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DETERMINATION OF ECOLOGICAL AND DIETARY PREFERENCES OF BLACKBUCKS (*ANTILOPE CERVICAPRA*) POPULATION AT THREE DIFFERENT SANCTUARIES IN CHOLISTAN DESERT, PAKISTAN

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Abstract

The study conducted on semi-captive and free ranging blackbucks (*Antilope cervicapra*) at three different localities; Lal Suhanra National Park (RD25), Sheikh Mohammad Bin Zayed Al-Nahyan Conservation Centre Black Buck Enclosure (SMBZA), and Dodhlan Forest, Fort Abbas under different conservation management practices. The assessments covered dry deciduous habitats and shrub/thorn forests in the same sanctuaries by visual observation and grid sections of 1km squares and for determine the dietary composition and palatability of certain indigenous plant species fecal slides were prepared. All slides were microscopically observed and compared for plant parts with reference slides. Nonparametric t-test was used to determine level of significance for ecological preference while dietary scores were represented as Median (IQR) and analyzed using a Kruskal Wallis test. Number of individuals observed were significantly different for Dry Deciduous and Shrub/thorn habitats. Mean blackbuck sightings were significantly higher in the dry deciduous habitats of RD25 ($P<0.0001$), SMBZA ($P=0.0041$), and Dodhlan Forest ($P=0.0357$). The highest number of sightings was reported in the dry deciduous section of SMBZA Black Buck Enclosure (24.8±8.17/Km). It was observed that grasses were most palatable and composed the greatest constituent of Blackbuck's diet, whereby *Cenchrus ciliaris* (12.90 %), *Aristida hystricula* (6.94%), *Cynodon dactylon* (8.53%), *Lasiurus scindicus* (9.53%) and *Ochthochloa compressa* (9.13%) served as significant

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contributors to diet. Higher encounter rates, larger group sizes and greater dietary composition of tall grasses, indicated a preference for Dry Deciduous habitats by Blackbucks in Cholistan Desert of Pakistan.

Keywords: Cenchrus Ciliaris, Dietary Composition, Dry Deciduous Habitats, Fecal Samples, Lal Suhanra National Park, Semi-Captive Blackbucks.

INTRODUCTION

Distributed across the entire Indian subcontinent, blackbucks exhibit habitat preferences for various landscapes, including thin forests, open areas, grassy plains, and semi-desert regions (Bhaskar et al., 2021). However, in Pakistan, blackbucks primarily dwell in tropical and sub-tropical zones (Tahir et al., 2022). These animals have adapted to thrive in grassy plains and semi-arid landscapes but can survive in literal wastelands (Choudhary and Chisty, 2022).

Researchers have postulated that ideal blackbuck habitats encompass grasslands and forests in close approximation of agricultural areas (Delu et al., 2023). More specifically, they exhibit seasonal preferences, showing a liking for grasslands during the monsoon while preferring deciduous forests during extreme summer and winter (Frank et al., 2021). Nevertheless, bushy and thorny areas consistently rank lower in preference across all seasons. Their grazing activities are remarkably malleable, as they could easily survive by merely browsing during seasonal scarcity of grasses (Choudhary and Chisty, 2022).

But in such cases, these herds often veer into nearby croplands and heavily rely on cereal crops for sustenance. It has been pointed out that blackbuck distribution is only limited by the availability of drinkable surface water (Rahmani and Sankaran, 1991). The influence of social dynamics, particularly male dominance, extends beyond reproductive implications to impact habitat selection.

Males that experience social subordination opt for less desirable habitats, resulting in diminished survival rates and reduced reproductive potential (Isvaran, 2005). Similarly, a difference in vegetation cover has also greatly influenced the number and composition of blackbuck herds (Baskaran et al., 2011).

Information pertaining to ecological preferences, social organization, and feeding behavior undertaken among a particular blackbuck group has been essential for their conservation in a specific region. Therefore, this present study was conducted to investigate the habitat and dietary preferences of blackbucks at Lal Suhanra National Park (RD25), Sheikh Mohammad Bin Zayed Al-Nahyan Conservation Centre Black Buck Enclosure, and Dodhlan Forest, Fort Abbas in Cholistan Desert of Pakistan.

MATERIAL AND METHODS

Ethical Consideration

This study was approved from the Islamia University Bahawalpur, Department of Wildlife and Forestry, Thesis Committee (Synopsis Approval no: 389/AS&R). Appropriate consent was obtained from the authorities managing these sanctuaries beforehand, while the

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methodology complied with the established guidelines stated in Punjab Wildlife Protection, Preservation, Conservation and Management Act (1974).

Location, Topography and Climate of Study Sites in Cholistan Desert

The present research was undertaken at three Blackbuck sanctuaries, namely Lal Suhanra National Park (RD25), Sheikh Mohammad Bin Zayed Al-Nahyan Conservation Centre Black Buck Enclosure (SMBZA), and sections of Dodhlan Forest, Fort Abbas. These protective sites are situated in the Cholistan region of Bahawalpur, Rahimyar Khans, and Bahawalnagar.

The Cholistan region has been classified as a desert for the most part. However, large sections have dry deciduous and shrub/thorn vegetation coverage, indicating more of an arid landscape consisting of alluvial flats and small sand dunes (Altaf, 2022; Hussain and Altaf, 2023).

Assessment of Habitat Preferences

Habitat types based upon the vegetation coverage were identified and the number of blackbuck sightings were recorded.

Identification of Habitat types on the basis of vegetation and cover

The author of the manuscript extensively surveyed Lal Suhanra National Park (RD25), Sheikh Mohammad Bin Zayed Al-Nahyan Conservation Centre Black Buck Enclosure, and Dodhlan Forest in Fort Abbas on foot. Based on vegetation coverage and satellite imagery from Google Earth, two distinct types of forestation habitats were identified where blackbucks were often sighted: dry deciduous vegetation and shrub/thorn vegetation (Baskaran et al., 2011). These habitats were further divided into several 1km squares across all three aforementioned areas.

Distribution of Blackbucks in available Habitat types

To comprehend the habitat preferences of Blackbucks in the prevalent dry deciduous and shrub/thorn vegetation, determining encounter rates was essential. These rates were calculated by assessing the total number of observed Blackbucks in relation to the overall distance covered during our survey period, expressed as the number of blackbucks sighted per kilometer walked (Baskaran et al., 2011).

In the case of Lal Suhanra National Park (RD25), 25 grid blocks were walked for each habitat type. Whereas, 16 and 8 grid blocks were chartered at Sheikh Mohammad Bin Zayed Al-Nahyan Conservation Centre Black Buck Enclosure for Dry deciduous and Shrub/thorn vegetation, respectively. However, Dodhlan Forest, Fort Abbas, being a much smaller enclosure, was divided into 5 (Dry Deciduous Forest) and 3 (Shrub/thorn forest) grid blocks only. The researcher then traversed these areas, recording the number of animals sighted after walking each kilometer. The total number of blackbuck sightings in the surveyed area was compared for both habitat types. Sizes for the surveyed area varied, owing to the differential availability of respective habitats.

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Determination of Group Size and Composition in different habitats

During sightings in both types of habitats, information on the size of blackbuck groups and their composition was recorded. However, the researchers sometimes had difficulty differentiating between the sexes, especially when it came to yearlings. To ensure consistent data, the individuals were classified into three age groups.

Animals larger than 45 centimeters were classified as adults, those between 30 and 45 centimeters were classified as yearlings, and those smaller than 30 centimeters were classified as fawns (Baskaran et al., 2011). A total of 82 recordings were made during the habitat investigation, with 46 in the Dry Deciduous habitat and 36 in the Shrub/Thorn forests.

Assessment of Dietary Preferences

The dietary preferences of blackbucks were determined by analyzing the percentage presence of specific plant species in their fecal matter.

Fecal analysis for inference of Dietary Preferences

Analyzing the feeding habits of blackbucks directly to determine their dietary preferences would have been labor-intensive. Therefore, fecal examination was used as an indirect method to infer the types of flora preferred by blackbucks native to the Cholistan desert. The author acknowledges the limitations of this approach, as most consumed plants are digested before being excreted as pellets.

Given the vast habitats of the studied animals and the impracticality of regularly observing their feeding or collecting stomach contents, fecal examination provided valuable insights into the feeding tendencies of blackbucks. This method has been widely used in previous investigations as a reliable taxonomic basis for determining the botanical composition of herbivores.

Collection of Fecal Samples

All antelope species have specific locations in their habitat where they defecate, known as lavatory sites. These sites can be identified by the presence of piles of pellets in open spaces, with fresher ones typically found in the center.

The research identified such defecation sites in the most densely populated habitats, specifically the dry deciduous and shrub/thorn forests found in all three sanctuaries. In order to study these lavatory sites, each site was divided into nine quadrants, each measuring 1m². A total of six lavatory sites were identified, with one site from either the dry deciduous or shrub/thorn habitats in each sanctuary.

These six sites were then further divided into nine quadrants, but only four of them were randomly sampled (see Fig. 1). To obtain representative data for all three seasons, sampling was carried out during the months of Summer (May), Monsoon (September), and Winter (December).

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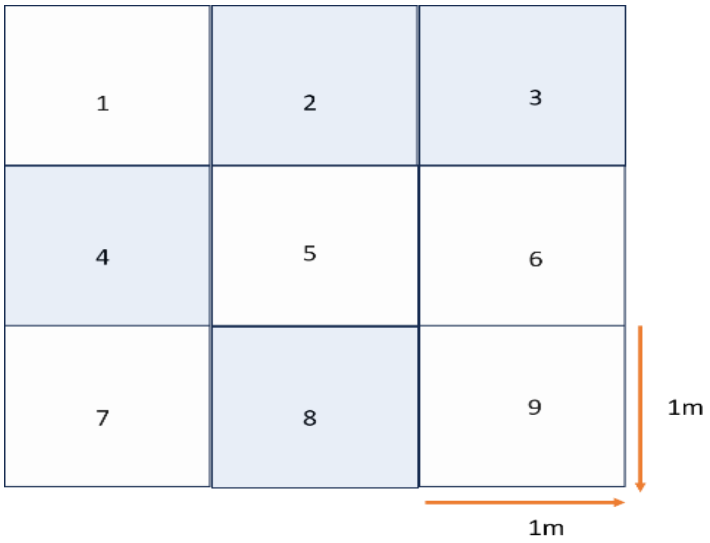

Figure 1: Fecal Sampling subsequent to division of Lavatory sites into 9 equal Quadrants

Dispatch and Processing of Fecal Samples for Microscopic Analysis

Fresh pellets were collected in polythene bags, identified based on their texture and moisture content, and appropriately labeled with location, date, and sample status (Pant *et al*., 2019). Processing fecal samples for estimation of vegetation cover required them being air-dried on drier sheets for over 3-4 days to remove moisture and prevent fungal growth.

Preparing plant reference slides

Samples of indigenous plants, believed to be part of the blackbuck's diet, were collected from their natural habitats. Plant parts such as leaves, twigs, and fruits were then processed to create reference slides. To do this, bits of leaves from each plant were coarsely shredded and placed in a test tube. A 250% Aqueous Chloral hydrate solution, about 2-3 ml, was added to the test tube.

The samples were then heated in a water bath at 100 °C for 2-3 minutes. This heating process effectively bleached all the chlorophyll, protein, and starch in the plant material. Once the solution had cooled to room temperature, the liquid was drained off and the samples were thoroughly rinsed with distilled water.

The plant material was then dehydrated using a mixture of alcohol and xylol in a series of steps. Each step involved increasing amounts of xylol until the samples were fully submerged in pure xylol. Finally, the samples were mounted using Canada balsam (Baskaran et al., 2011).

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Fecal analysis

Samples were coarsely grounded and passed through three sizes of American Society for Testing and Materials (ASTM) test sieves, i.e., 30, 40 and 50. The pulverized part of sample that passes through these sieves is boiled with 250% Aqueous Chloral hydrate solution until the powdered sediment is fairly clarified. The supernatant is poured off and the clarified sediment is repeatedly washed with distilled water. The processed material was dehydrated in successively higher concentrations of xylol mixtures with alcohol (Baskaran *et al*., 2011).

Finally, Canada balsam was used for mounting, resulting in a total of 72 slides, one for each incidence of sampling. The slides were examined using binocular microscope and structure of plant remains, namely epidermal cells, stone cells, cuticles and trichomes were identified after comparing them with the plant tissue particles of reference slides.

Quantitative estimation of dietary preference

All 72 slides were microscopically observed and compared for plant parts with reference slides. After observing slides the percent occurrence of a particular plant part was visually estimated and scored based upon the following scoring table (Table 1).

Table 1: Quantitative Scoring for the Percent occurrence of a particular plant part

Sr. No.	Percent occurrence of a particular plant part	Score
1	None	0
2	Lesser than equal to 2.5 percent (≤2.5%)	1
2	Lesser than equal to 5 percent (≤5%)	2
3	Lesser than equal to 10 percent (≤10%)	3
4	Lesser than equal to 20 percent (≤20%)	4
5	Lesser than equal to 40 percent (≤40%)	5
6	Lesser than equal to 80 percent (≤80%)	6
7	Lesser than equal to 100 percent (≤100%)	7

RESULTS

Habitat Preference

Number of blackbucks encountered after crossing every kilometer were tabulated and compared for both major habitats (Dry Deciduous Forest and Shrub/thorn Forest) at Lal Suhanra National Park (RD25), Sheikh Mohammad Bin Zayed Al- Nahyan Conservation Centre Black Buck Enclosure and Dodhlan Forest, Fort Abbas. A nonparametric t-test or Mann-Whitney test was used to determine level of significance.

Encounter rates within all three enclosures were observed significantly different for Dry Deciduous and Shrub/thorn habitats. Mean encounter rates at Dry Deciduous habitats of Lal Suhanra National Park (RD25), Sheikh Mohammad Bin Zayed Al- Nahyan Conservation Centre Black Buck Enclosure and Dodhlan Forest, Fort Abbas were 6.31±2.08, 24.8±8.17, 6.4±1.81 respectively (Table 2).

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Table 2: Number of Blackbucks sighted after every Km walking across Dry Deciduous forests and Shrub/Thorne forests. Mean Values are represented as Mean ± SD and analyzed for variations using a Nonparametric Mann-Whitney U test

Sr. No.	Blackbuck Sanctuaries in Cholistan Desert, Pakistan	Mean Encounter Rates per Km ± SD		Mann-Whitney U	P Value
		Dry deciduous habitat	Shrub/thorn habitat		
1	Lal Suhanra National Park (RD25)	6.31±2.08	1.06±1.18	9	<0.0001
2	Sheikh Mohammad Bin Zayed Al-Nahyan Conservation Centre Black Buck Enclosure	24.8±8.17	7.4±8.02	19	0.0041
3	Dodhlan Forest, Fort Abbas	6.4±1.81	0	0	0.0357

These rates were observed to be significantly higher for Dry deciduous habitats in Lal Suhanra National Park (RD25) (P<0.0001), Sheikh Mohammad Bin Zayed Al- Nahyan Conservation Centre Black Buck Enclosure (P=0.0041) and Dodhlan Forest, Fort Abbas (P=0.0357). Whereby, mean encounter rates were greatest in the dry deciduous sections of Sheikh Mohammad Bin Zayed Al- Nahyan Conservation Centre Black Buck Enclosure (24.8±8.17), probably due to a greater population density and a smaller enclosure size (Fig. 2).

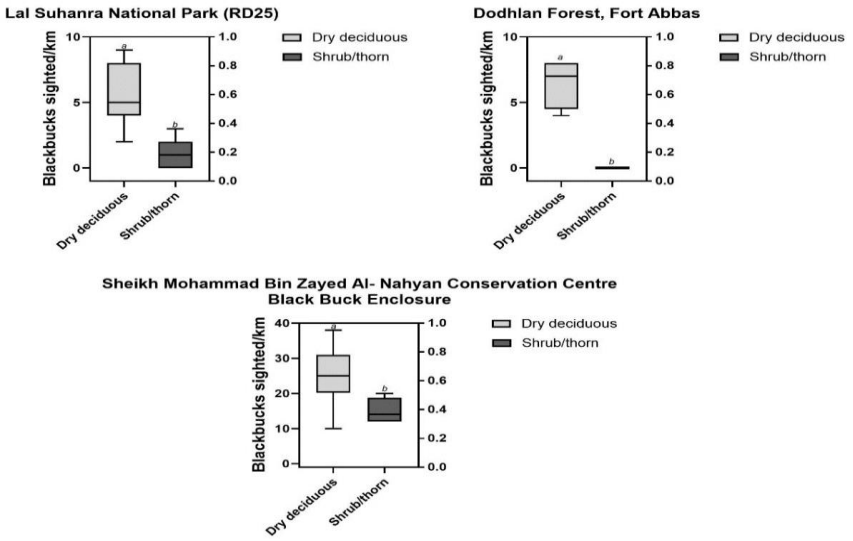

Figure 2: Box and Whisker Plot illustrating the minimum and maximum number of Blackbucks sighted in a 1 Km area while walking across Dry Deciduous and Thorne Forests in Lal Suhanra National Park (RD25), Sheikh Mohammad Bin Zayed Al- Nahyan Conservation Centre Black Buck Enclosure and Dodhlan Forest, Fort Abbas Significant differences (P<0.05) amongst Habitats have been indicated by superscripts [a, b]

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Group Size and Composition

During current investigation, data was reported for 82 recording, out of which 46 were for Dry Deciduous habitats while 36 were for Shrub/Thorn forests. In case of Dry Deciduous forests, 34.78 % observations (n=16) reported the herd sizes to be ranging between 1 to 5 individuals and 32.6 % observations were for herd sizes ranging between 6 to 10 (n=10) individuals. Only 4.34 % (n=2) of herds were reported to have greater than 36 individuals. Conversely, in case of Shrubs/Thorn forests, 41.66 % recordings (n=15) reported no sightings. However, 36.11 % observations (n=13) were for 1-5 individual groups. Medium sized herds were far more common in case of Shrub/Thorn forests rather than Dry deciduous ones, whereas >20 individuals sized herds were only sighted in Dry Deciduous habitats (Fig. 3).

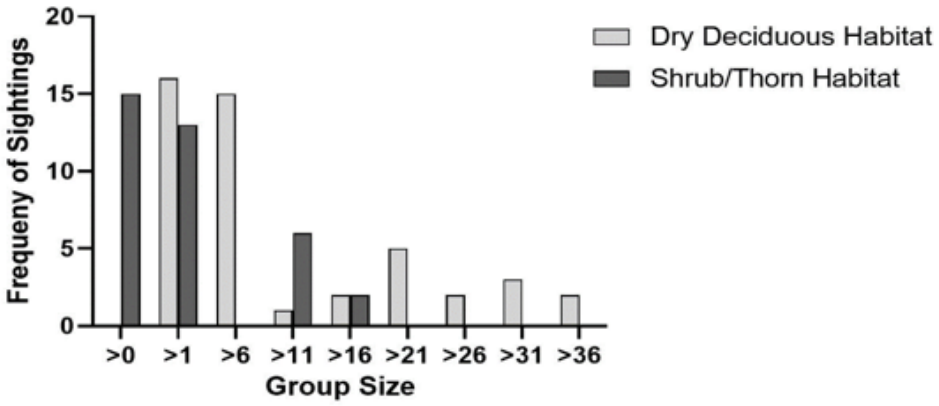

Figure 3: Interleaved Bar Graph illustrating the Frequency of Blackbucks sighted for different group/herd sizes in Dry Deciduous and Shrub/Thorn Habitats at Lal Suhanra National Park (RD25), Sheikh Mohammad Bin Zayed Al- Nahyan Conservation Centre Black Buck Enclosure and Dodhlan Forest, Fort Abbas

Out of 46 recordings in Dry Deciduous forests, Group size of 1 to 5 was recorded in 32 observations for adults, 27 for Yearlings and 30 for fawns. Similarly, out of 36 observations in Shrub forests, Group size of 1 to 5 was recorded in 16 observations for adults, 8 for Yearlings and 13 for fawns (Table 3).

Table 3: Group Composition and Sizes of different Age Classes sighted across Dry Deciduous forests and Shrub/Thorne forests

Habitats	Age Classes	Frequency of sighting according to Group sizes				
		0	1 to 5	6 to 10	11 to 15	16 to 20
Dry Deciduous	Adults	2	32	8	2	2
	Yearlings	7	27	4	3	5
	Fawn	4	30	11	1	0
Shrub/Thorn	Adults	15	16	5	0	0
	Yearlings	26	8	2	0	0
	Fawn	23	13	0	0	0

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Dietary Preference

A total of 72 fecal samples collected from dry deciduous and shrub/thorn forests were microscopically analyzed for plant remains. Each slide was scored for the percentage presence of a particular plant's part by comparing it to the previously sampled plant species and reference slides for Cholistani flora. Three different categories of plant species, namely tree, shrub, sedge, herb, and grass, were identified in the fecal matter of blackbucks. The median scores and interquartile ranges for the relative presence of different species of flora have been tabulated in Table 4. Kruskal-Wallis's test was employed to ascertain the level of significance among the different flora and determine their mean ranks based on their percentage presence. The statistical analysis indicated that there was a significant difference ($P<0.0001$) among the quantities consumed of different plant species by the blackbuck population, owing to the variable content of their feces.

Table 4: Quantitative scores for Percent occurrence of a particular plant part represented as Median and Interquartile Ranges (IQR) and analyzed for significance using a Kruskal-Wallis Test

Sr. No.	Families	Species	Local Name	Habit	Median	IQR	Mean Rank	Preference
Graze Species								
1	*Poaceae*	*Cenchrus ciliaris*	Dhaman	Grass	1	1	1653	+++
2	*Poaceae*	*Aristida hystricula*	Lumb	Grass	0	1	1464	+++
3	*Poaceae*	*Cynodon dactylon*	Khabbar	Grass	0	1	1463	+++
4	*Poaceae*	*Lasiurus scindicus*	Sewen	Grass	0	2	1457	+++
5	*Poaceae*	*Ochthochloa compressa*	Gandeel	Grass	0	1	1452	+++
6	*Poaceae*	*Panicum turgidum*	Bansi	Grass	0	0.25	1328	++
7	*Poaceae*	*Panicum antidotale*	Murrot	Grass	0	1	1363	++
8	*Poaceae*	*Stipagrostis plumosa*	Lumb	Grass	0	0	1283	+
9	*Poaceae*	*Sporobolus iocladus*	Swag	Grass	0	1	1350	++
10	*Poaceae*	*Aeluropus lagopoides*	Kalar Ghaa	Grass	0	0	1174	+
11	*Poaceae*	*Pennisetum divisum*	Morrot	Grass	0	0	1193	+
12	*Poaceae*	*Cymbopogon jwarancusa*	Khavi	Grass	0	0	1058	+
13	*Poaceae*	*Saccharum bengalense*	Sarkanda	Grass	0	0	1027	-
Browse Species								
14	*Salvadoraceae*	*Salvadora oleoides Decne*	Pilu	Shrub	0	0	1109	++
15	*Rhamnaceae*	*Zizyphus nummularia*	Mallah	Shrub	0	0	1109	++
16	*Rhamnaceae*	*Zizyphus spina*	Beri	Tree	0	0	1109	++
17	*Rhamnaceae*	*Zizyphus mauritiana*	Beri	Tree	0	0	1125	++
18	*Mimosaceae*	*Acacia jacquemontii*	Banwali	Shrub	0	0	1109	++
19	*Mimosaceae*	*Acacia nilotica*	Kiker, Babul	Tree	0	0	1125	++
20	*Mimosaceae*	*Prosopis cineraria*	Druce. Jand, Kanda	Tree	0	0	1109	++
21	*Tamaricaceae*	*Tamarix aphylla*	Frash, Ukan	Tree	0	0	1074	+
22	*Asclepiadaceae*	*Calotropis procera*	Ak	Bush	0	0	1074	+
23	*Polygonaceae*	*Calligonum polygonoidesLinn*	Phog	Shrub	0	0	1058	+
24	*Chenopodiaceae*	*Haloxylon recurvum*	Khar, Sajji	Shrub	0	0	1058	+
25	*Chenopodiaceae*	*Suaeda fruticose*	Kali Lani	Shrub	0	0	1058	+
26	*Chenopodiaceae*	*Salsola baryosma*	Lani	Shrub	0	0	1058	+
27	*Chenopodiaceae*	*Haloxylon salicornicum*	Lana Shrub	Shrub	0	0	1043	+
28	*Capparaceae*	*Capparis spinosa*	Kubber	Bush	0	0	1043	+
29	*Capparaceae*	*Capparis decidua*	Karir	Shurb	0	0	1043	+
30	*Asclepiadaceae*	*Leptadenia pyrotecnica*	Khip	Shurb	0	0	1027	-
31	*Amaranthaceae*	*Aerva javanica*	Bui	Bush	0	0	1027	-
32	*Mimosaceae*	*Prosopis juliflora*	Mesquite, Vilate Kiker	Tree	0	0	1027	-
33	**Unidentified Plant remains**				1	1	1573	

*****High Palatability (+++), Moderate Palatability (++), Low Palatability (+), Unpalatable (-)

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The statistical rank of all species was identified using Kruskal Wallis test and thereby the relative preference of different grazing and browsing species of plants were estimated. Furthermore, a Post-hoc Dunn's multiple comparisons test was performed was also performed to identify the specie of plant which was most preferred by the Blackbucks in current research parameters. The statistical results have been present in the form of a Box plot graph with error bars and superscripts indicating level of significance to ascertain the range of observations in graphical terms (Fig. 4).

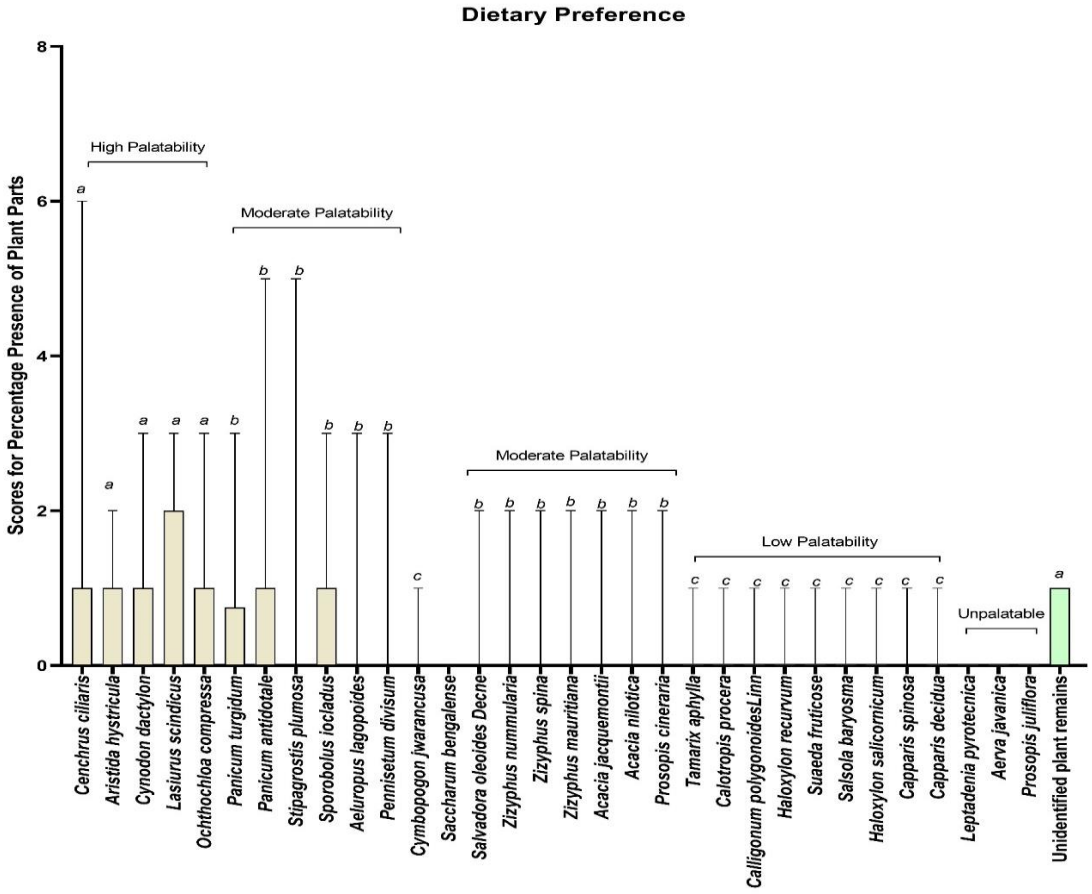

Figure 4: Box and Whisker Plot illustrating the minimum and maximum score for different Plant parts observed under microscope. Significant differences (P<0.05) amongst Plant Species have been indicated by superscripts [a, b, c]

Plant remnants of Grasses namely *Cenchrus ciliaris, Aristida hystricula, Cynodon dactylon, Lasiurus scindicus,* and *Ochthochloa compressa* were observed in significantly greater proportions than all the other indigenous plants consumed by Blackbucks reared in Cholistani sanctuaries. Amongst browse species, *Salvadora oleoides, Zizyphus nummularia, Zizyphus spina, Zizyphus mauritiana, Acacia jacquemontii, Acacia nilotica,* and *Prosopis cineraria* were also present in significantly greater proportions in fecal

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samples than other browse species. *Cenchrus ciliaris* constituted the greatest percentage of diet (12.90 %), while an average of about 6.94 % of plant remains observed on microscopic slides remained unidentified. The data pertaining to relative constitution of blackbuck's diet, as estimated by fecal examination has also been presented in form of simplified mean percentages (Fig. 5).

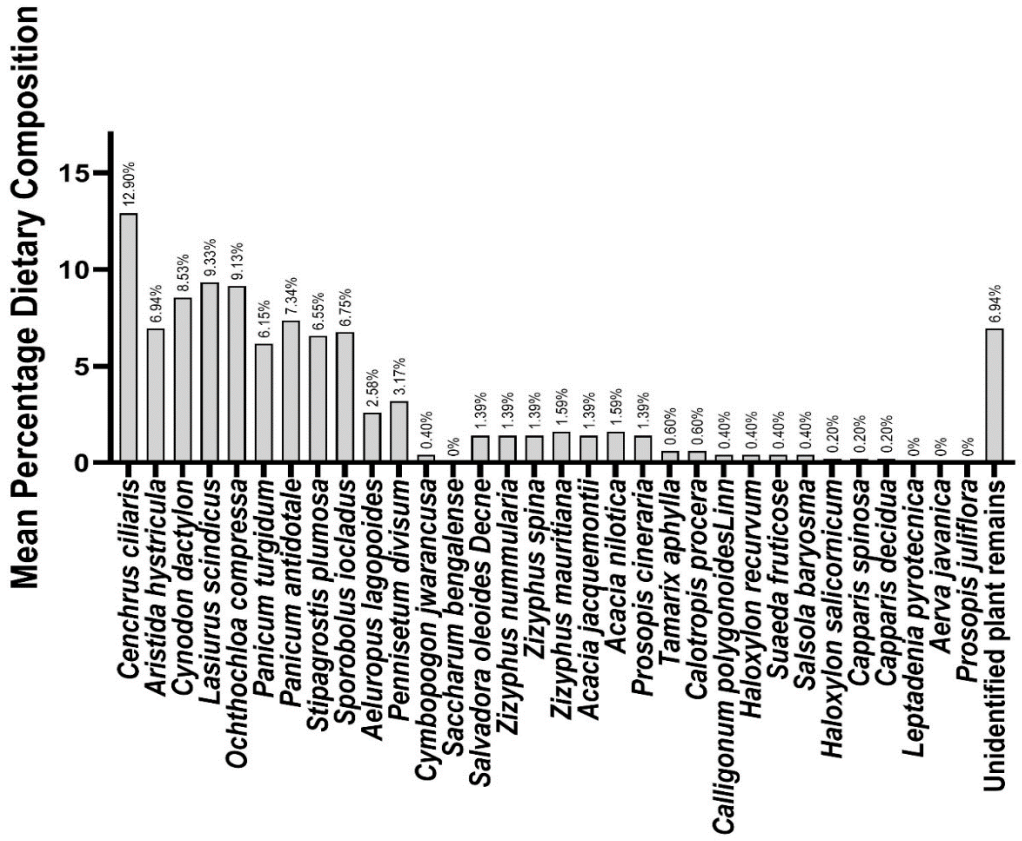

Figure 5: Bar graph illustrating the estimated Mean Percentages of Plant parts of various species identified by Fecal Examination under microscope

DISCUSSION

Cholistani Blackbuck Sanctuaries are prime examples of diverse landscapes encompassing wetlands, thinly populated dry deciduous forests, and arid deserts with shrubs (Mirza and Waiz, 1973). Lal Suhanra enclosure, situated 35 kilometers eastward of Bahawalpur, Punjab, was proposed in 1966. However, it received its first consignment of animals for reintroduction during the 1970s (Mirza and Waiz, 1973).

The researcher of this manuscript has noted that, to date, a fairly large population of blackbucks is thriving in this sanctuary. In our current study, encounter rates with

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blackbucks were grounded on the number of individual animals observed per kilometer across dry deciduous or thorn forests. The sanctuary grounds were surveyed on foot so as not to alert these animals. A similar methodology has been employed by prior researchers to effectively sight blackbuck herds across thin forests using only binoculars (Choudhary and Chisty, 2022). Moving across these habitats on foot made it easier for the researcher to get pretty close to the animals without scaring them away. The nature of these habitats was identified by the researcher by utilizing a multipronged approach similar to previous publications (Delu et al., 2023; Chandel et al., 2022; Meena and Chourasia, 2018; Choudhary and Chisty, 2022). The author of this manuscript primarily relied on previous investigations studying the habitats in Lal Suhanra National Park (Mirza and Waiz, 1973; Wariss et al., 2014).

Moreover, the flora and fauna species identified by the researcher while surveying these habitats also helped in delineating the nature of the respective habitats. The researcher also utilized satellite imagery from Google Earth to differentiate the degree of floristic coverage by the depth of green on the images within the premises of the sanctuary.

All these approaches have been justified by prior researchers to approximate the type of habitats in a particular territory. A prior study at Mudumalai National Park, in the Nilgiri Mountains in Tamil Nadu in southern India, reported that a higher abundance of blackbucks was observed in dry deciduous areas (0.26 individuals/km, 95% CI = 0.22–0.29), whereas only 0.09 individuals/km (CI = 0.001–0.18) were sighted in dry thorn forests (Baskaran et al., 2011). However, the author of this manuscript could not corroborate prior findings. It was observed that in the Lal Suhanra Enclosure, 6.31±2.08 individuals were sighted per kilometer in dry deciduous habitats, whereas 1.06±1.18 animals were seen after every kilometer of thorn/shrub surveyed. These sightings indicated a much greater population density in a similarly set-up sanctuary, as the Blackbuck Conservation Area is located in Gulariya, Bardiya District, Nepal. Moreover, sightings in the dry deciduous habitats of Sheikh Mohammad Bin Zayed Al-Nahyan Conservation Centre Black Buck Enclosure (24.8±8.17 individuals/km) were even greater.

The author of this manuscript has posited that this variation could be rationalized by the fact that, in the last few decades, Blackbuck populations have flourished in these desert sanctuaries. Furthermore, the allocated landmass for these sanctuaries was much smaller in the current settings compared to prior reporting. Unlike studies in Nepal (Khanal, 2002; Choudhary and Chisty, 2022), the study area in the current scenario had a very dry climate and received 100 to 200 mm of rainfall erratically, only during the monsoon season. Therefore, observations for habitat preferences were made during the post-monsoon months before fall. This approach was chosen to ensure optimal visibility by avoiding foggy months, while also allowing the herds to disperse across a broader terrain as the semi-arid lands flourished following rainfall. In current settings, most of the blackbuck individuals were sighted in smaller herd sizes of 1 to 5 individuals. Prior investigations have indicated a similar pattern whereby smaller herds, or solitary adult

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females with yearlings or fawns were predominantly sighted. Moreover, authors noted that larger herd sizes (>30), were only observed in case of Dry Deciduous habitats, while only smaller sized herds were recorded in Shrub/Thorn forests. This phenomenon could be justified by the fact that observations were predominantly conducted during drier months causing for greater numbers to be sighted under shade in deciduous landscapes. Similar to previous researchers, author noted that though blackbuck visibility was much better in dry thorn habitats, while the overall encounter rates proved higher in dry deciduous regions which were primarily covered with short to medium grasses (Baskaran et al., 2011). Additionally, author of this current manuscript has posited that a greater frequency of larger group sizes being more frequently observed in Dry Deciduous habitats was indicative of the overall preference of that habitat. It was quite impractical to assess the dietary preferences of blackbucks by directly observing them, however, it would become pretty feasible if the undigested plant parts are identified in their feces by microscopy (Pant and Joshi, 2019).

This methodology was termed as pellet analysis and outlined by multiple researchers for determining the botanical composition of herbivores diets (Baskaran et al., 2011). However, prior researchers have discussed the imperative of obtaining representative fecal samples from different Blackbuck Habitats (Pant et al., 2019). Moreover, season changes have quite a consequential bearing upon availability of certain highly palatable plant species. Therefore, to obtain a most expansive sample pool, author of this manuscript sampled multiple lavatory sites across all three Cholistani sanctuaries. Additionally, sampling was performed through all three seasons as to obtain cross sectional data for an entire year, irrespective of the nature and habit of concerned palatable plant species. Researchers have understood that fecal sampling could be easily performed for blackbucks by identifying defecation sites where pellets are piled up in the open. Freshest pellets are always selected from the middle of the heap (Frank et al., 2021).

Similar to prior researches, author selected two characteristic sites from both the major habitats where blackbucks were sighted (Sathishkumar et al., 2023). Multiple quadrants of either sites were sampled during both pre and post monsoon seasons. Freshness of pellets at the time of collection must be ascertained by texture and moisture content as proposed by Baskaran et al. (2011). Prior studies have identified 13 graze, and 19 browse species that could be palatable for Blackbucks in Cholistan desert (Abdullah et al., 2017). Subsequent Indian researchers have expanded this list to almost 62 species of plants, and categorized them into 7 highly preferred plants, 9 second choice preferences, 16 lowly preferred ones and the remaining ones were indicated to be negatively preferred (Pant and Joshi, 2019).

Twenty-four plant species, indigenous to Mudumalai Wildlife Sanctuary were identified to compose the diets of native blackbucks (Baskaran et al., 2011). *Grewia hirsuta* (a shrub) was discovered to be the most abundantly consumed plant by blackbucks, contributing almost 5.6% of the overall diet. to the overall diet. However, our current study was

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undertaken in a completely different climate and ecological set-up. Author discovered that *Cenchrus ciliaris* (12.90 %), served as the staple of diet amongst Cholistani blackbucks. Notably, other significant contributors to the diet included *Aristida hystricula* (6.94%)*, Cynodon dactylon* (8.53%)*, Lasiurus scindicus* (9.53%) *and Ochthochloa compressa* (9.13%) as per the sampled fecal matter. Similar findings were identified by Pant et al. (2019) and Khanal (2002). Prior researchers have noted that grasses constituted a major part of the blackbuck diet followed by shrubs, trees, and then herbs (Pant et al., 2019; Khanal, 2002; Sathishkumar et al., 2023).

Our present research corroborated earlier findings and indicated that Blackbucks kept in the Chloistan area, preferred to graze rather than browse. However, certain studies have reported an equal proportion of grass and browse in the Blackbuck diet (Khanal, 2002). Nevertheless, remnant of grasses was far more prevalent in the blackbuck's fecal matter during current investigation. Scientist have postulated that blackbucks could adapt themselves to sustain by browsing during drier seasons when grass species become coarser and less nutritious (Frank et al., 2021). Certain studies have indeed also reported persistent browsing habit amongst tamed and free-ranging antelopes (Tahir and Ghaffar, 2021).

In the current scenario, the presence of certain specific grasses and herbs in fecal matter cannot be grounds for completely negating prior reporting. Conversely, the high dietary percentage of grasses across seasonal changes could be justified by the climate-resistant tendencies of grasses native to the Cholistan desert. Prior investigations relied upon pellet collection, predominantly undertaken during the early dry season (January-February) (Baskaran et al., 2011). In the present study, the author collected multiple samples during summer, monsoon, and winter months to ensure a reliable composite result. Unlike Baskaran et al. (2011), a much lower percentage (6.94%) of unidentified plant parts was observed on the slide.

This finding is contrary to the prior understanding that a large percentage of plant parts cannot be identified due to the extreme versatility of tropical flora and the excessive digestion of these feedstuffs by ungulates. The author of this manuscript believes that such findings could be rationalized by understanding the fact that most of the deciduous section of the forest at Lal Suhanra National Park was not natural and had been artificially planted following a planned intervention. Therefore, the overall flora was not as diverse (Hameed et al., 2002; Wariss et al., 2014).

Consequently, a smaller number of plants had to be identified and compared, which would be understandably more efficient and easier. Moreover, sampling in the current study was more elaborate and multi-seasonal, incorporating samples from various micro and macro habitatsto ensure that seasonal dietary preferences did not affect the outcome of our investigation. Prosopis juliflora was abundantly observed by the researcher while surveying the Blackbuck habitats. Prosopis juliflora is utterly unpalatable for Blackbucks and quite injurious to their health due to the presence of abnormally large thorns. Habitats dominated by Prosopis effectively witness a decline in detectability and density of

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blackbuck. The rapid onslaught of Prosopis juliflora on open semi-arid rangelands in the subcontinent, physically encroaching on the grasslands, blocks sunlight from reaching the ground-level grass species (Rajput et al., 2019).

CONCLUSION

In conclusion, during the current investigation, it was observed that Blackbuck preferred dry deciduous habitats significantly more than shrub/thorn habitats in all three enclosures. The mean encounter rates were highest in the dry deciduous sections of Sheikh Mohammad Bin Zayed Al-Nahyan Conservation Centre Black Buck Enclosure (24.8±8.17), likely due to a higher population density and smaller enclosure size. Out of 46 recordings in dry deciduous forests, group sizes of 1 to 5 were recorded in 32 observations for adults, 27 for yearlings, and 30 for fawns. Similarly, out of 36 observations in shrub forests, group sizes of 1 to 5 were recorded in 16 observations for adults, 8 for yearlings, and 13 for fawns. The higher encounter rates in all enclosures and larger group sizes indicated a clear preference for dry deciduous forests by Blackbucks in the Cholistan Desert of Pakistan. The dietary composition and palatability of certain indigenous plant species of grasses, shrubs, and trees were analyzed through fecal analysis. Fecal samples were collected from various habitats throughout the summer, monsoon, and winter months. It was observed that grasses were the most palatable and made up the largest portion of the Blackbuck's diet, with Cenchrus ciliaris (12.90%), Aristida hystricula (6.94%), Cynodon dactylon (8.53%), Lasiurus scindicus (9.53%), and Ochthochloa compressa (9.13%) serving as significant contributors to the diet.

Conflict of Interest: There was no conflict of interest with respect to authors reporting their research findings.

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