Calotropis procera(aak)*	No	Yes
2	*Acacia nilotica*	Yes	Yes
3	*Prosopis cineraria*	Yes	Yes
4	*Gorkha (Lasiurus hirsutus)*	Yes	Yes
5	*Prosopis glandulosa*	No	Yes
6	*Cymbopogon jwarancusa*	No	Yes
7	*Cynodon dactylon*	Yes	Yes
8	*Tamarix aphylla*	No	Yes
9	*Zyziphus sp*	Yes	No
10	*Cenchrus pennisetiformis*	No	Yes
11	*Sesbania bispinosa(jantar),*	Yes	Yes
12	*Sorghum bicolor(jwar)*	Yes	Yes
13	*Cicer arietinum(chany),*	Yes	Yes
14	*Cymbopogon martinii(katran)*	No	yes
15	*Dalbergia sisso*	Yes	No
16	*Cenchrus ciliaris(dhaman)*	yes	yes

In past many of the plant species eaten by blackbucks were present naturally in the premises of the LSNP, but presently due to excessive deforestation, all of these plant species were not available to the blackbuck. Over time some species have been cultivated for the fodder of the animals and to meet their food needs in areas around the enclosures. These species were cut and provided to the blackbucks in their enclosures. This practice has changed the food preferences of the reintroduced

blackbuck over time. Table (2) shows the list of naturally occurring and cultivated food species given to the blackbucks in both enclosures.

Bite Count and Bite Rate

A total of 3840 bites and 3929 bites were recorded in the RD 25 and RD 65 enclosures respectively. The average dry weights of the bites were 0.047 g in the enclosure RD 65 and 0.038 g in RD 25. The number of bites recorded by observing black bucks in both enclosures. The average bite rate per minute was 40 in the RD 25 and 40.93 in the RD 65 enclosure. The bite rate and weight are given in Table (3).

The table showed that significant differences occurred at the level ($p \leq 0.05$) in the number of bites, total bites recorded, average bite rate/min, and average dry bites weight (grams) in RD 25 and RD 65 males and females.

Table 2: Occurrence of plant species in LSNP (natural, cultivated or provided by food supplier

Sr. no	Plant species	Naturally present	Harvested
1	*Dalbergia sisso*	✓	
2	*Acacia nilotica*	✓	
3	*Prosopis cineraria*	✓	
4	*Gorkha (Lasiurus hirsutus)*	✓	
5	*Prosopis glandulosa*	✓	
6	*Cymbopogon jwarancusa*	✓	
7	*Cynodon dactylon*	✓	
8	*Tamarix aphylla*	✓	
9	*Zyziphus sp*	✓	
10	*Cenchrus pennisetiformis*	✓	
11	*Sesbania bispinosa(jantar),*		✓
12	*Sorghum bicolor(jwar)*		✓
13	*Cicer arietinum(chany)*	Bought from outside the park	Bought from outside the park
14	*Cymbopogon martinii(katran)*	✓	
15	*Calotropis procera(aak)*	✓	

Table 3: Average bite rate and bite weight of blackbuck in LSNP

SN	Enclosure	Male/Female	Obs. Time (min)	No of bites	Total bites recorded	Average bite rate/min	Average dry bite wt.(g)
1	RD 25	Male (N=4)	48	1872 ± 1.29^{d}	3840 ± 0.96^{b}	40 ± 0.81^{a}	0.0675 ± 0.39^{b}
		Female (N=4)	48	1968 ± 1.25^{b}			
2	RD 65	Male (N=4)	48	1914 ± 0.81^{c}	3929 ± 0.79^{a}	40.93 ± 0.81^{a}	0.081 ± 0.12^{a}
		Female (N=4)	48	2016 ± 1.29^{a}			
Total			**192±2.13**	**7770±4.64**	**7769±1.75**		

Data demonstrate mean ± S.E at level of significance $p \leq 0.05$.

Diet in RD 25 enclosure

The blackbucks were observed to consume 8 species of plants in RD 25 enclosure as shown in Figure 1. The total dry matter intake (DMI) in RD 25 was 1.07 kg/day. Daily time spent feeding was 6 h in RD 25 (Table 4).

Diet in RD 65 Enclosure

The RD 65 blackbuck consumed more variety as compared to the one in the RD 25 enclosure. The food preferred by the animals in RD 65 is given in Figure 2. The total dry matter intake (DMI) in RD 65 was 1.09 kg/day. Daily time spent feeding was 8 h in RD 25 (Table-5).

Table 4: Diet Composition and Dry Matter Intake (DMI) of Blackbuck in LSNP as estimated by Bite Counts, Time Spent Feeding/Grazing in Captive Area, Bites Rate and Bites Weights in enclosure RD 25

Food plants (Local and scientific names)	Bite rate (X)	DW/bite (Y)	A	B	C	D	Total DMI in g E	%age in diet
Cice rarietinum (chany)	45.98	0.1	7.184	0.156	0.75	2069.1	206.91	19.24
Sesbania bispinosa(jantar)	44.34	0.09	6.928	0.156	0.75	1995.3	179.57	16.70
Sorghum bicolor (jwar)	44.98	0.08	7.028	0.156	0.75	2024.1	161.92	15.05
Acacia sp.	41.44	0.08	6.475	0.156	0.75	1864.8	149.18	13.87
Cynodon dactylon	45.68	0.07	7.137	0.156	0.75	2055.6	143.89	13.38
Zyziphus sp	44.68	0.04	6.982	0.156	0.75	2010.6	80.42	7.47
Lasiurus hirsutus (Gorkha)	44.29	0.04	6.920	0.156	0.75	1993.0	79.72	7.41
Calotropis procera(aak	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tamarix aphylla(frash)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cymbopogon jwarancusa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Prosopis cineraria	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cenchrus ciliaris(dhaman)	40.89	0.04	6.389	0.156	0.75	1840.0	73.60	6.84
Cenchrus pennisetiformis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total			55.043	1.25	6	15852.6	1075.2	100

Table 5: Diet Composition and Dry Matter Intake (DMI) of Blackbuck in LSNP as estimated by Bite Counts, Time Spent Feeding/Grazing in Captive Area, Bites Rate and Bites Weights in enclosure RD 65

Food plants (local and scientific names)	Bite rate (X)	DW/bite (Y)	A	B	C	D	Total DMI in g E	%age in diet
Cice rarietinum (chany)	46.95	0.11	9.55	0.203	0.67	1878	206.58	18.83
Sesbania bispinosa(jantar)	45.01	0.10	9.16	0.203	0.67	1800.0	180.4	16.41
Sorghum bicolor(jwar)	44.87	0.07	9.13	0.203	0.67	1794.8	125.63	11.45
Acacia sp.	42.96	0.05	8.74	0.203	0.67	1718.4	85.92	7.83
Cynodon dactylon	42.00	0.04	8.55	0.203	0.67	1680.0	67.20	6.12
Zyziphus sp	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lasiurus hirsutus (Gorkha)	43.66	0.06	8.88	0.203	0.67	1746.4	104.78	9.55
Calotropis procera(aak	44.21	0.04	9.00	0.203	0.67	1768.4	70.73	6.44
Tamarix aphylla(frash)	41.77	0.03	8.50	0.203	0.67	1670.8	50.12	4.56
Cymbopogon jwarancusa	43.03	0.02	8.76	0.203	0.67	1721.2	34.43	3.13
Prosopis cineraria	41.56	0.02	8.46	0.203	0.67	1662.4	33.24	3.03
Cenchrus ciliaris(dhaman)	43.54	0.04	8.86	0.203	0.67	1714.6	69.66	6.35
Cenchrus pennisetiformis	42.89	0.04	8.73	0.203	0.67	1715.6	68.62	6.25
Total			106.3	2.44	8	20898	1096.98	100

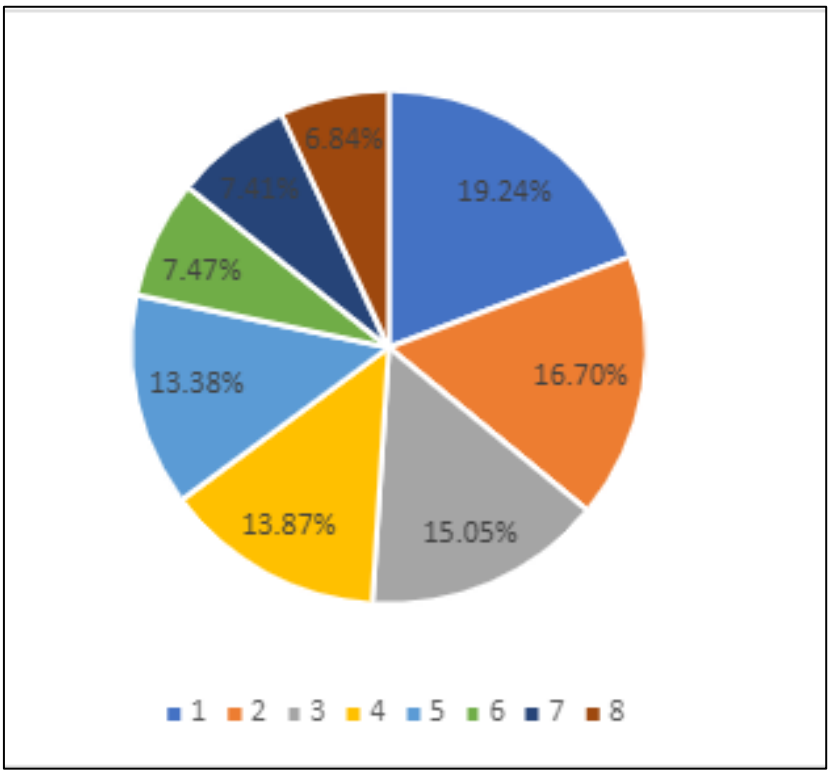

Figure 1: Food preferred by blackbucks in RD 25 enclosur

1. Sesbania bispinosa(jantar) was prefered 19.24 %, 2. Cicer arietinum(chany) 16.70 %, 3. Sorghum bicolor(jwar) 15.05 %, 4. Acacia sp., 13.87 %, 5. Cynodon dactylon 13.38 %, 6. Gorkha (Lasiurus hirsutus) 7.47 %, 7. Zyziphus sp 7.41 %, and 8. Cenchrus ciliaris(dhaman) 6.84 %

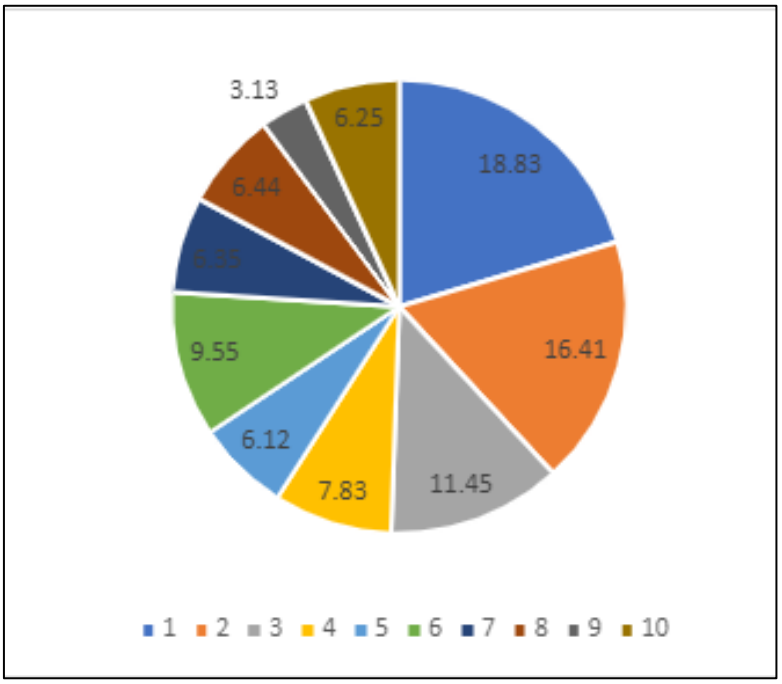

Figure 2: Food preferred by blackbucks in RD 65

1. Sesbania bispinosa(jantar) 18.83 %, 2. Cicer arietinum(chany) 16.41 %, 3. Sorghum bicolor(jwar) 11.45 % ,4. Cynodon dactylon 7.83 % ,5. Acacia sp. 6.12 % ,6. Lasiurus hirsutus (Gorkha) 9.55 % ,7. Calotropis procera(aak) 6.83 % ,8. Tamarix aphylla. 6.44 % ,9. Prosopis cineraria 3.13 % , 10. Cymbopogon jwarancusa 6.25 % .

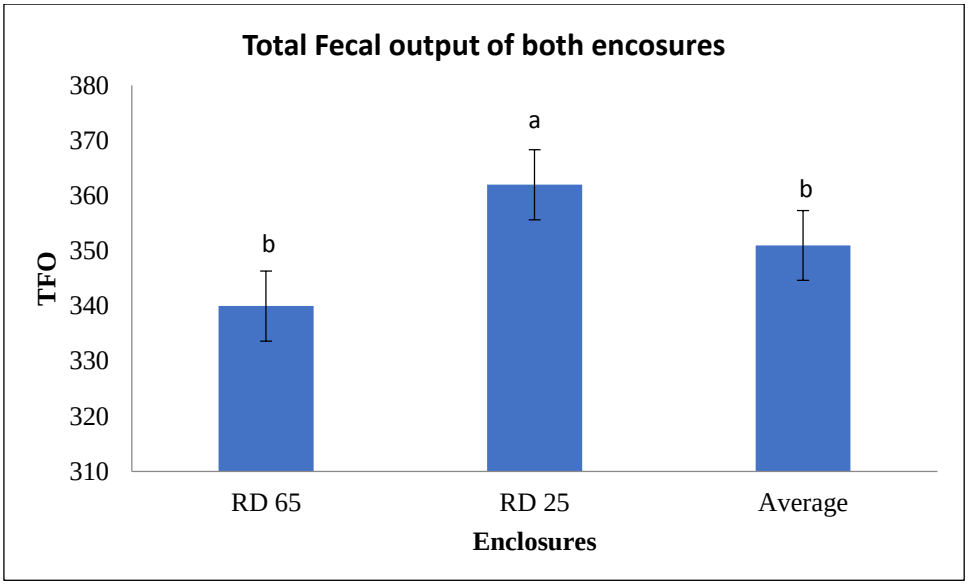

Figure 3: Total fecal output in RD 25 enclosure and RD65 enclosure along with average. It is very clear that the fecal output in RD 65 was greater than RD 25, even though the average of both is also less than RD 65.

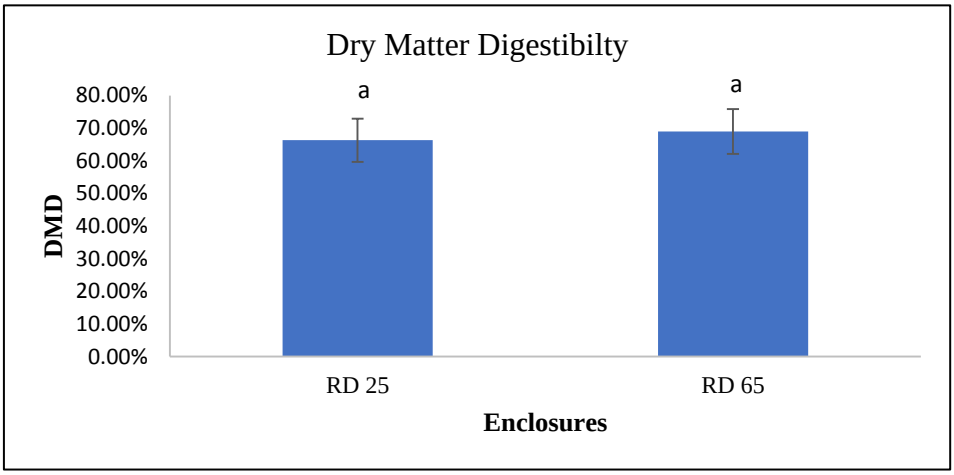

Figure 4: Average Dry Matter Digestibility of Blackbucks in both enclosures of LSNP The figure is showing that the dry matter digestibility is almost similar in blackbucks of both enclosures RD 25 & 65.

Total Fecal Output

The average daily defecation rate was 7.89 times in the RD 65 enclosure and 7.34 times in the RD 25. Average daily fecal output in terms of dry weight was 362±1.23 g for the RD 25 enclosure and 340± 2.15 g for the RD 65 enclosure (Figure 3). The average TFO of both enclosures was 351±1.17 g per day (24 h). The average fresh weight of fecal matter (per defecation) was 41.50 g for the animals in RD 25 and 43.66 g for those in RD 65 enclosure. The average dry weight per defecation was 34g in RD 25 g and 36 g in RD 65.

Dry Matter Digestibility

The dry matter digestibility was calculated to be 66.32±1.02 % g for the RD 25 enclosure and 68.97±1.50 % g for the RD 65 enclosure no significant difference occurred in RD 25 and RD 65 (Figure 4).

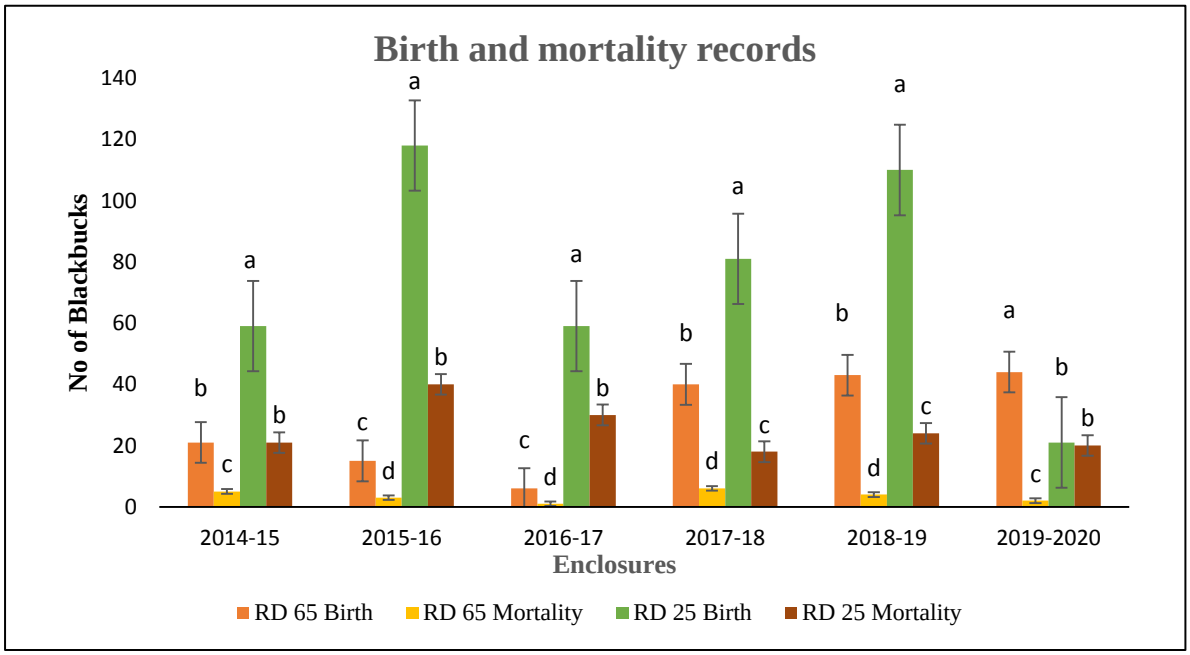

Figure 5: No. Of births and mortalities in RD 25 and RD 65

The highest birth rate is observed at RD 25 and then RD 65, but the mortality is also higher at RD 25 as compared to RD 65.

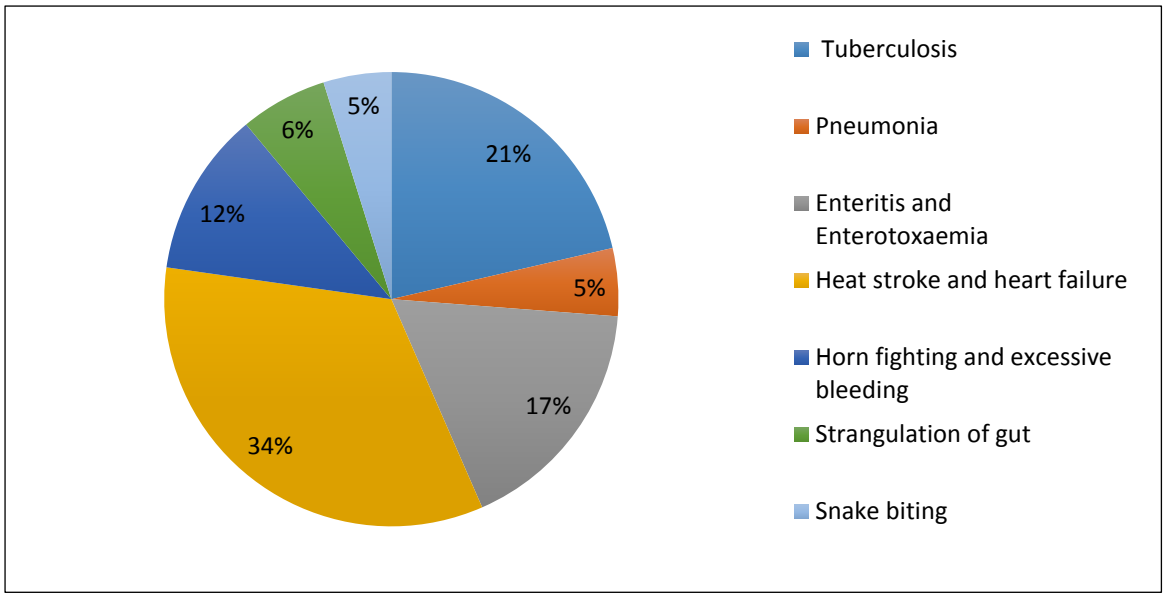

Figure 6: Blackbuck deaths due to different dieases at LSNP

The major reasons for deaths in blackbucks were heat stroke and heart failure 34 %. The 5 % of deaths were occurred due to snake bites.

Birth and Mortality Records of RD 25 and 65

According to available birth and mortality data collected from park management there was 450 births and 180 deaths during the last five years in the enclosure RD 25. In the past five years, 25 mortalities and 159 births have been reported in enclosure RD 65. The information in Figure 5 is based on

documents obtained from the LSNP administration.

Estimation of Threats to the Blackbuck Population in LSNP

After field observations and study of the blackbucks feeding ecology in the LSNP, it is observed that the park needs lots of maintenance and improvement for better up keeping of ecologically important antelopes. The threats that should be resolved priority are given below. Some threats like illegal hunting and poaching are still reported there and need to be controlled at priority basis.

i. Diseases

Although the population of blackbuck is somehow stable but among the major threats to the population of blackbucks in LSNP it was found that presences of diseases and the unavailability of veterinary facilities are problems of concern (Figure 6).

ii. Illegal Hunting and poaching

Illegal hunting and poaching were the reasons for the extinction of blackbuck from Pakistan. To the present reintroduced population hunting and poaching are still a threat, especially in the RD 65 enclosure. Becasue the fence of this enclosure was old and broken at a number of places. It was not secured enough to house the blackbucks here because the poachers and hunters can easily came into enclosure. To safe animals it was also tried to shift the blackbucks to a smaller enclosure of 1 Km x 1 Km (1000 m x 1000 m) constructed inside the same RD 65. This space is insufficient for the animals being reared for reintroduction to the natural habitat. Other than, poaching and hunting blackbucks were badly effected by stray dogs and jackals due to broken enclosure fences.

iii. Absence of a Proper Veterinary Hospital

Lal Suhanra National Park is the largest national park of Pakistan but it did not have a proper veterinary hospital. The veterinary doctors from the Cholistan University of Veterinary Sciences, Lahore Zoo and Zoo Safri occasionally visited the enclosures at time of emergencies. Due to this a lot of deaths were may caused due to unavailability of proper treatment on time.

iv. Overgrazing and Reduction of Vegetation Cover

When the blackbucks were reintroduced in the LSNP the vegetation cover was thick in those areas at that time, but due to blackbuck grazing the vegetation cover inside the enclosures has reduced greatly. To solve this problem fodder plants are being cultivated in the areas around the enclosures to meet the food needs of species. This leads to change in food preferences and health issues.

v. Lack of Trained Staff and Awareness

Lack of proper information about the native population and most of the keepers in the park being uneducated. The majority of the workers in the park are native laborers who did not have any kind of knowledge related to this important species. It is very necessary to educate people about the importance of this beautiful animal. As the blackbuck is a national heritage so that the people could be involved in the conservational practices rather than being creating problems to the existing antelope population.

DISCUSSION

Food is the major factor for the survival of any species and food availability is also a major challenge to

the reintroduction plans of many species. In their natural environment, wild species have free-ranging habits that enable them to pursue more nutritious grazing and therefore satisfy their feeding requirements. Therefore, an understanding of the feeding behavior and ecology of the animals is necessary to meet their needs in the area they are reintroduced. Further more understanding foraging behavior and gauging habitat appropriateness for future translocations and management requires information on the diet of reintroduced wildlife in natural environments (Robinson et al., 2020). The present study was conducted to gain insight into the food availability and feeding habits of reintroduced blackbuck in LSNP.

The present study recorded a total of 3840 bites in the RD 25 enclosure and 3929 bites in the RD 65 enclosure with average bite rates being 43.53/min in RD 25 and 44.03/min bites in RD 65 enclosure. This recoded bite count is less than the bite rate recorded by (BK and Awasthi, 2018). They recorded 4335 bites in the monsoon with a bite rate of 45.16/min. The bite rates in our study were low possibly because there are several factors that could affect bite rates in captivity as compared to the bite rates in the wild and natural conditions. On the other hand the average bite rate per minute was 10.22 ± 0.34 in rhinoceros (Adhikari, 2015) which is lower than blackbuck. Bite sizes are a little smaller in our study resulting in less time spent feeding in the enclosures in comparison to the time spent in the natural habitat as studied by BK and Awasthi, 2018. As they reported in natural habitat, the blackbucks have plenty of time to graze and choose the food species but in the enclosures, they are only given a specific amount and a specific number of plant species which is also a factor for decreased bite rate in current study. Also, it has been observed that as the abundance and quality of forage increased, feeding activity would still be high, although time spent searching for quality food would decrease (Bunnell and Gillingham, 1985). Contrary to that Schipansky et al., 2018 reported that White-tailed deer in northern Michigan, both in captivity and in the wild, have been studied for their feces, and the results show that their diets varied greatly. The blackbuck average dry weight of bite was 0.067g in RD 25 enclosure and 0.081g in enclosure RD 65. This is quite similar to the 0.066g estimated by (BK and Awasthi, 2018). Dry matter intake (DMI) of adult blackbuck was 1.07 kg/day in the RD 25 enclosure and 1.09 kg/day in the RD 65 enclosure which is quite lower in comparison with the 2.44kg/day in Haripur Phanta of Suklaphanta National Park (ShNP) Nepal.

The average daily defecation rate was 7.34 times in RD 25 and 7.89 times per day in RD 65 which is less than 9.76 times according to (BK and Awasthi, 2018). The average daily fecal output (DFO) in terms of dry weight was 362 g for RD 25 and 340g for RD 65 which is also less than the 444.08 g for the monsoon season recorded by (BK and Awasthi, 2018), DMD of both enclosures was less than 80.19 %. The study found that average dry matter digestibility was 66.325in RD 25 and 68.97 % in RD 65 enclosure similarly was reported by Staudenmaier etal., 2022. The reduction in the average daily defecation rate is an indication of less forage intake due to seasons and a reduction in food availability after extensive deforestation. The Vega-Hernández et al., 2021 also found the same in white-tailed deer's diet variation seasonally in response to changes in the climatic conditions that cause shifts in their defecation rate, their food consumption fluctuates seasonally in accordance with the fiber content of the foods available to them.

Although the breeding success achieved in the LSNP in past years is good. The reasons for mortalities are diseases, hunting, poaching, and unavailability of proper medical treatment. One major reason for mortality was the stress and the cardiac failure in the enclosures. Similar cardiovascular problems in caged animals, especially apes, have been observed in other research. Another study found that cardiovascular disease was the leading cause of death for zoo-kept great apes (Murray *et al.,* 2019), and yet another found that cardiovascular disease was the leading cause of death for zoo-kept chimpanzees (Pan troglodytes) in captivity (Laurence et al., 2017). In contrast to this, the life expectancy of captive Roe deer was found to be lower than that of free-ranging animals in a study by (Muller *et al.,* 2010) that compared the lifespans of three species of deer (reindeer, red deer, and roe deer, Capreolus capreolus). One way to measure how well a species is being cared for in captivity is to compare the average lifespan of its captive population to that of its free-living counterpart.

The blackbuck population in Pakistan has effectively been wiped out due to hunting and poaching. Even now, the RD 65 enclosure is under constant attack from poachers and hunters who target the reintroduced population. Similarly, the Barking deer population in Pir Lasorha National Park (PLNP) and the surrounding area is in grave danger due to hunting and poaching. The barking deer population is in serious decline because of the insistent shooting of these invaders (Zulfiqar et al., 2011).

This space is insufficient for the animals being reared for release to the natural habitat. Different unhealthy conditions could be a cause of stress among them, such as lameness, stress, weakness, hypothermia, hyperthermia, dehydration, heat stroke, and anorexia constituted 23 % of overall health conditions in animals. Conditions like starvation, general weakness, and stress were also reported in captive animals in another study (Sharma et al., 2014). Shade is a vital resource within the enclosure to prevent animals from thermal discomfort in the summer months coupled with the provision of a water pool (Young et al., 2013), as the temperature of the surrounding environment has a substantial impact on the health of captive animals. In this way, heat-related illnesses like heat stroke and heat stress can be avoided. In addition, shelter helps shield animals from the bitter cold in captivity. If these measures are taken the conditions of animals could be better in LSNP because 34 % of deaths at study sites are due to heat stress. Pérez-Barbería et al., 2020 also found that male calves, being more energy-intensive to produce, are particularly susceptible to the deleterious effects of heat stress in hot conditions on calf growth. Overgrazing and tree cutting are also key threats to habitat degradation at the study site. Timber is a common building material for homes, barns, and other structures in the area. Trees are often chopped down to make room for more farmland (Zulfiqar et al., 2011). Keeping all this in view, recultivation of local plants, freedom grazing, improvement and repair of cages, increase in living space, provision of veterinary facilities, keepers training, education, and awareness of locals would be of great importance for the healthy existence of re-introduced blackbucks.

CONCLUSION

This study concluded that blackbucks feeding habits, food preferences, and foraging activity depend on availability and quality of food materials. They feed on fresh tender leaves, grass (highly preferred), and occasionally on leaves of shrubs and herbs. The food preferences of blackbuck have changed over the years. Primarily,

an adult blackbuck needs approximately 2 kg of dry matter per day for survival, good health, and daily activities, but the present provided quantity is less than 2kg. It is concluded for their long-term survival and viable population in the study area, availability and re-cultivation of indigenous plants with better housing facilities as points of key importance.

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CONFLICTS OF INTEREST

The Authors declare that there is no conflict of interest.

AUTHORS' CONTRIBUTION STATEMENTS

BNK, TE and ZIK write the manuscript, AB and MA executed research; BNK conceived the idea and supervised the work. AB wrote review and editing, MA and BNK data curation, validation ZIK and AMF formal analysis. All the authors contributed in writing the manuscript, reading and approving the final manuscript.

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