



Full Length Article

Population Estimation and Habitat Preference of Grey Francolin and Black Francolin Species in Darmalak and Darwazai Game Reserve, District Kohat, Khyber Pakhtunkhwa Province, Pakistan

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Abstract

Present research was carried out for the purpose of conservation and management of gray francolins (*Francolinus pondicerianus* J.F. Gmelin, 1789) and black francolins (*Francolinus francolinus* Linnaeus 1766), in Darmalak and Darwazai Game Reserves in Kohat, Khyber Pakhtunkhwa, Pakistan. Interviews were conducted with local residents to gather information about the current status of both species in the study area. Black Francolins were found to be stable in both game reserves, while Grey Francolins were only observed in Darwazai Game Reserves. The maximum number of Francolin species individuals were observed in winter and in the morning. The study also provided important value index data for tree, shrub, and herb species in both game reserves, and found a significant correlation between the abundance of plant species and the presence of Francolins. Francolin habitats were predominantly rangelands (63.4%), followed by forests (29.7%) and water bodies (6.9%). Black Francolins preferred herbaceous habitats, while Grey Francolins favored tree-rich environments. Despite their ecological importance, these species face threats such as uncontrolled hunting and habitat destruction. The study provides valuable insights into the habitat preferences and conservation challenges faced by Grey and Black Francolin species in the study area. The findings highlight the critical importance of implementing targeted conservation strategies, such as habitat protection, breeding programs, and public awareness campaigns, to ensure the survival and growth of these species. Regular monitoring of species populations and habitats, as well as engaging local residents in conservation initiatives, can provide valuable information about the current status of species and help build support for conservation efforts. © 2024 Friends Science Publishers

Keywords: Black francolin; Grey francolin; Game reserve; Habitat; Hunting; Population

Introduction

Grey francolin (*Francolinus pondicerianus* J.F. Gmelin, 1789) and black francolin (*Francolinus francolinus* Linnaeus 1766) is mainly found in Pakistan, Iran's south-eastern provinces, India, Bangladesh and Northern Sri Lanka. Because of its origin, it can readily live in cultivated region where it may find cover, food and nesting ground (IUCN 2010; Anwar *et al.* 2015). In Pakistan these are abundant in undisturbed tropical thorn forests and can be found in the lower hills Baluchistan province. Sand dunes deserts such as Cholistan in Bahawalpur district, are home of them. They

can be found in lower protected hills (parts of Manglot wildlife Park) around Cherat and in some portions of Kohat in the Khyber Pakhtunkhwa (KP) (Sangam Khalil and Hussain 2021). Francolin species is very important for agriculture as well as for forest ecosystem because they mostly feed on insect which help farmer in agriculture field (Mishra and Pal 2020). The Grey Francolin has remained a popular game bird on the sub-continent, and it has been hunted for food since it is a cheap source of meat for locals (Khalil and Anwar 2016). Species also use grassland, agricultural and forest land used for foods and always feeds like seeds, insects, shoots, ants and caterpillars etc.

Generally, in India, Francolins mostly use herbs, shrubs and some small trees for nesting (Khan *et al.* 2021). This species is a good biocontrol agent as it eats insects, their eggs and larvae (Khan *et al.* 2021). Grey francolin is often raised in Captivity and released for the purpose of Hunting. The meat of francolin is used for diet purposes with little cholesterol (Kumar *et al.* 2020). Due to high hunting pressure on game birds in particular game reserve, it is necessary to understand the status of francolin in game reserve (Owolabi and Akinpelu 2020). Both the Black and grey francolin are protected in the research region in Pakistan. The government issues special permits for hunting these animals for plus season in exchange for a price. Permits are normally provided during hunting season (the francolin' non-breeding season), and there is a bag limit (Khan and Mian 2013). Legal hunting may be permitted on certain days (such as holidays), however unlawful hunting is punishable by monetary fines of up to a few thousand rupees for a single bird of these francolin species (Mahmood *et al.* 2010). The cause of species loss in the area are due to hunting, free grazing, cutting of plants and increase in human population, which cause loss of habitat (Haq 2012). Plants damaged due to carelessness, illegal cutting and smuggling of valuable trees and shrubs, excessive grazing, and habitat loss. Forest conversion for agriculture purpose puts huge pressure on the vegetation and results in environmental degradation. These broader threats are particularly concerning in the context of Community Game Reserves. Community game reserves have more threats than private game reserves because community will use area according to their needs. Exotic species in the area have great impact in population decline (Dad *et al.* 2014). Community game reserve will not be managed according to wild fauna needs. It has illicit cutting, fire, exotics species etc. which will destroy the preferred habitat of francolin. The current study was conducted to evaluate the population density and habitat preference of two-francolin species; Grey and Black francolin, in light of their diminishing trend in Asia in two Game reserve (Darwazai Community Game reserve and Dermalak Private Game Reserve) Kohat, KP, Pakistan

Study area

Kohat is a division of Khyber Pakhtunkhwa, Pakistan, with medium population density. It is located at 33°35'13 N, 71°26'29 E, at a height of 1600 feet. The Kohat division is divided into three ecological zones. The winter in the northern zone are bitterly cold, the summer are brief, and the mountaintops remain snow-covered (Shinwari *et al.* 2011). Dermalak Game reserve is Private game reserve, its total area is about 9995 hectares. While Darwazai game reserve is a community game reserve and its total area is about 1000 hectares. Both game reserves have rangeland, agriculture fields and forested area. Study area having about 20–30 percent tree cover, which includes scattered vegetation of xerophytic trees. In Darwazai Game Reserve Plantation

campaign was carried out in Billion Tree Afforestation Project (BTAP) which include most of the Eucalyptus spp. Dermalak Game reserve situated in District Kohat. It is 55km away from the main city of Kohat. The reference Coordinate of the area is 71.268235 33.434212 Decimal Degrees. The elevation is 540 m above sea level is a mountain tract with a very hot weather in summer (Zaman *et al.* 2020). Maize, wheat and vegetables are cultivated here. The coordinates of Game reserve are 71.444636 N, 33.380788 E Decimal Degrees. The weather is very hot in summer. Wheat, maize and vegetables are cultivated here (Fig. 1).

Data collection

Objective 1: To achieve the first objective, two game reserves. The area of both game reserve was divided into grids (76 in Dermalak and 21 in darwazai) of 1x1 km. From these game reserves, 20 and 5 potential grids were selected from different habitats in Dermalak and Darwazai, respectively. To determine the population density of Francolins within each grid, transects of 1km trails were adopted. in every grid, we applied five transects, each measuring 200 m in length. This approach ensured comprehensive coverage of each grid. However, in some grids, we employed a different strategy by using a single transect that extended approximately 1 km. As a result, the total length of transect lines in each grid was 1 km, although the division of the transects varied from one grid to another. Data collection took place during two seasons: summer and winter. A total of 25 transect trails with a width of 30 m were examined by walking between 6:00–8:00 am in the dawn and 4:00–6:00 pm in the dusk hours in both game reserves. For the population estimation of Francolins, a total area of 60 hectares was observed. The number of birds was observed using direct sightings and call counts methods (Kumar *et al.* 2020). The GPS coordinates of the line transects were collected with the help of a Garmin GPS 64s handheld receiver, whereas visual observations were made using Olympus binoculars (20x50). Important photographs of the study sites and footprints of Francolin species were recorded using a Canon digital camera (200D). The density was calculated using the formula;

$$D = \Sigma n / 2 LW$$

Where L= Length of transect

n= Number of birds sighted.

W= width of the transect.

D= calculated density of the species.

Now

The total number of species is estimated;

Total population = Number of francolins in all the transects × Total Area of study area.

Indirect data was collected by transect method from feet marks, feathers and calls etc. in both game reserves. In transect line the calls count method was adopted. Sighting distance was also calculated and the measurements were recorded according

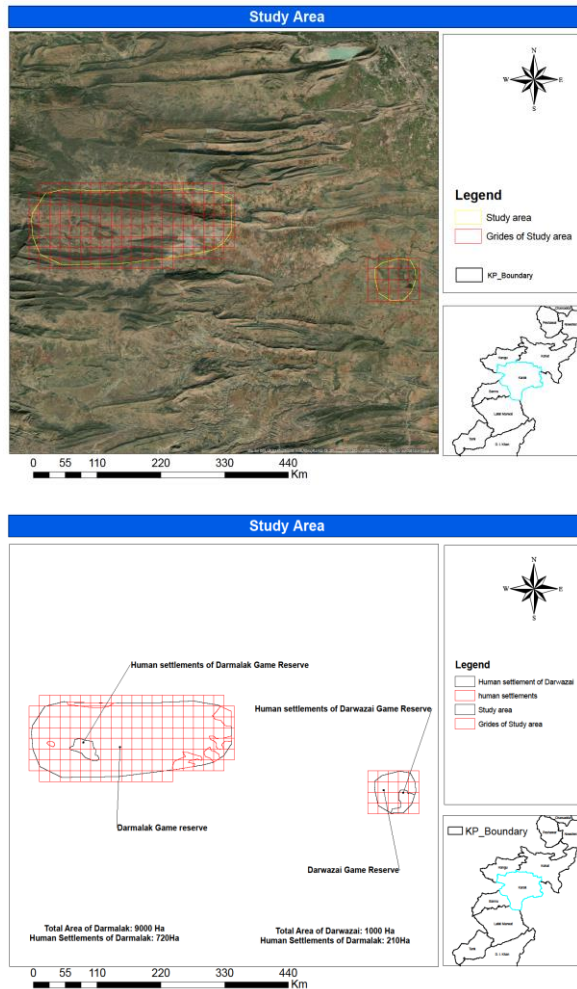


Fig. 1: Map of study area showing both Game Reserve

to the guidelines provided by (Burnham *et al.* 1980).

Objective 2: A comparison of the four different habitats (rangeland, water bodies, agricultural fields, and forests) in the study area was performed to find the preferred habitats of the Francolin species. Major plant species were collected and identified to study habitat preference. Sampling was carried out using the "quadrates method" discussed by (Schemnitz 1980). Samples were collected in different habitats by plotting quadrates at random points. Three samples were collected in each of the four different habitats, with each quadrates measuring 100 square meters for trees, 16 square m for shrubs, and 1 square meter for herbs. A total of 72 quadrates in both game reserves were plotted for trees, shrubs, and herbs. A measuring tape was used to plot the quadrates. The relative frequency, relative density, and relative dominance of herbs, shrubs, and trees were calculated in the four different habitats. The important value index (IVI) for tree species in each transect was also determined using the following formula:

$$\text{Important value index of all trees, shrub, and herb species} = (\text{RD} + \text{RF} + \text{RDo})$$

Where RD is relative density, RF is relative frequency, and RDo is relative dominance (Coroi *et al.* 2004).

In addition to conducting interviews with local residents who have francolins in their captivity or who have hunted these birds legally or illegally in the study area for a long time, a questionnaire was also administered. The questionnaire gathered information on the presence, identification, and habitat associations of gray and black francolins. To ensure the authenticity of the information, respondents were assured that their personal details would be kept confidential.

Statistical analysis

Distribution of francolin species at various points and association with transect length and widths were compared by Chi-square goodness of fit test. Data obtained were subjected to statistical analysis using Analysis of variance (ANOVA). All tests were two tailed and the significance was set at 0.05. All statistical comparison was executed in SPSS Statistical package for window.

Results

In this study Grey francolin was only observed in Darmalak Game Reserve, while Black francolin was observed in both game reserves through direct sightings and by counting their calls.

Population density of Francolin species in game reserves by direct sighting

The highest number of individuals was observed in hilly areas, with direct sightings of 0.082 individuals per hectare for Grey Francolin and 0.073 individuals per hectare for Black Francolin in Darmalak Game Reserve. In Darwazai Game Reserve, the population density for Black Francolin was 0.016 individuals per hectare, while Grey Francolin was not observed. Several factors contribute to these differences. Firstly, Darmalak Game Reserve is effectively managed under community control, while Darwazai Game Reserve lacks effective management. Secondly, Darmalak Game Reserve provides the necessary habitat for francolins, while Darwazai Game Reserve does not (Table 1).

Number of individuals recorded in winter and summer for francolin species in both game reserves during morning and evening hours

The data was collected during both winter and summer seasons. The maximum number of Francolin species individuals were observed in winter, while the minimum number of individuals were observed in summer. This decrease in population during summer can be attributed to the breeding season occurring in early summer, resulting in a lower population count. In the present study, both Grey

Table 1: Population density of grey and black francolin in Darmalak and Darwazai game reserves

Survey Sub- Locality	Transect length (km)	Transect width (Km)	Area of the Transect (Km ²)	Area in Hectares	Population of Grey francolin (Average)	Population of Black Francolin (Average)	Population density of Grey Francolin	Population density of Black Francolin
Darmalak	20	30	600	60	49.5	44	0.0825	0.073
Darwazai	5	30	150	15	0	2.5	0	0.016

and Black Francolins were mostly observed in the morning. In the Darmalak Game Reserve, 55 Black Francolins and 63 Grey Francolins were observed in the morning of the winter season, while 33 Black Francolins and 36 Grey Francolins were observed in the evening. On the other hand, in the Darwazai Game Reserve, no Grey Francolins were observed, but 3 Black Francolins were observed in the morning and 2 Black Francolins were observed in the evening during the winter season. In summer season, 20 Black Francolins and 14 Grey Francolins were observed in the morning in the Darmalak Game Reserve, while 11 Grey Francolins and 11 Black Francolins were observed in the evening. In the Darwazai Game Reserve, 2 Black Francolins were observed in the morning and 2 were observed in the evening. No Grey Francolins were observed in the morning or evening of the summer season in the Darwazai Game Reserve during the study period (Table 2).

The presence of both Francolin species in Darmalak and Darwazai Game Reserves did not show statistical significance ($\chi^2 = 2.992$, $df = 1$, $p > 0.05$), indicating that the encounter of Francolin species was equal in both game reserves. The same was true for the number of individuals encountered in Darmalak and Darwazai regions ($\chi^2 = 7.287$, $df = 7$, $p > 0.05$). There was a significant difference in the number of individuals encountered during morning and evening times ($\chi^2 = 22.631$, $df = 7$, $p < 0.05$). Francolins observed through direct visual sightings significantly differed from those observed through call record methods ($\chi^2 = 11.660$, $df = 1$, $p < 0.05$). However, the direct visual sightings of birds did not show a uniform association with the number of individuals recorded ($\chi^2 = 6.962$, $df = 7$, $p > 0.05$). The distance of direct visual sightings, measured in m, showed significant differences from the distance noted for the origin of birds' calls ($\chi^2 = 109.022$, $df = 20$, $p < 0.001$). Observations of birds' footprints also showed statistical differences from direct visual sighting patterns ($\chi^2 = 7.324$, $df = 1$, $p < 0.05$), but the association was similar for birds' call sites ($\chi^2 = 1.315$, $df = 1$, $p > 0.05$).

The habitats where Black and Grey Francolins exist showed similar associations with scattered and dense vegetation covers, respectively ($\chi^2 = 3.155$, $df = 3$, $p > 0.05$). The observations of Francolins' presence in solitary, pairs, and groups were statistically dissimilar to the observations taken for the number of individuals in a single sighting ($\chi^2 = 89.922$, $df = 21$, $p > 0.001$).

Habitat associations and observation patterns of black and grey francolins: Insights from survey

A 33.7% of the respondents observed calls on a monthly

Table 2: Number of individuals recorded in winter and summer for Francolin species in both game reserves during morning and evening hours

season	Timing	Game reserve	Black francolin	Grey francolin
Winter	Morning	Darmalak	55	63
		Darwazai	03	0
	Evening	Darmalak	33	36
		Darwazai	2	0
Summer	Morning	Darmalak	20	14
		Darwazai	2	0
	Evening	Darmalak	11	11
		Darwazai	2	0

basis, while 66.3% observed them on a seasonal basis. A 77.2% of the respondents were able to describe the habitat association of black francolins with rangelands, while 22.8% described them in agricultural land in the study area. A 70.3% of the respondents were able to describe the habitat association of grey francolins with forested areas, followed by 24.8% who described them in rangelands and 5% in agricultural lands in the study area. Grey francolins were observed by 67.3% of the respondents in groups, while 32.7% observed them in pairs in both game reserves. Black francolins were observed by 84.2% of the respondents alone, while 15.8% observed them in pairs in both game reserves. According to 87.1% of the respondents, francolin species hide themselves in vegetation cover, while 12.9% of the respondents observed that francolins are exposed in open areas. Similarly, most of the respondents (81%) are hunters, and they perform hunting for obtaining meat (61.4%) and recreational purposes (38.6%) (Table 3).

Habitat preference – Important value index of vegetation of Darmalak Game reserve habitat

In Darmalak Game Reserve, the highest important value index for tree species was found for *Acacia modesta*, followed by *Monthea*, *capparis*, *Dalbergia*, *Ziziphus*, *Acacia nilotica*, *Olea cuspidate*, and *Phoenix*. while in Darwazai Game Reserve the important value index for trees was found to be maximum for *Monthea* and minimum for *phoenix dactylifera* (Table 4).

Among the shrub species in Darmalak Game Reserve, the highest important value index was observed for *Dodonia Viscosa*, followed by *Prosopis glandulosa*. While in Darwazai game reserve the important value index was maximum for *Dodonia Viscosa* followed by *Prosopis glandulosa* (Table 5). For herbs in both game reserves, the highest important value index was found for

Table 3: Habitat associations and observation patterns of black and grey francolins: Insights from a survey in the study

Category of response	Sub-category	Frequency of response	Percent	Cumulative percent
Notice breeding calls of francolins?	No	0	0.0	0.0
	Yes	100	100.0	100.0
Observation pattern of breeding calls?	Observed monthly	34	33.7	33.7
	Observed seasonally	67	66.3	100.0
preferable feeding source for Francolins	<i>Acacia modesta</i> & <i>Triticum aestivum</i>	1	1.0	1.0
	<i>Triticum aestivum</i> only	61	60.4	60.4
	Insects	39	38.6	38.6
Habitat of Black Francolin in Darmalak and Darwazai Game reserves	Agricultural lands	23	22.8	22.8
	Rangelands	78	77.2	100.0
Habitat of grey Francolin in Darmalak and Darwazai Game reserves	Agricultural lands	5	5.0	5.0
	Rangelands	25	24.8	29.7
	Forested areas	71	70.3	100.0
Social behavior of Grey Francolins when they were observed during an encounter?	Pairs	33	32.7	32.7
	Groups	68	67.3	100.0
Social behavior of Black Francolins when they were observed during an encounter?	Pairs	16	15.8	15.8
	Groups	85	84.2	100.0
What was the social behavior of Black Francolins when they were observed during an encounter?	Pair	16	15.8	15.8
	Solitary	85	84.2	100.0
	Hidden in Vegetation	88	87.1	87.1
Most preferable region of francolin for their activities in a particular habitat?	Exposed to Open Areas	13	12.9	100.0
	Yes	82	81	87.1
Perform hunting	No	19	19	100.0
	Recreational	39	38.6	38.6
purpose of hunting	Meat	62	61.4	100.0

Saccharum spontaneum (Table 6).

The habitats of Francolin species in Darmalak and Darwazai Game Reserves exhibited a significant statistical linear correlation with the number of plant individuals ($r = 0.291$, $p < 0.001$). The linear relationship indicated a positive direction, meaning that habitats more conducive to Francolins had a higher number of plant individuals. However, correlation was found to be non-significant with nineteen plant species ($r = 0.072$, $p > 0.001$) that were recorded in the study areas.

Discussion

The human-mediated reshuffling of wildlife has raised concerns regarding the conservation of biodiversity. Globally, the population of the grey francolin is categorized as 'Least Concern' in the Red List of threatened species."(Kakakhel 2020). Present study was designed to assess the Population estimation, Habitat preference and

effect of hunting on francolin species in selected game reserves of Kohat district KP.

Mishra and Pal (2020) conducted a study on Francolin from January to December and reported the minimum population count during the pre- and post-monsoon periods (Mishra and Pal 2020). Similarly, Mann and Chaudhry (2000) estimated the population of Francolin using the call count method, and they found the highest frequency in Lal Suhanra National Park for both Black and Grey Francolin (Mann and Chaudhry 2000). There is a direct association between Francolin and seasonal factors ($p < 0.05$) and no significant difference observed between morning and evening samples of Grey Francolin species (Khan *et al.* 2021).

During the present study, maximum numbers of francolins species was observed in winter as compared to summer, this decrease in population during summer can be attributed to the breeding season occurring in early summer, resulting in a lower population count.

Table 4: Important value index of vegetation (Trees) on habitat of both Game Reserve

Trees	Game Reserve	Density/100 m ²	Frequency	Relative dominance	Important value index
<i>Dalbergia sisso</i>	Darwazai	1.5	18	1.001990532	8.395703682
	Darmalak	2.083	25	1.000840841	8.34980288
<i>Ziziphus mauritiana</i>	Darwazai	1.33	16	0.999485555	7.490157128
	Darmalak	1.5	18	1.001001001	6.105785272
<i>Phoenix dactylifera</i>	Darwazai	0.16	2	0.96191091	1.198449458
	Darmalak	0.33	4	0.990990991	1.606606607
<i>Capparis decidua</i>	Darwazai	1.66	20	0.997982569	9.272180183
	Darmalak	2.41	29	0.998239619	9.619437076
<i>Salvadora oleoides</i>	Darwazai	2.25	27	1.001990532	12.4265571
	Darmalak	2.5	30	1.001001001	9.953864121
<i>Acacia Nilotica</i>	Darwazai	0.416	5	1.000387347	2.571032188
	Darmalak	1.083	13	1.000693001	4.501674752
<i>Acacia Modesta</i>	Darwazai	2.16	26	0.998907484	11.9597241
	Darmalak	4	48	1.001001001	15.72598239
<i>olea cuspidate</i>	Darwazai	0.416	5	1.000387347	2.571032188
	Darmalak	0.41	5	0.984984985	1.918861169
<i>Monothea buxifolia</i>	Darwazai	2.5	30	1.001990532	13.77017491
	Darmalak	3	36	1.001001001	11.87790354
	Darwazai	12.392	149	8.965032807	69.65501094
Total	Darmalak	17.316	208	8.97975344	69.65991781
Mean	Darwazai	1.37	16.55	0.99	7.73
	Darmalak	1.92	23.11	0.99	7.73

Table 5: Important value index of vegetation (Shrubs) on habitat of both Game Reserve

Shrubs	Game Reserve	Density/100 m ²	Frequency	Relative dominance	Important value index
<i>Prosopis glandulosa</i>	Darmalak	0.75	9	1.021827985	13.24589434
	Darwazai	0.5	6	1	13.66666667
<i>Dodonia viscosa</i>	Darmalak	3.083	38	0.994830214	54.09299173
	Darwazai	2	24	1	53.66666667
Total	Darmalak	3.833	47	2.016658199	67.33888607
	Darwazai	2.5	30	2	67.33333333
Mean	Darmalak	1.9165	23.5	1.0083291	33.66944303
	Darwazai	1.25	15	1	33.666667

Table 6: Important value index of vegetation (Herbs) on habitat of both Game Reserve

Herbs	Game Reserve	Density/100 m ²	Frequency	Relative dominance	Important value index
<i>Calotropis procera</i>	Darmalak	0.66	8	0.992237044	5.160411241
	Darwazai	0.83	10	0.99769821	5.055256873
<i>Fagonia cretica L.</i>	Darmalak	1	12	1.00225964	7.615030692
	Darwazai	0.91	11	0.994419902	5.517908035
<i>Withania coagulans dunal</i>	Darmalak	1.5	18	1.00225964	11.25550276
	Darwazai	1.58	19	0.999596177	9.314836401
<i>peganum harmala</i>	Darmalak	1.416	17	1.001787988	11.25550276
	Darwazai	1.58	19	0.999596177	9.31483640
<i>justica adhatoda</i>	Darmalak	1.66	20	0.998250601	12.44335991
	Darwazai	1.75	21	1.00170503	10.27144438
<i>Saccharum spontaneum</i>	Darmalak	2.91	35	0.999968761	21.54511281
	Darwazai	5.083	61	1.001698461	29.20000023
Total	Darmalak	9.14	110	5.996763674	68.66558789
	Darwazai	11.7333	141	5.994713957	68.67428232
Mean	Darmalak	1.524	18.333333	0.999460612	11.44426465
	Darwazai	1.95555	23.5	0.999119	11.44571

In another study, Grey Francolin was observed mostly during the morning (46%), while 19% were observed during noon, 23% in the afternoon, and 23% in the evening. (Kakakhel 2020). In 2008–2009, the average population of Grey and Black Francolin was highest during autumn and then declined from winter to spring 2009. The main reason behind this decline was the loss of vegetation during winter

and expected natural predation in Lehri Nature Park, Punjab. Similarly, the density of both Francolin species was observed to be highest in the morning compared to the evening. This can be attributed to more feeding opportunities in the morning as compared to the evening (Mahmood et al. 2010).

Our findings indicate that both Black and Grey

Francolins exhibit higher activity levels in the morning compared to the evening. This is likely attributed to the increased availability of feeding opportunities during the morning hours and the cooler temperatures. Similarly, the absence of Grey Francolins in the Darwazai Game Reserve during both winter and summer seasons is consistent with the concerns raised in the literature about habitat quality and management practices in community-controlled reserves, which may lead to the absence of suitable wildlife habitats.

In the current study, the feeding sources of Francolin species were reported as *Triticum aestivum*, insects, and *Acacia modesta*, with respondents indicating the eradication of *Pennisetum glaucum* and the negative impact of Zea mays on the population of Francolin species in the study area. This aligns with previous studies that have highlighted the omnivorous nature of Grey Francolins, which rely on fruits, tubers, seeds, leaves, shoots, flowers, insects, and worms as part of their diet (Madge *et al.* 2002). The dietary habits of Grey Francolins in Lal Suhanra National Park, Pakistan, were reported to consist of ground-picking seeds, insects, and leaves, reflecting a varied diet similar to the findings of the present study. a, the main sources of food for Black Francolins in the grasslands of Mang Game Reserve, Haripur, were reported to include seeds, shoots, caterpillars, bugs, ants, and aphids, further supporting the diverse dietary preferences of Francolin species (Shahriari 2009; Mahmood *et al.* 2010; Khan and Mian 2012). Similarly, seeds, shoots, caterpillars, bugs, ants, and aphids are the main sources of food for black francolin in the grasslands of Mang Game Reserve, Haripur (Shahriari 2009; Mahmood *et al.* 2010).

The population of grey francolin was higher in areas with lower vegetation cover (10.08 ± 2.12 birds per km^2) compared to areas with higher cover (4.66 ± 0.96 birds per km^2). No francolins were found in areas with less than 8% cover (Khan 2010). A study conducted by Kakakhel (2020) revealed that grey francolin preferred wood ravines the most (46%), followed by agricultural fields (17%) and shrub lands (26%). In the present study, it was found that both francolins' species preferred rangelands habitat followed by forested areas and water bodies. In the current study, the habitat associations of Black Francolins with rangelands and agricultural land, and Grey Francolins with forested areas, were reported through survey, reflecting the species' preference for specific habitats in the study area. This aligns with previous research that highlighted the association of Grey Francolins with wood ravines, agricultural fields, and shrub lands, and Black Francolins with herbaceous species, shrub habitats, and tree species, indicating the diverse habitat preferences of these species (Khan 2010). The observed population density of Francolin species in the Darmalak and Darwazai Game Reserves, with a higher density in Darmalak, is consistent with previous studies that reported variations in population density based on habitat characteristics and vegetation cover.

The observed territorial behavior, with both Grey and Black Francolins emitting breeding calls, is consistent with

earlier studies conducted by Mann and Chaudhry (2000), that reported territorial behavior and vocalizations in these species. Additionally, the study's findings of a higher frequency of breeding calls in the study area resonate with previous research that indicated the territorial behavior of Francolin species through vocalizations. These findings contribute to a better understanding of the habitat preferences, territorial behavior, and population fluctuations of Grey and Black Francolins, emphasizing the importance of habitat preservation and conservation efforts for these species. Hunting is also a major concern for the population of francolin species. People usually engage in illegal hunting of francolins for recreational purposes and meat (Mahmood *et al.* 2010).

The findings from the present study indicate a decline in the population of both Grey and Black Francolin species in the Darmalak and Darwazai Game Reserves. The study highlights the prevalence of illegal hunting of francolins for recreational and meat purposes, with a majority of respondents reporting hunting activities. The highest number of hunting and poaching cases were observed between October and December, further emphasizing the threat posed by illegal hunting to the francolin populations. Additionally, the presence of a significant number of Grey and Black Francolins in captivity raises concerns about the impact of human activities on the wild populations.

Conclusion

The study found that both Grey and Black Francolin species prefer habitats with scattered and dense vegetation. Black Francolins prefer herbaceous habitats, while Grey Francolins tend to prefer tree-rich environments. The population of Francolin species in the community Game Reserve was found to be declining due to inadequate management, hunting, and habitat loss. The study provides valuable insights into the habitat preferences and conservation challenges faced by Grey and Black Francolin species in the study area. To safeguard their populations, targeted conservation strategies such as habitat protection, breeding programs, and public awareness campaigns should be implemented. Regular monitoring of species populations and habitats can help identify areas where conservation efforts are needed and track the effectiveness of implemented measures. Engaging local residents in conservation initiatives can provide valuable information about the current status of species and help build support for conservation efforts.

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Author Contributions

Muhammad Tayyab Khan and Najeebullah Field survey, Data Collection and Methodology; Faiz Ur Rahman Data write a manuscript; Data analysis was performed by Muhammad Zarkish Tariq; Muhammad Ilyas and Sultan Muhammad Provide accessibility to study area and review manuscript; Sajida Noureen supervised the research and approved the manuscript for submission.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability

Data will be provided upon request to the corresponding author.

Competing Interests

“The authors have declared that there is no conflict of interest regarding the publication of this article”.

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Not Applicable

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