FLUCTUATIONS IN *CHINKARA GAZELLE* POPULATION AND GENDER RATIOS: A FOUR-YEAR STUDY IN KHUZDAR AND LASBELA, BALOCHISTAN

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(Received 8th Sep 2023; accepted 30th Oct 2023)

Abstract. The Chinkara gazelle (*Gazella bennettii*), an endangered species, faces a serious threat from anthropogenic activities and climate change. In Balochistan, climate change and drought have created extremely challenging circumstances for its survival. The population status of many species cannot be determined due to a lack of data. If the current situation persists, there is a high risk of extinction for this species in its natural habitat. The purpose of this study was to examine the population dynamics and distribution patterns of Chinkara gazelle in the Khuzdar and Lasbela districts of Balochistan, Pakistan. The study covered an area of approximately 45,123.97 km^2 and involved a double-observer survey at six sites from 2019 to 2022, using the BBRecapture package in the R programming language. The study detected a decreasing population trend in the Chinkara population over a four-year period. A population of 700, 683, 613 and 583 individuals were observed in 2019, 2020, 2021 and 2022, respectively. Rocky shrub land consistently recorded the highest number of chinkara sightings among various habitats. This study provides valuable information about the Chinkara gazelle population, including population trends, gender ratios, habitat preferences, and density. The findings contribute significantly to our understanding of the species and will be used to develop local-level conservation initiatives.
Keywords: *Chinkara gazelle, population status, demographic structure, distribution range, habitat preference, wild ungulates, Southern Balochistan*

Introduction

Ungulates play a critical role in the maintenance of ecosystem by influencing vegetation structure, plant species composition and nutrient cycling (Bagchi and Ritchie, 2010) therefore, it is important to monitor the population status of these species for the better conservation management. The ungulates have successfully adapted to their natural habitats

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2201_555567

through coevolution with the environment, enabling them to efficiently utilize essential resources like food, water, and shelter (Arshad and Hussian Gill, 2010a). As a result, these factors significantly influence the spatial distribution of these animals.

The chinkara gazelle, *Gazella bennettii* (hereafter "chinkara") is the only gazelle species found in the Indian subcontinent out of the 19 species that exist in Asia and Africa (Mallon and Kingswood, 2001). Chinkara is widespread and well-adapted to arid and semi-arid environments (Kumar et al., 2020). It exhibits a distribution range extending from the north-central regions of Iran in the west, traversing through Pakistan and Afghanistan, and extending to the eastern states of India (IUCN, 2018). Chinkara primarily feeds on twigs, leaves, flowers, and fruits of small trees, bushes, grasses, and herbs (Jaipal, 2015) and thus ecologically, holds significant importance.

Chinkaras are highly adaptable species and can live in various arid environments. Their ecological niche encompasses dry steppes, semiarid deserts, and arid valleys, where they can survive for extended periods of time without visiting water sources (Roberts and Bernhard, 1977; Dookia et al., 2009). In Pakistan, the chinkaras are found in the elevation ranges from sea level up to 1,500 meters (Jamshidi et al., 2019). The IUCN reported approximately 50,000–70,000 mature individuals worldwide. Specifically, India is home to over 100,000 of these individuals, while Iran has an estimated population of around 1,300 (IUCN, 2018). The species is facing several threats from illegal hunting, urbanization, and climate change. There is lack of baseline data and unavailability of population estimates for chinkara in Pakistan (Arshad and Hussian Gill, 2010b; Akbari et al., 2014; Mallon and Kingswood, 2019).

Chinkara typically form small herds comprised of 5 to 10 individuals (Gehlot, 2006). According to Gehlot (2006), approximately 48.83% of the herds consisted of 5 or more individuals, 38.95% were composed of 2 to 4 individuals, and 12.20% were reported as solitary. Rahmani (1990) recorded an average herd size of 3 to 6 animals in mixed herds of chinkara gazelles. They are either found as a group comprising of a single buck, one or more does and the fawns, or as solitary bucks, and a group of all male individuals (Dookia and Goyal, 2007).

The population of chinkaras in Afghanistan, Iran, and Pakistan is severely affected by indiscriminate hunting and habitat loss (Michel and Ghoddousi, 2020). Hunting practices and human activities such as overgrazing, agriculture, and industrialization have caused significant damage to habitats, depleted resources, and worsened their population decline. Urgent conservation efforts are required to safeguard these animals and their habitat. The International Union for Conservation of Nature (IUCN) classifies the chinkara as "Vulnerable" primarily because it is prone to hunting for meat in regions like Pakistan, Afghanistan, and Iran (Dookia and Jakher, 2013), the ongoing population decline calls for measures to ensure their long-term survival.

The chinkara is a species that can be found in different parts of Pakistan, such as the Sibi plains, Makran, Turbat, Lasbela of Balochistan, Kirthar hills in Sindh, Margalla hills in Islamabad, and around the Kala Bagh area in salt range and Cholistan desert in Punjab province. However, its distribution in Pakistan was historically even more extensive (Khan et al., 1985). According to a survey by the Ministry of Climate Change and the Ten Billion Tree Tsunami Programmed Team, the population of chinkara are threatened due to habitat loss and illegal hunting in the wild. However, experts believe this species can be found in zoos and wildlife parks, bringing the estimated total population in Pakistan to around 3,000 chinkara deer (Akbari et al., 2016).

The study aimed to assess the chinkara population in the Lasbela and Khuzdar districts of Balochistan, Pakistan, with a focus on population size, demographic characteristics, and

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2201_555567

spatio-temporal patterns. Multiple research methodologies were employed to achieve these objectives, including population estimation, density analysis, and abundance studies. These methods encompassed the use of double-observer techniques to determine population abundance and demographic dynamics, the identification of factors influencing density patterns, the location of high-density habitats, and the monitoring of population trends over time. The primary goal of this study was to provide invaluable data for evidence-based conservation planning, equipping stakeholders with the information required to make informed decisions for the long-term survival of chinkara populations in the region.

Material and Methods

Description of the Study Areas

The research study was carried out in the Khuzdar (27.5758° N, 66.8082° E) and Lasbela (25.8700° N, 66.7129° E) districts of Balochistan, Pakistan, which harbor the highest biodiversity concentration in the province (Ali et al., 2012). These areas are located near the Sindh-Balochistan border, bordered in the north by district Kalat; in the east by Sindh's Malir and Karachi (West) districts; in the south by the Arabian Sea; and in the west by Gwadar and Awaran districts (Khan et al., 2020). There is a wide range of elevations in the study area, ranging from sea level to 1494 m. There are a number of rivers and streams that flow from the Moro and Pub hills, as well as the Haro and Hala ranges, on the western edge of the plain (Khan et al., 2020).

Climatic Conditions

In Khuzdar and Lasbela districts, a hot climate prevails during the summer months, and a moderate climate prevails during the winter months. During the summer months of April to October, June is the hottest month, with an average temperature of 32°C (Time and date, 2023), and during the winter months of November to March, January is the coldest, with an average temperature of 19°C (Time and date, 2023). The majority of rainfall occurs between July and August during the monsoon season, with an average annual rainfall of 3.4 mm (Fund, 2015).

Major Flora and Fauna of the Study Areas

The key tree species in the landscape are *Olea ferrugenia, Prosopis cineraria, Zizyphus mauritiana, Caparis aphyla, Salvadora oleoides, Acacia nilotica,* and shrubs, i.e., *Nannorrhops ritchiana, Rhazya stricta, Euphorbia nerifolia, Euphorbia caducifolia, Seddera latifolia, Zizyphus nummularia,* and *Salsola iberica*. The grass species encompass *Ochthochloa compressa, Lasiurus scindicus, Indigofera oblongifolia, Cymbopogon jwarancusa, Lepidium draba,* and *Euphorbia caduucifolia* (Schaller, 1977). A diverse range of fauna, such as gray wolf (*Canis lupus*), hill fox (*Vulpes vulpes grifithii*), Asiatic jackal (*Canis aureus*), striped hyena (*Hyaena hyaena*), cape hare (*Lepus capensis*), porcupine (*Hystrix indica*), hedgehog (*Hemiechinus auritus megalotis*), Sindh ibex (*Capra aegagrus*), Afghan urial (*Ovis vignei cycloceros*), Chinkara (*Gazella benetti*), desert cat (*Felis silvestris*), and bush rat (*Golunda ellioti)* are reported from the area (Ghalib et al., 2007).

Data Collection

A double-observer method using line transect survey techniques were applied over a four-year period (2019–2022) to investigate the population trend of chinkara. In order to make the

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2201_555567

survey easier to access, the two districts were divided into smaller blocks (union councils) so that the entire area could be covered (*Figure 1*). The survey blocks were supervised by two observers, OB1 and OB2. Both observers followed the same route, but OB2 started 30 minutes later (Tumursukh et al., 2016). The detail of line transects are given in *Table 1*.

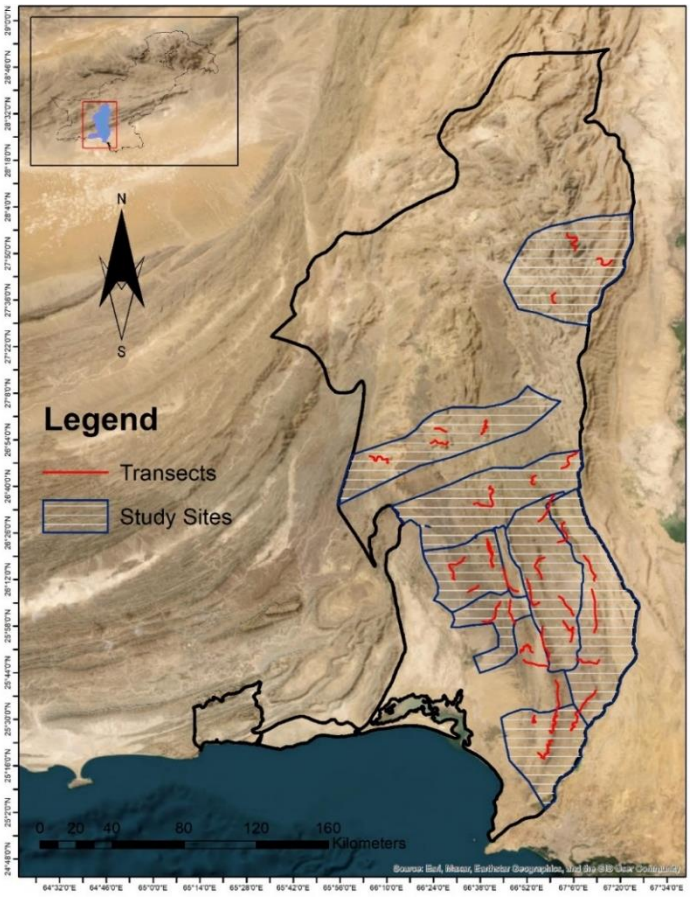

Figure 1. *Map of study area shows the transects and the study blocks where the double observer survey was carried out*

Table 1. *Survey Transects and Habitat Characteristics in the Study Area*

S.no	Survey transects	Species	Latitudes	Longitudes	Elevation (ft)	Transect (km)
1	Sajj	Chinkara	26.02137	66.78889	1525	13.9
2	Kareji	Chinkara	25.78792	67.17968	1198	13.8
3	Zarro	Chinkara	25.92611	67.09383	1235	17.2
4	Kangori	Chinkara	26.05138	67.08284	1502	13.9
5	Karawal	Chinkara	26.57129	66.97836	2968	16.8
6	Barki	Chinkara	26.24387	67.18981	2011	15.7

During surveying chinkara, observers used binoculars (08 x 42 WP Field 7.0, SICONG), spotting scopes (20 x 60 Swarovski), 20x zoom lens Canon cameras, and a GPS device (Garmin ETrex 30x). A binocular and spotting scope were used to scan the area every 200 metres for chinkara. Mountain ungulates are challenging to identify based on their coat pattern, however, they can be identified on their herd size, herd composition,

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herd sighting location, time of herd sighting, etc. (Khanal et al., 2020). After spotting a herd, the first step was to count the animals and categorize them into male, females, and young ones on the basis of their horns and body size. Horns are present in both sexes; however, they are smaller in females. They are completely ringed in male and remain throughout the life. The horns of the male appear almost straight when seen from the front; in profile they take a slightly S-shaped curve. Each horn of the male has 15 to 25 rings. Horns of the female animals are ring less and are straight smooth spikes (Dookia and Goyal, 2007). Males were further classified into four different age classes; Class I (0 – 2.5 years), Class II (2.5 – 3.5), Class III (3.5 – 4.5), and Class IV (> 4.5) (Schaller, 1977). GPS was also used to detect the locations of chinkara. At the end of the day, both sets of observers cross-tally their data using herd sighting location, composition, time, and unique characteristics, such as male-only herds, to verify unique and common herds and avoid double-counting (Khanal et al., 2020). Datasets were removed if there were any instances of double counting. The methodology was followed as explained by Masood (2011) and Khanyari et al. (2021).

Statistical Analysis

The data from each study, gathered through a double-observer survey, were organized using a capture–mark–recapture framework. Three different codes were employed based on the sightings of chinkara herds: '11' indicated a herd seen by both observers, '10' for observer A, and '01' for observer B. To estimate the chinkara population, we employed a Bayesian behavioral capture–recapture model, utilizing the BBRecapture package in R software (Team, 2010). Our approach for estimating the number of chinkara groups, mean group size, total population, confidence intervals (CIs), and detection probability for both observers followed the methods outlined by Suryawanshi et al. (2021a) and Khanyari et al. (2021). To determine chinkara density we divided the estimated population by the total area of the site.

Results

Observational Analysis

In the current study, chinkara herds were observed in six different blocks (Sajj, Kareji, Zarro, Kangori, Karawal and Barki). The species were sighted at elevation ranges from 1198 – 2968 feet above sea level along the transects (*Table 1*). The same blocks were surveyed for the period of four years (2019 – 2022) with a total effort of 365.24 km (Transects). The estimated number of chinkara groups were 155.21, 178.47, 161.12 and 161.12 with a mean group size of 6.24, 5.96, 6.56 and 5.51 in 2019, 2020, 2021 and 2022 respectively. The numbers of chinkara groups observed by OB1, OB2, and both observers are shown in *Table 2*. The detection probabilities for both Observer-1 and Observer-2 were 0.308 to 0.346, and 0.295 to 0.327, respectively.

Density and Population Dynamics

A significant decrease in population was observed in four years as shown in *Table 2*. The density calculated was 0.021, 0.024, 0.023 and 0.019 per square kilometer in 2019, 2020, 2021 and 2022, respectively. In 2019, total of 700 chinkaras were counted which consist of 300 males, 320 females, and 80 juveniles having male-to-female of 1:1.067. In 2020 the population was 683, including 263 males, 340 females, and 80 juveniles having

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2201_555567

male-to-female ratio of 1:1.293. In 2021, we observed 613 chinkaras, with 253 males, 270 females, and 90 juveniles having male-to-female ratio of 1:1.067. In 2022, a total of 583 chinkaras were spotted, consisting of 253 males, 255 females, and 75 juveniles having male-to-female ratio of a 1:1.008 (*Figure 2*, *Table 3*).

Table 2. *Estimated population of chinkara based on a multi-year study conducted from 2019 to 2022 in different study sites using the double-observer technique*

Variable	2019	2020	2021	2022
Group sighted by observer 1	18	18	16	16
Group sighted by observer 2	37	43	35	35
Group sighted by both observer 1 & 2	34	36	36	36
Estimated No of groups	155.21	178.47	161.12	161.12
Mean Group size	6.24	5.96	6.56	5.51
Estimated Population	968	1063	1057	887
Variance in mean group size	0.02	0.02	0.02	0.03
Variance in estimated no of groups	517.14	731.12	667.54	667.54
Variance in estimated population	20650.8	26526	29265.6	20945
95% confidence interval	285.28	323.32	339.61	312.88
Detection probability of observer 1	0.346	0.333	0.308	0.308
Detection probability of observer 2	0.327	0.295	0.314	0.314

Figure 2. *Photographic records of chinkara from the study area*

Table 3. *Sex ratio and fecundity in chinkara population in Balochistan*

Period	Species	Number of seen				Ratio
		Adult male	Adult female	Young	Total	M-F
2019	Chinkara	300	320	80	700	1:1.067
2020	Chinkara	263	340	80	683	1:1.293
2021	Chinkara	253	270	90	613	1:1.067
2022	Chinkara	253	255	75	583	1:1.008

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2201_555567

Population Structure

A total of 2579 chinkara individuals of different classes were observed in this study (*Table 2*). From 2019 to 2022, the population structure saw consistent trends (*Figure 3*). In each of these years, adult females made the highest contribution, with percentages ranging from 43.9% to 54.67%. Conversely, Class I consistently had the lowest contribution, with percentages ranging from 2.38% to 2.98%. The overall distribution of the species in these four years are shown in *Table 4*.

Table 4. *Age groups wise distribution of chinkara population in different study sites*

Year	Classification	Barki	Kangori	Karawal	Kareji	Sajj	Zarro
2019	Male I 0 – 2.5 (years)	3.77	10.29	10.52	2.56	4.1	12.62
	Male II 2.5 – 3.5 (years)	10.37	7.35	13.68	5.12	6.8	5.825
	Male III 3.5 – 4.5 (years)	15.09	7.35	21.05	12.82	13.6	7.76
	Male IV > 4.5 (years)	19.81	10.29	20	14.1	27.39	17.47
	Adult Female	38.67	51.47	28.42	48.7	32.87	45.63
	Young	12.26	13.23	6.31	16.67	15.1	10.67
2020	Male I 0 – 2.5 (years)	7.059	6.098	7.69	2.38	7.6	4.54
	Male II 2.5 – 3.5 (years)	9.41	3.65	10.57	11.9	13.5	8.18
	Male III 3.5 – 4.5 (years)	14.2	9.75	14.4	13.09	8.47	12.727
	Male IV > 4.5 (years)	18.82	21.95	18.26	22.619	16.94	20.9
	Adult Female	40	43.9	40.38	35.71	37.28	42.7
	Young	10.59	14.63	8.65	14.29	16.1	10.9
2021	Male I 0 – 2.5 (years)	4.44	9.87	5.82	0	9.9	7.14
	Male II 2.5 – 3.5 (years)	8.88	2.46	12.62	3.33	6.9	8.03
	Male III 3.5 – 4.5 (years)	14.44	14.8	14.56	13.3	10.89	8.03
	Male IV > 4.5 (years)	25.55	19.75	15.53	13.3	19.8	16.96
	Adult Female	36.67	40.75	42.7	54.4	37.62	51.78
	Young	10	12.34	8.73	15.55	14.85	8.035
2022	Male I 0 – 2.5 (years)	4.81	2.98	4.34	0	3.797	3.45
	Male II 2.5 – 3.5 (years)	9.63	2.98	10.86	5.33	6.33	6.9
	Male III 3.5 – 4.5 (years)	15.66	11.94	15.2	13.33	8.86	9.19
	Male IV > 4.5 (years)	25.3	23.88	17.4	10.67	21.5	20.69
	Adult Female	37.35	43.28	44.56	54.67	40.5	49.42
	Young	7.22	14.9	7.6	16.67	18.98	10.34

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
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Figure 3. *Distribution of different classes on study sites in 2019-2022*

Habitat Preference

The graph presents data on group sizes of various habitats over a four-year period, specifically from 2019 to 2022. Among the habitats observed, rocky shrub land consistently had the highest number of sightings across all four years. Following rocky shrub land, the habitats with the next highest number of sightings were rocky mountains, pastureland, cliff peaks, plain rocky, and stony foothills (*Figure 4*).

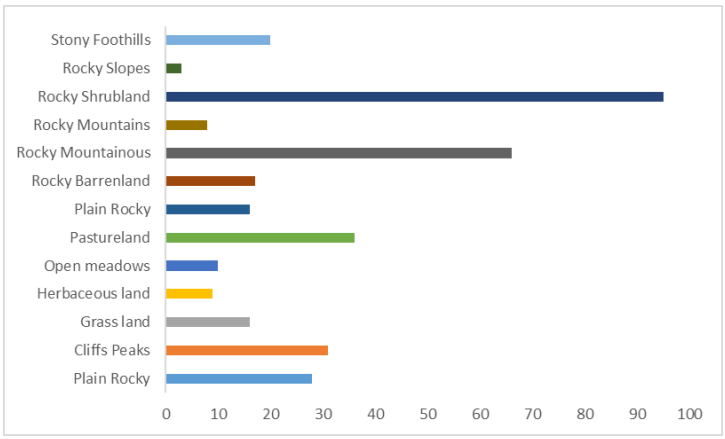

Figure 4. *Group Sizes of Chinkara in Different Habitats Over Four Years*

It is evident from the graph that the rocky shrub land habitat consistently supports a larger number of observed groups compared to the other habitats. This suggests that rocky shrub land may provide favorable conditions for group formation and survival of the studied species. However, it is important to note that the specific numerical values representing the group sizes for each habitat and year are not provided in the graph.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
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Discussion

The current research on Chinkara populations in Khuzdar and Lasbela, Balochistan, has important implications for future conservation efforts. This study provides valuable insights into the fluctuations of chinkara populations and offers a comprehensive strategy for assessing and monitoring. This strategy involves double-observer surveys and statistical modelling tools. Suryawanshi et al. (2012) standardized the double-observer survey method to estimate populations of mountain ungulates. Since then, the method has been applied successfully to estimate the populations of the blue sheep *Pseudois nayaur*, ibex *Capra ibex,* argali *Ovis ammon*, urial *Ovis vignei* and markhor *Capra falconeri* (Michel et al., 2015; Tumursukh et al., 2016; Suryawanshi et al., 2017). A recent study by Suryawanshi et al. (2021b) in the Anamalai Tiger Reserve, India, indicates that the double-observer survey method is a reliable and effective way to estimate the population of ungulates.

The current study analyzed population changes in Khuzdar and Lasbela, Balochistan, and found several factors affecting population size. These factors include habitat availability, predation, and other ecological factors. The availability and distribution of food and water and the level of predation pressure are essential external environmental factors that affect group size (Jiang, 2004). The chinkara gazelle is globally threatened and is facing severe pressure due to habitat loss at ground level (Dookia, 2009). Changes in land use patterns, a growing human population, mechanized agriculture, and local hunting practices have all contributed to the local extinction of this species in several areas (Dookia, 2009). According to the findings of Rais et al. (2010) the chinkara population in Pakistan faces various challenges. Human activities such as land conversion, overgrazing, and infrastructure development have all had a significant impact on the survival of these species by destroying and fragmenting their natural habitat.

Our results indicate variations in the male to female ratio over the years (2019 – 2022). The male to female ratio was 1:1.067, 1:1.293, 1:1.067 and 1:1.008, respectively. Previous studies, such as the one conducted by Rahmani (1990), reported a sex ratio of 1:1.3 (male to female) in Desert National Park, Jaisalmer, India. Another study by Jakher et al. (2002) found a male to female sex ratio of 1:1.41 in summer and 1:1.53 in winter in Gogelao Nagaur Rajasthan. Arshad and Hussian Gill (2010a) observed a female bias in their study, with ratios of 1.15, 1.25, and 2.33 females for every male in three consecutive surveys. Similarly, Dookia (2002) found a female bias in the sex ratio of chinkara gazelles. According to Behera et al. (2022) Chinkara populations often have a higher proportion of adult females, possibly due to social factors such as female philopatry and male dispersal. A balanced male-female ratio is essential for long-term sustainability and genetic diversity (Tainaka et al., 2006; Morán et al., 2016). It promotes healthy population dynamics and allows for successful breeding. Compagnoni et al. (2017). A skewed ratio, with either an excess of males or females, can result in lower reproductive success, increased competition for mates, and age structure imbalances (Krackow, 1995).

In the present study, the species were primarily sighted in rocky shrub land, followed by rocky mountains, pastureland, cliff peaks, plain rocky areas, and stony foothills with lower elevations, specifically up to 900 meters. The presence of chinkara depends entirely on the quality of the habitat, as good quality habitat can support large-sized groups in ungulates. This species thrives in arid to semi-arid environments and can be found in various habitats, ranging from plains to sandy regions in the scrub desert. Chinkaras were previously the most abundant wild ungulates in India's arid and semi-arid areas (Rahmani, 1990). The species is primarily habituates in the Indian subcontinent (Rahmani, 1990;

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Prakash, 1991; Kankane, 2000), with the biggest share is reported in the Rajasthan state of India and in Khyber Pakhtunkhwa Province of Pakistan (Roberts and Bernhard, 1977; Dookia et al., 2009; Mallon and Kingswood, 2019). Their distribution is now facing a drastic population decline (Jakher et al., 2002; Dookia, 2007; Dookia et al., 2009; Arshad and Hussian Gill, 2010a; Hussain et al., 2020) due to over hunting, habitat depletion, poaching, road widening projects, vehicular movement and lack of conservation awareness (Hadas et al., 2015; Gaikwad and Narwade, 2016; Hussain et al., 2020). Hunting has been identified as the most severe threat to gazelle populations, along with recent anthropogenic and climate changes (rapid human population rise, extraordinary infrastructural development, intensive agriculture). These have resulted in the fragmentation of gazelle populations throughout their habitats, raising recent worries about their conservation status and future survival (Hadas et al., 2015). According to IUCN Red Data list (2002), this species has been categorized under "Lower Risk/Conservation Dependent (LR/CD)". According to authors Roberts and Bernhard (1977) this species has been exterminated in the Pakistan sector of the Thar Desert chiefly by habitat loss. Based on Punjab Wildlife Act, they are protected animals in Punjab province but their population status is not well known (Arshad and Hussian Gill, 2010a).

The density of Chinkara were recorded 0.021, 0.024, 0.023 and 0.019 per square kilometer in 2019, 2020, 2021 and 2022, respectively. In Cholistan Game Reserve, Punjab, the estimated population density was 0.16/km^2 (Arshad and Hussian Gill, 2010a). Dookia (2009) reported that the overall estimated density was 1.089 ± 3.04/km^2 in the 12 districts of Thar Desert of Rajasthan and 1.87 ± 2.02/km^2 in Jodhpur.

Conclusion

We studied the chinkara population in Khuzdar and Lasbela, Balochistan and has found a periodic decreases in the population and herd size of the species. As this was the baseline study in the area which concluded multiple factors involved in the decline of species population. As a result of these factors, habitat quality has declined, food resources have become scarcer, predation pressure has increased, disease outbreaks have occurred, hunting restrictions have been imposed, habitat fragmentation has increased, and reproductive success has been reduced. This change was also significantly affected by the local administration's efforts to protect and manage the chinkara population. These results highlight the ever-changing nature of the population, highlighting the need for constant monitoring and study of trends. Policymakers, researchers, and stakeholders in wildlife and demographic planning can gain useful insights from the offered data.

Author Contributions. Conceptualization, Zhang Minghai; Methodology, Najeeb Ullah and Irum Basheer; Software and Formal Analysis, Muhammad Tayyab Khan; Writing – Original Draft Preparation, Najeeb Ullah and Irum Basheer; Writing – Muhammad Rehan, Faiz Ur Rehman, Zhang Minghai; Critical review and manuscript editing Supervision, Zhang Minghai.

Funding. The research was funded by the Chinese Government Scholarship Council of China (CSC) under grant number 2018410021 through the College of Wildlife and Protected Area, Northeast Forestry University, Harbin, China.

Data Availability Statement. Data is available from the author upon request.

Conflicts of Interests. The authors declare no conflict of interests.

http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2201_555567

Ethics Statement. We followed the Balochistan Wildlife Protection Act of 1974 and pertinent international conventions for the safety of the animals under observation throughout the entire investigation. No animal was in any way threatened or hurt while the information/data was being gathered.

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http://www.aloki.hu ● ISSN 1589 1623 (Print) ● ISSN1785 0037 (Online)
DOI: http://dx.doi.org/10.15666/aeer/2201_555567