A Comparative Study on the Populations and Habitats of the Grey Francolin *Francolinus pondicerianus* and the Black Francolin *Francolinus francolinus* in Lehri Nature Park, Punjab, Pakistan

SAJID MAHMOOD[1], TARIQ MAHMOOD[1*], MUHAMMAD RAIS[1], IRFAN ZIA QURESHI[2] & MUHAMMAD SAJID NADEEM[3]

1. Department of Wildlife Management, PMAS Arid Agriculture University Rawalpindi 46300, PAKISTAN.

2. Department of Animal Sciences, Quaid-I-Azam University Islamabad, PAKISTAN

3. Department of Zoology, PMAS Arid Agriculture University Rawalpindi, 46300, PAKISTAN.

** Correspondence Author. Email: tariqjanjua75@uaar.edu.pk*

Received 28 April 2010; accepted 7 September 2010

Abstract: The population and habitat preferences of the Grey Francolin *Francolinus pondicerianus* and Black Francolin *Francolinus francolinus* were studied in three different habitats in Lehri Nature Park, Jhelum, Pakistan. The populations of the two species were estimated using direct (Line transect method) and indirect methods ("calls" of the two species). Data were collected monthly from September 2008 to July 2009. The results showed average population densities of 0.47±0.09/ha and 0.06±0.01/ha for Grey and Black Francolin, respectively. A noticeably higher population was found in the morning compared to that of the evening. Maximum densities at both morning and evening were found in October 2008 with significant differences (P<0.01). Maximum seasonal populations were recorded during autumn 2008 - 0.76±0.26/ha and 0.07±0.02/ha for Grey and Black Francolins, respectively. For an assessment of the habitat preferences of the two species, relative density, relative frequency and relative dominance were calculated for trees, shrubs and herbs species in the three selected habitats. The Importance Value Index (IVI) for tree species was also determined. The most preferred habitat of Grey Francolin was habitat-II having maximum IVI for trees (31.18) and maximum frequency of shrubs (52.5) while for Black Francolin, Habitat-III was most preferred, having maximum frequency of herbs and shrubs (36 and 37.3, respectively).

Keywords: Black Francolin, density, Grey Francolin, habitat, Pakistan, population.

INTRODUCTION

The Grey Francolin and the Black Francolin belong to the group "Francolin" which comprises 21 species (Cramp & Simmons 1980) and which has a worldwide distribution. The Grey Francolin *Francolinus pondicerianus* occurs in southeastern Iran and Pakistan, India to Bangladesh and northern Sri Lanka. It was introduced to northern Oman, the Hawaiian island in the Pacific Ocean and also on several islands in the Indian Ocean including the Seychelles and Mauritius. An attempt was also made to introduce it in the USA, but sustainable populations are not confirmed (BirdLife International 2009). The Black Francolin *Francolinus francolinus* is one of the few francolins (including Grey Francolin) to have its range outside Africa. It is a resident breeder in Cyprus and southeastern Turkey eastwards through Iran to southwest Turkmenistan and northeast India, Kashmir. In the past its range was more extensive, but over-hunting has reduced its distribution and numbers. A few populations of this species also persist in the USA. In Europe it occurs in Cyprus and the Caspian region; once occurred in southern Europe west into Spain but has now been re-established in central Italy (Johnsgard 1988, BirdLife International 2009).

In Pakistan five partridge species are found; the Chukar Partridge *Alectoris chukar*, the Snow Partridge *Lerwa lerwa*, the See-See Partridge *Ammoperdix griseogularis*, the Grey Partridge *Francolinus pondicerianus* and the Black Partridge *Francolinus francolinus* occur (Roberts, 1991). The formerly called Grey Partridge is nowadays known as Grey Francolin to distinguish it from the European Grey Partridge *Perdix perdix* and is a species found in the plains and drier parts of South Asia. Both Grey and Black Francolin are distributed widely throughout Pakistan; they are found in the Indus plains, plentiful in undisturbed tropical thorn forests and occur throughout lower hills of Makran and Lasbela in Balochistan Province. They can be encountered in sand dune deserts like Cholistan in Bahawalpur district. They also occur on the Potohar Plateau and in the Salt Range in Punjab Province. In the Khyber Pakhtoonkhawah province (NWFP), they are found in lower protected hills (part of Manglot Wildlife Park) around Cherat and in some parts of Kohat (Roberts 1991).

The Grey Francolin is slightly larger in size than the Black Francolin (del Hoyo *et al.* 1994). It is associated with shrub land, savannas, and coastal Kiawe *Prosopis juliflora* forest (having thorny trees of the legume family) in dry and low elevation areas; often seen on well-watered or human altered environment. It is also frequently seen along roadsides at dawn or dusk (Scott *et al.* 1986, Pratt *et al.* 1987).

The Grey Francolin mostly occurs along permanent water sources during late summer and fall, and is also attracted to available water resources especially during drought conditions (Roberts 1991). It roosts at night and rests during the daylights, primarily on the ground in dense cover consisting of tamarisk thickets; reeds grass clumps and cultivated crops (such as wheat, barley, cotton, mustard, sugarcane and legumes) generally near water. It lives singly or in scattered pairs and parties of 3–5 individuals. The Black Francolin is found in various ecological zones of Pakistan (Ali & Ripley 1961); well adopted in vegetated, grassy, irrigated plantations, cultivated fields and in scrub and juniper forests (Charalambides 1994). It is the most preferred game bird and is thus the rarest of all the francolin species in Pakistan.

The Grey Francolin feeds chiefly in the morning and evening; however, it may feed continuously throughout the day to some extent, especially during winter (Gould 1966). Its daily movements are quite limited but are chiefly concerned with securing food, resting and taking dustbaths. In autumn and winter, movements of the coveys are apparently more restricted to definite territories, where grains or weed seeds, succulent vegetation and grits are available. Shortage of any of these necessities will cause the coveys to move farther away (Roberts 1991). The Black Francolin feeds mainly on insects and is considered as “a friend of farmers”. Its usual diet includes seeds, shoots, insects, especially caterpillars, beetles, bugs, ants and aphids (Ali & Ripley 1969).

In Pakistan, both the Grey and Black Francolins are protected in the study area under Punjab Wildlife Acts and Rules 1974. They fall in Schedule-I of the act, which contains all the game birds including 22 species of ducks, partridges like Chukar, Grey and Black Francolins and so on. Special permits are issued for a particular season by the Government on payment of a specific fee for hunting these species. The permits are usually issued from November to mid-January (the non-breeding season of the francolins) and there is also a bag limit (6 birds per day for Chukar, 5 birds per day for both Grey and Black Francolins). Legal hunting may also be allowed for specific days (such as holidays) while illegal hunting is penalized by financial fines which may be up to few thousands rupees for one bird of these francolin species (Shafiq 2005).

In Asia, populations of both these francolin species are on the verge of decline, for which various factors have been speculated such as the loss of food, excessive predation, hunting and habitat destruction as well as too much use of guns for hunting (Roberts 1991). Unfortunately, very few studies address the various aspects of francolins found in different parts of the country. In view of their declining trend in Asia, the current study was designed to estimate the population size of these two Francolin species; Grey Francolin and Black

Francolin, in Lehri Nature Park, Jhelum, Punjab Province, Pakistan.

STUDY AREA

The present study was conducted in Lehri Nature Park (33º09'N, 73º53'E, 7006.32 ha) about 10 km north of Dina Town, Jhelum District of Punjab Province (Fig. 1). The Grand Trunk (GT) Road from Lahore to Islamabad serves as a boundary of the park in the south. The northern edge is at the Mangla Reservoir, while its east and west boundaries are close to the Mangla Cantonment and Lehri village, respectively. This park consists of somewhat steep and rugged mountains ranging from 250 to 1,025 m above sea level and forms the most eastern part of the Salt Range in Pakistan (WWF 2006).

Preliminary surveys were conducted in the study area to locate the potential habitats of the two species. The surveys indicated one core area of the park intersected throughout by a pathway leading from the south side (Jindi village) to the north side up to the Mangla Cantonment. The path was about ten metres in width and it was selected as one of the line transects for estimating the population of the two francolin species. The observations were recorded on either side of the ten-metre wide transect by measuring the perpendicular sighting distance when flushing the birds (see next section for details). Overall, three different line transects were established in the study area, depending upon the different habitats of the park. Transect I consisted of wild area with wetland as a water resource (Fig. 2), Transect II contained purely natural wild area Fig. 3), while Transect III consisted of wild area with some agricultural fields (Fig. 4). Each transect was one kilometre in length with variable width.

Figure 1. A map showing area and boundary of Lehri Nature Park, District Jhelum, Punjab, Pakistan.

Figure 2. Transect-I showing wild area with wet land.

Figure 3. Transect-II showing purely wild habitat available to the two Francolin species.

Figure 4. Transect-III, showing wild area with croplands.

MATERIALS AND METHODS

Population estimation

Data were collected for three consecutive days every month, both in the morning (from 05:00 to 09:00 hours during summer and from 06:30 to 10:30 hours during winter) and the evening (from 16:00 to 19:00 hours during summer and from 15:00 to 18:00 hours during winter). Direct as well as indirect methods were applied to estimate the population of these species in the study area. The direct method included "line transect method" essentially described by Burnham *et al.* (1980) while indirect population estimation employed the "Calls Method" as described by Spiker (1929).

In the line transect method, the sighting distance and sighting angle was calculated to assess the accuracy of the perpendicular measurements. When flushing the birds, the measurements were recorded according to the guidelines provided by Burnham *et al.* (1980). The population density was then calculated using the formula; $D= \sum n / 2 LW$, Where L= Total length of transect, n= Number of birds detected, W= Width of the transect and D= Estimated density of the species. Total populations of the two species were then calculated as: Total population = No. of Francolins in all the transects × Total Area of study site.

Habitat preference

A comparison of the three different habitats in the study area was performed in order to find the preferred habitats of the Grey and Black Francolins. For investigating the preferred habitat, major plant species were collected and identified. The vegetation sampling was carried out using the "Quadrate Method" as described by Schemnitz (1980). The quadrates were laid out randomly in various habitats. Three sampling quadrates were used in each habitat and each quadrate was 10×10m for trees, 4×4m for shrubs and 1×1m for herbs. A measuring tape was used for the layout of the quadrates. Relative density, relative frequency and relative dominance, for trees, shrubs and herbs species were calculated in the three selected habitats. The Importance Value Index (IVI) for tree species in each transect was also determined. For this purpose the following formula was used: IVI for tree species = RD + RF + RDo where RD = Relative density, RF = Relative frequency and RDo = Relative dominance (Coroi *et al.* 2004).

Statistical analysis

One way ANOVA test was used to analyze and interpret the data regarding different habitats, population densities and seasonal fluctuations in populations, while paired *t*-student test in "Origin 7.0" software was used for comparison of population densities.

RESULTS

Population density

The densities of the two francolin species were estimated in three different ways; monthly, morning and evening and according to season.

Monthly population

The density of Grey Francolin was found to be highest during October 2008 (1.29±0.44 / ha). It decreased thereafter until May 2009 (0.14±0.005/ ha). However, from June 2009 onwards, its density showed an increasing trend and during July 2009 the estimate was 0.78±0.02 / ha. The average density of the Grey Francolin during all the months of the study period was found to be 0.47±0.09 / ha (Table 1). On the other hand, the average density of Black Francolin in the same habitat was found to be much lower than that of the Grey Francolin (Table 1). It was also found to be highest during October 2008 (0.12±0.01/ ha). An inconsistent

declining trend was observed until June 2009 (0.03±0.004 / ha) when the population started to increase and in July it was 0.04±0.01 /ha. The average density of the Black Francolin during the whole study period was found to be 0.06±0.01 / ha. The *t*-test test showed a significant difference (P<0.05) between the monthly estimates of the monthly densities of the two species.

Table 1. Density estimates of Grey and Black Francolins (per hectare) in the three selected habitats of Lehri Nature Park, Jhelum, from September 2008 to July 2009.

Months	Grey Francolin	Black Francolin
Sep. 08	0.50±0.05	0.02±0.01
Oct. 08	1.29±0.44	0.12±0.01
Nov. 08	0.49±0.22	0.07±0.05
Dec. 08	0.35±0.03	0.12±0.08
Jan. 09	0.46±0.01	0.04±0.01
Feb. 09	0.34±0.07	0.08±0.03
Mar. 09	0.28±0.13	0.03±0.04
Apr. 09	0.41±0.07	0.08±0.02
May 09	0.14±0.05	0.06±0.01
Jun. 09	0.14±0.02	0.03±0.04
July. 09	0.78±0.02	0.04±0.01
Mean	**0.47±0.09**	**0.06±0.01**

*(Values expressed as Mean±S.E)

Morning and evening populations

A considerably higher population of Grey Francolin was recorded in the morning compared to that of the evening during the whole study period (Fig. 5). The average density of Grey Francolin was highest in October 2008 (1.74 and 0.85 /ha, respectively for the morning and evening). After that it showed a declining trend which continued until June 2009. After June, its population started to increase and in July it was estimated to be 0.81 and 0.75 /ha, for the morning and evening respectively. The highest density of Black Francolin in the evening was also recorded in October 2008 (0.12 /ha), while the highest density in the morning was observed in December 2009 (0.21 /ha). The population decreased thereafter until June 2009, after which it started to increase and in July 2009 it was 0.06 and 0.03 /ha for the morning and evening, respectively (Fig. 6). The students paired *t*- test showed a significant (P<0.01) difference between the average densities of the two species. However, no significant difference was found between the morning and evening populations for Grey Francolin.

Seasonal population fluctuations

During autumn 2008, the average density of Grey Francolin in all the three selected habitats was 0.76±0.26/ha. It decreased gradually through the winter (0.41±0.02/ha), spring (0.35±0.03/ha) and summer seasons (0.35±0.21/ha); while the average population during all the seasons in habitat-I was 0.43±0.10/ha (Table 2). The mean density of Black Francolin was found to be comparatively lower than that of the Grey Francolin in the same habitat. During autumn and winter it sustained a density of 0.07±0.02/ha. Thereafter, a gradual decline was noticeable during spring (0.06±0.01/ha) and also through summer 2009 (0.04±0.01/ha) (Table 2). The seasonal densities of both the Grey and Black Francolins were statistically analyzed using one-way ANOVA. There was no significant difference among the values of seasonal densities of the same species (P>0.05). However, there was a significant difference (P≤0.05) among the seasonal densities of the Grey and Black species.

Estimates of total populations of the two species

The total number of Grey Francolin in the morning in Lehri Nature Park was estimated to be 3853. while in the evening the estimate was 2803, for the whole study period. The average number of Grey Francolin both in the morning and evening was 3327.7±525.2 (Table 3). On the other hand, the total number of Black Francolin in the morning in Lehri Nature Park was 630.50 while in the evening it was 351.60 for the whole study period with a mean number of 490.41±140.1 (Table 3). The average collective population of both the species estimated was 0.549/ha. When multiplied by the total area of the park (7006.32 ha), the total population of Grey and Black Francolins was calculated to be (0.549 × 7006.32=) 3847

Habitat preference

In Habitat-I, *Acacia modesta* (IVI=39.8), *Acacia nilotica* (IVI = 28.9), *Ziziphus spina-christi* (IVI= 6.2) and *Dalbergia sissoo* (IVI = 58.1) were the major tree species. Relative density, Relative frequency, Relative dominance of shrubs in habitat-I were 1.14, 1.09, 48.00 and 6.90 respectively. Similarly Relative density, Relative frequency,

Relative dominance of herbs were 28.9, 27.6, 51.1 and 7.3, respectively (Table 4).

In Habitat-II, *Acacia modesta* (IVI= 44.9), *Acacia nilotica* (IVI= 38.0), *Ziziphus spina-christi* (IVI= 10.4) and *Dalbergia sissoo* (IVI = 14.5) were the major tree species for the francolins. Relative density, relative frequency, Relative dominance of shrubs were 1.2, 1.4, 52.5 and 7.5, respectively. Similarly, Relative density, relative frequency, Relative dominance of herbs were 23.2, 27.8, 48.9 and 7.0, respectively (Table 4).

In Habitat-III, the major tree species included *Acacia modesta* (IVI= 35.6), *Acacia nilotica* (IVI= 31.6), *Ziziphus spina-christi* (IVI= 03.4) and *Dalbergia sissoo* (IVI= 51.5). Relative density, relative frequency, Relative dominance of shrubs were 1.2, 0.7, 36 and 6.7, respectively. Similarly Relative density, relative frequency, Relative dominance of herbs were 31.3, 18.4, 37.3 and 5.7, respectively (Table 4). The most preferred habitat of Grey Francolin appeared to be Habitat-II (0.54±0.2) while the highest density of Black Francolin was recorded in Habitat-I (0.07±0.01).

Table. 2. Seasonal fluctuations in the number of individuals (per ha) of Black and Grey Francolins in three different habitats in Lehri Nature Park, District Jhelum (Values expressed as Mean±S.E (Standard Error of Mean)).

Grey Francolin					
Habitat-type	**Autumn**	**Winter**	**Spring**	**Summer**	**Mean ± S.E***
I	0.50 ± 0.05	0.36 ± .003	0.35 ± 0.07	0.14 ± 0.005	0.33 ± 0.07
II	1.30 ± 0.44	0.46 ± 0.01	0.29 ± 0.13	0.14 ± 0.020	0.54 ± 0.20
III	0.49 ± 0.22	0.41 ± 0.01	0.41 ± 0.07	0.78 ± 0.020	0.52 ± 0 .08
	0.76 ± 0.26	**0.41 ± 0.02**	**0.35 ± 0.03**	**0.35 ± 0.21**	**0.43 ± 0 .11**
Black Francolin					
I	0.03 ± .001	0.12 ± 0.080	0.08 ± 0.030	0.07 ± 0.01	0.07± 0.01
II	0.13 ± 0.01	0.05 ± 0.001	0.03 ± 0.004	0.03 ± .001	0.06± 0.02
III	0.07 ± 0.50	0.05 ± 0.001	0.09 ± 0.020	0.04 ± 0.01	0.06± 0.01
	0.07 ± 0.02	**0.07 ± 0.02**	**0.06 ± 0.01**	**0.04 ± 0.01**	**0.06 ±0.013**

Table 3. Total estimated populations of the two Francolin species in Lehri Nature Park Jhelum during the study period (Values expressed as Mean±S.E).

Francolin species	**Morning**	**Evening**	**Mean ± SE**
Grey Francolin	3853 ± 0.577	2802.3 ± 1.09	3327.7 ± 525.2
Black Francolin	630.5 ± 0.577	351.60 ± 1.98	490.41 ± 140.1

Table 4. Different species of trees, shrubs and herbs in the three selected Habitats of Lehri Nature Park Jhelum from September 2008 to July 2009. D = Density, RD = Relative Density, F = Frequency, RF = Relative Frequency, RDo = Relative Dominance, IVI = Importance Value Index (IVI = RD + RF + RDo).

Scientific name		**Habitat-I**				
Trees	**D /10 m^2**	**RD**	**F**	**RF**	**RDo**	**IVI**
Acacia modesta	2.8	2.7	80	11.5	25.6	39.8
Acacia nilotica	3.2	3.1	60	8.6	17.2	28.9
Ziziphus spina-christi	0.6	0.6	20	2.8	2.8	6.2
Dalbergia sissoo	3.8	3.6	80	11.5	43.0	58.1
Eucalyptus camaldulensis	0.8	0.8	60	8.6	11.3	21.7
Mean						**30.7**
Shrubs	**D/4m^2**					
Radia tetraspermia	0.9	0.9	60	7.6		
Typha angusta	1.2	1.1	40	5.8		
Ostostegia limbata	0.8	0.8	30	4.3		
Dodonia viscose	1.2	1.1	60	8.6		
Adhatoda vesica	1.6	1.5	50	7.2		
Mean	**1.14**	**1.09**	**48.00**	**6.90**		
Herbs	**D/m^2**					
Desmotachya bipinata	29.8	28.7	53.3	7.6		
Cynodon dactylon	30.1	29.0	53.3	7.6		
Cinchrus ciliarus	26.8	25.8	46.6	6.7		
Mean	**28.9**	**27.6**	**51.1**	**7.3**		
		HABITAT-II				
Trees	**D /10 m^2**					
Acacia modesta	3.2	3.8	80	11.4	32.7	44.9
Acacia nilotica	2.2	2.6	80	11.4	24.0	38.0
Ziziphus spina-christi	0.6	0.7	40	5.7	4.0	10.4
Dalbergia sissoo	1.2	1.4	80	11.4	1.7	14.5
Eucalyptus camaldulensis	1.6	1.9	60	8.6	37.6	48.1
Mean						**31.2**
Shrubs	**D/4m^2**					
Adhatoda vesica	1.3	1.6	70	10.0		
Radia tetraspermia	1.1	1.3	50	7.2		
Ostostegia limbata	1.2	1.4	40	5.7		
Dodonia viscose	1.2	1.4	50	7.2		
Mean	**1.2**	**1.4**		**7.5**		
Herbs	**D/m^2**					
Desmotachya bipinata	21.9	26.3	40	5.7		
Cynodon dactylon	37.1	44.5	60	8.6		
Cinchrus ciliarus	10.6	12.7	46	6.6		
Mean	**23.2**	**27.8**	**49**	**7.0**		
		HABITAT-III				
Trees	**D /10 m^2**					
Acacia modesta	1.6	0.9	60	9.2	25.5	35.6
Acacia nilotica	3.2	1.8	80	12.3	17.5	31.6
Ziziphus spina-christi	0.2	0.1	20	3.0	0.3	3.4
Dalbergia sissoo	1.6	0.9	80	12.3	38.3	51.5
Eucalyptus camaldulensis	0.6	0.3	40	6.1	17.9	24.4
Mean						**29.3**
Shrubs	**D/4m^2**					
Adhatoda vesica	1.1	0.6	60	9.2		
Radia tetraspermia	0.1	0.6	40	12.3		
Ostostegia limbata	0.7	0.4	20	3.0		
Dodonia viscose	1.3	0.7	50	7.7		
Calotropis procera	1.9	1.1	10	1.5		
Mean	**1.2**	**0.7**	**36**	**6.7**		
Herbs	**D/m^2**					
Desmotachya bipinata	14.3	8.2	27	4.1		
Cynodon dactylon	28.8	18.8	60	9.2		
Parthenium hysterophorus	5.6	3.2	20	3.0		
Cinchrus ciliarus	15.2	8.7	33	5.1		
Triticum aestivum	93	53.4	46	7.2		
Mean	**31.3**	**18.4**	**37.3**	**5.7**		

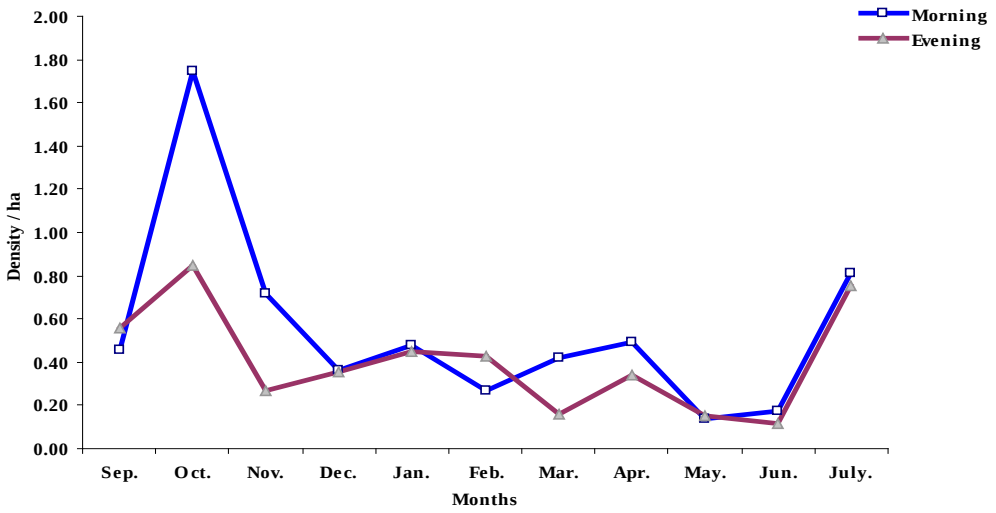

Figure 5. Average density of Grey Francolin (per hec.) in the morning and evening in the three selected habitats of study area from September 2008 to July 2009.

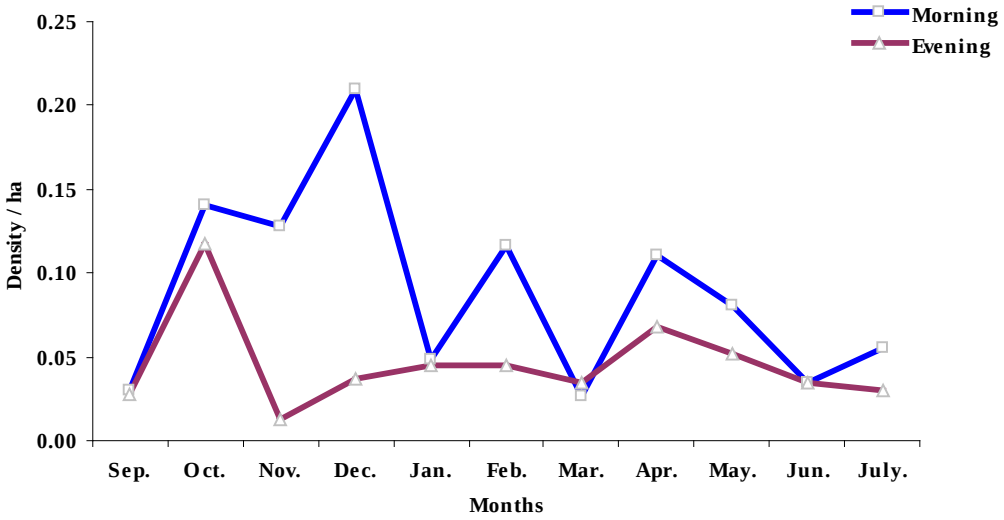

Figure 6. Average density of Black Francolin (per ha) in the morning and evening in the three selected habitats of study area from September 2008 to July 2009.

DISCUSSION

The results of population estimates of the current study have shown that the Grey Francolin is generally more abundant in the study area as compared to the Black Francolin. The highest densities of both the species during the study period were recorded in the month of October. The normal trend seems to be that a decline in populations of both the francolin species is observed from November until the following June. But in July the populations of both the francolin species start increasing substantially. This increase in population is the result of the breeding season of the francolins that has just finished. This fact is supported by the studies of Khan (1987) who demonstrated that the breeding season of francolins occurs from February to June every year in this part of the world, during which they are mostly seen in pairs and afterwards live in groups.. Therefore, in summer 2009, when suitable environmental conditions prevailed and plenty of resources were available for the new generation to exploit, the population flourished automatically. These results are further supported by the studies of various researchers who have shown that primary factors governing the abundance of francolins operate during the period of reproduction and breeding season (Twomey

1936, Cahn 1938, MacCabe & Hawkins 1946, John 1973).

The average density of Grey Francolin throughout the year estimated in the study area was 0.50±0.09/ha. The past published literature shows different density estimates for partridge species; Hunt (1974) estimated 0.54/ha partridges in Saskatchewan. Mendel & Peterson (1980) estimated 0.84/ha Grey Partridge *Perdix* sp. in Idaho, Ratti *et al.* (1983) reported 0.48/ha Grey Partridges in South Dakota while Rotella *et al.* (1996) reported 0.29 /ha Grey Partridge *Perdix perdix* in eastern Washington.

The population of the Grey Francolin in the current study during the morning was to be found higher than that in the evening. Rotella & Ratti (1987) recorded more calls of Grey Partridges as well as more calling groups during morning surveys than that in the evening during winter and summer seasons. Average seasonal populations of both the species in the study area were at their maximum number during autumn 2008 after which a progressive decline occurred from the start of winter until spring 2009. This fact could be attributed to two main factors; loss of cover due to severe winter conditions and expected natural predation. During autumn 2008, the density of Grey as well as Black Francolin was considerably higher in the morning than in the evening. This might be a result of appropriate environmental conditions and the availability of relatively more feeding opportunities in the morning (Figs. 6–7). According to Rotella & Ratti (1986), early morning call counts of Grey Partridges give a more reliable index to density than evening call counts. Therefore it would seem that early morning call counts for Grey Francolin may be a more appropriate method of monitoring its population.

The average estimated density of Black Francolin was found to be highest during October 2008 (0.12±0.01/ha). An invariable declining trend was observed until June 2009 (0.03±0.004/ha), when it started increasing rapidly and in July it was 0.04±0.01/ha. However, the average density of Black Francolin during the whole study period was 0.06±0.01/ha. According to Cramp & Simmons (1980) Black Francolins are seen more abundantly at wet places and are observed in pairs as well as in flocks in moist ecotonal lands. Heidari *et al.* (2009) studied the population of Black Francolin on the Sistan plain, in Iran, in relation to plant vegetation and drought. They showed that a period of long drought from 1998–2005 resulted in the decreased distribution of Black Francolin due to changes in habitat. According to their results, the population of Black Francolin was over 1,000 individuals for at least three months per year in the period 1998–1999 but in other years and in particular after 2000 there was no significant population .Maan & Chaudhry (2000) made population estimates for Black and Grey Francolins through call-counts. The density of *Francolinus francolinus* per km^2 ranged from 0.12 in Shorkot plantation to 5.81 in Lal Suhanra National Park. In sub-mountainous tract, a high density/km^2 was measured in Kala Chitta Game Reserve, Attock District, while the density of *F. pondicerianus* per km^2 ranged from 0.03 in Changa Manga to 2.35 in Lal Suhanra. A similar study was reported in Pakistan on Black Francolin by Khan *et al.* (1991) at Sandal Bar, Faisalabad District, where densities of Black Francolin were estimated to be 1.8, 0.7, 4.6 and 5.6 per hectare, in cropland, dry lands, wetland areas and cropland along the wetland, respectively. But in the current study, the density of Black Francolin has been found to be quite lower than those estimated earlier in Faisalabad region (central Punjab).

The presence of sufficient trees, shrubs and herbs is very important for the survival of francolin species in any habitat since these plant species provide all sorts of cover, including roosting sites, day time shelter as well as nesting cover. Therefore, the value of IVI for tree species and frequencies of shrubs and herbs can indicate the relative population of francolin species that might survive there. The results of the current study have revealed that a maximum average seasonal population of Grey Francolin occurred in Habitat-II (0.54±0.2) while Habitat-I had the lowest population 0.33±0.07). Habitat-II consisted of purely wild area and it had maximum values of IVI for trees (31.18) and maximum mean frequency of shrubs (52.50). These results are supported by findings of Roberts (1991), who showed that Grey Francolins roost in shrubs and low trees, often on lateral

branches away from the trunk, occasionally roosting on the ground in areas with little or no tall vegetation. Although among all the three selected habitats, there is very little difference in relative frequencies and relative densities of shrubs and herbs, the main difference lies in the values of IVI for trees. The IVI for trees is found to be at a maximum in Habitat-II and it could be the decisive factor for the Grey Francolin to prefer this habitat among all the three.

As regards the habitat preference of Black Francolin in the study area, its maximum density was associated with Habitat-I (0.07±0.01). This shows that Black Francolin prefers a slightly different habitat than that of the Grey Francolin. Habitat-I was found to have maximum frequency of herbs (51.1) among all the three selected habitats Moreover, the mean value of IVI for tree species was the second highest (30.75) in Habitat-I. These results indicate that the Black Francolin's most preferred habitat is one which contains more herbs. This may be associated with foraging behavior since Black Francolin feeds mainly on insects and is considered as "a friend of farmers". Its diet includes seeds, shoots, insects, especially caterpillars, beetles, bugs, ants and aphids (Ali & Ripley 1969). The availability of these food items especially seeds, and insects might be more on the ground than on the trees. Heidari *et al.* (2009), recorded that habitat preference of Black Francolin is correlated with the ground cover and the height of vegetation due to the fact that the Black Francolin needs to be hidden from its predators among the plants as well as to the availability as food resources. The reduction of vegetation cover decreases the population size and range distribution of Black Francolin since its range was formerly more extensive, but it decreased from 50% of the Sistan Plain in normal years to less than 20% in drought periods. According to Cramp & Simmons (1980) severe cold weather and snow could also limit the populations of Black Francolins, and drought is also another threatening factor. Some other studies also support the results of the present work; according to Liao *et al.* (2007), Common Hill Partridge *Arborophila torqueola* in Baiposhan Natural Reserve Sichuan, China, utilised sites that had greater tree cover, shrub cover and thicker defoliation layers. Similarly, Salek *et al.* (2004) suggested that higher densities of wild Grey Partridge in Prague, the Czech Republic were associated with the existence of unmanaged wasteland, herbaceous patches, and its surrounding agricultural landscape. Moreover, density estimations, home range analysis, weed seed sampling and plant composition analysis are factors influencing the habitat preference of francolins.

CONSERVATION

The study concludes that Lehri Nature Park, Jhelum, Pakistan contains a much greater population of Grey Francolin as compared to that of Black Francolin. As regards habitat preference, the two species have got a distinct preference for habitat that depends upon their requirements and to reduce the feeding niche overlap.

The study recommends that in order to maintain the populations of the Grey and Black Francolins in this park, the habitats of the area should be placed among high priority conservation measures; trees, shrubs and herb species should be maintained and tree cutting must be prohibited. Habitat conservation should be achieved by creating awareness among local people living in the vicinity of the park about the losses due to deforestation, overgrazing and habitat degradation, since all these activities ultimately affect the francolin populations in the study area. Land encroachment for the purpose of housing schemes, commercial poultry farming and other business oriented disturbances must be checked and prohibited through public awareness and strict implementation of Wildlife Acts and Rules.

Illegal hunting of the two francolin species must be strictly prevented through public awareness and also by observing and implementing the Punjab Wildlife Acts and Rules 1974. The Salt Range Protection Force present in the area has not yet been successful in protecting the wildlife of the area. It is therefore essential that this Force is made more efficient and effective in its protection activities.

Moreover, in the immediate vicinity of the Lehri Nature Park there is much environmental disturbance due to the

movement and billeting of the army troops at Mangla Cantonment area who perform their professional exercises (i.e., shooting exercises and so on) which causes stress to these two francolin species. Increased awareness among the army personnel and the residents of the surrounding area must be developed through seminars, brochures and radio programmes about the importance of the francolin species as a national asset in the park and about beauty and importance of nature in general. The students of the area can also be educated through their school programmes about wildlife conservation.

REFERENCES

Ali S. & Ripley S.D. 1961. *Handbook of the birds of India and Pakistan.* Oxford Univ. Press, New Dehli (compact edition), 737 pp.

Ali S. & Ripley S.D. 1969. *Handbook of the birds of India and Pakistan.* Vol. II. Oxford Univ. Press, New York.

Baxter E.V. & Rintoul L.J. 1953. *The birds of Scotland. Vol. II.* Oliver & Boyd, Edinburgh & London.

BirdLife International. 2009. Species factsheet: *Francolinus francolinus.* Downloaded from http://www.birdlife.org

Burnham K.P., Anderson D.R. & Laake J.L. 1980. Estimation of density from line transect sampling of biological populations. *Wildlife Monograph.* **72:** 1–202.

Cahn A.R. 1938. A climographic analysis of the problem of introducing three exotic game birds into the Tennesses valley and vicinity. *Trans. North American Wildlife* **2:** 806–817.

Charalambides M. 1994. Black Francolin. ***In:*** Tucker G.M. & Heath M.F. (Eds.), *Birds in Europe: their conservation status.* Birdlife Conservation. Ser. No. 3, Birdlife Intl. Cambridge, U.K., pp. 218–219.

Coroi M., Skeffingtonb M.S., Gillera P., Smitha C., Gormallyc M. & O'donovan G. 2004. Vegetation diversity and stand structure in streamside forests in the south of Ireland. *Forest Ecology and Management* **202**: 39–57.

Cramp S. & Simmons K.E.L. 1980. *Hand book of the birds of Europe, the Middle East and North Africa. The Birds of the Western Palearctic. Vol. II. Hawks and Bustards.* Oxford Univ. Press, New York.

del Hoyo J., Elliott A., & Sargatal J. (Eds.) 1994. *Handbook of birds of the world.* Vol. 2. New world Vultures to Guineafowl. Lynx Edicions, Barcelona.

Gould J. 1966. *Birds of Europe*. Methuen and Co. Ltd. London.

Heidari N., Arbabi T., Noori G., & Shahriari A. 2009. Distribution, population and ecology of Black Francolin *Francolinus francolinus bogdanovi* in Sistan Plain, in relation to plant coverage and drought. *Podoces* **4(1):** 28–36.

Hunt H.M. 1974. *Habitat relations and reproductive ecology of Hungarian partridge in a Hedgerow complex in Saskatchewan.* Saskatchewan Department of Tourism and Renewable Resources, Wildlife Report No. 3.

IUCN. 2006. Red List of Threatened Species. Retrieved on 11th May. Database entry includes justification for why this species is of least concern. *Trends in Ecology & Evolution* **21(2)**: 71–76.

John M.G. 1973. *Grey Partridge Ecology in south east Wisconsin*. Department of Natural Resources, Madison, Wisconsin, Technical Bulletin No. 70.

Johnsgard P.A. 1988. *The Quails, Partridges and Francolins of the World.* Oxford University Press, New Yark.

Khan A.A. 1987. Bird life of the Daphar and Pakhowal irrigated forest plantation of Punjab. Pakistan Agricultural Database, Punjab Government.,228 pp.

Khan M.S., Khan R.A & Ishaque M. 1991. Studies on the distribution and habitat preference of black partidge (*Francolinus francolinus*) in Sandal Bar..*Journal of Animal and Plant Sciences* **1(3)**:129–130

Khan S.B., Javed S. & Shah J.N. 2009. Distribution and status of Galliformes in the United Arab Emirates. *International Journal of Galliformes Conservation* **1:** 58–62.

Liao W.B., Hu J.C. & Li C. 2007. Habitat utilization during the pairing season by the Common Hill Partridge *Arborophila torqueola* in Baiposhan Natural Reserve, Sichuan, China. *Ornithological Science* **6(2)**: 87–94.

MacCabe R.A. & Hawkins A.S. 1946. The Hungarian partridge in Wisconsin. *Am. Midl. Nal.* **36(1)**: 1–75.

Mann M.A. & Chaudhry A.A. 2000. Francolins in irrigated forest plantations and sub-mountainous tract of the Punjab, Pakistan. *Pakistan Veterinary Journal* **20(3):** 118**–**122.

Mendel G.W. & Peterson S.R. 1980. Grey partridge population structure and densities on the Palouse Prairie. ***In:*** Peterson S.R. & Nelson L., Jr. (Eds), Proceedings of Perdix II: grey partidge workshop. Forestry, Wildlife, and Range Experiment Station, University of Idaho, Moscow, pp. 118**–**136.

Pratt H.D., Bruner P.L. & Berrett D.G. 1987. *A Field Guide to the Birds of Hawaii and the Tropical Pacific.* Princeton Univ. Press, Princeton, NJ.

Ratti J.T., Smith L.M., Hupp J.W. & Laake J.L. 1983. Line transect estimates of density and

the winter mortality of grey partridge. *Journal of Wildlife Management* **47**: 1088–1096.

Roberts T.J. 1991. The Birds of Pakistan. Vol. I, Oxford University Press Oxford. U.K, pp. 230–233.

Rotella J.J., Ratti J.T., Reese K.P., Taper M.L. & Dennis B. 1996. Long-term population analysis of gray partridge in eastern Washington. *Journal of Wildlife Management* **60(4):** 817–825.

Rotella J.J & Ratti J.T. 1986. Test of critical density index assumption: a case study with gray partridges. *Journal of Wildlife Management* **50(4):** 532–539.

Rotella J.J. & Ratti J.T. 1987. Seasonal variation in grey partridge vocal behavior. The Cooper Ornithological Society. *The Condor* **90**: 304 – 310.

Šálek M., Marhoul P., Pintí J., Kopecký T. & Slabý L. 2004. Importance of unmanaged wasteland patches for the grey partridge *Perdix perdix* in suburban habitats. *Acta Oecologica* **25(1-2**): 23–33.

Schemnitz D.S.1980. Wildlife Management Technique Manual. Wildlife Society, USA, Washington. pp. 147.

Scott J.M., Mountainspring S., Ramsey F.L. & Kepler C.B. 1986. *Forest Birds Communities of Hawaiian Islands: their dynamics, ecology, and conservation.* Stud. Avian Biol. no. 9. Cooper Ornithol. Soc., Allen press Inc., Lawrence, ES.

Shafiq M.M. (Comp.). 2005. *Wildlife Acts and Rules of Pakistan.* Unpublished Report. Pakistan Forest Institute, Peshawar, 297 pp.

Spiker C.J. 1929. The Hungarian Partridge in north- west Iowa. *Wilson Bull.* **41**: 24–29.

Twomey A.C. 1936. Climographic studies of certain introduced and migratory birds. *Ecology* **17(1):** 122–132.

WWF. 2006. Pakistan. Survey of the status, distribution and home range requirements of the Punjab Urial.