Distribution, Population, and Ecology of Black Francolin *Francolinus francolinus bogdanovi* on the Sistan Plain, in Relation to Plant Coverage and Drought

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Abstract: The population of Black Francolin was studied during the 2007–2008 period in Sistan Plain in relation to plant vegetation and drought. The distribution of the species was mapped for the periods of before (2000) and after the drought (2000–2008) divided into three groups of habitats. Monthly Black Francolin number in Sistan is given for the 1995–2007 period based on data obtained from Zabol Office of the Department of the Environment with a maximum number of 2,740 recorded in December 1999. Details of bird number are also given for some areas during the 2004–2007 period. Additionally plant coverage preferred by Black Francolin was studied in two areas of Niyatak Forest and Doost Muhammad Khan. A total of 33 plant species was identified in Niyatak and 28 species in Doost Muhammad Khan. The dominant plant species in spring was *Phragmites australis* in Niyatak and *Stuvvie* sp. in Doost Muhammd Khan; however *Alhaji camelorum* was the dominant species in summer and overall in both areas. Of 23 plots in Niyatak, crown cover of 30–40% and height of 50–60 cm had more birds and of 59 plots in Doost Muhammad Khan, crown cover of 20–30% and height of 20–30 cm also had more birds detected. Of 18 nests, clutch size varied from 4 to 11 eggs. Drought and illegal hunting are two main threatening factors for the Black Francolin population in Sistan Plain.

Keywords: Black Francolin, *Francolinus francolinus bogdanovi*, drought, ecology, Iran, population, Sistan, vegetation.

INTRODUCTION

In the Western Palearctic, Black Francolin *Francolinus francolinus* occurs only in the southeast at mid to lower altitudes not normally subject to severe cold. This species is resident or sedentary throughout its range, even on the Transcaucasian steppes where mortality can reach 95% in particularly severe winters (Cramp & Simmons 1980). In the Indian subcontinent, it is restricted to well-watered scrub, tamarisk and tall grass jungle. Millet and sugar cane fields in riverine or canal-irrigated country are favourite haunts, as well as tea gardens and their environs in the outer Himalayas. It enters crops to feed in the morning and evenings (Ali 2002). "It avoids open or arid steppe and desert, but sometimes occurs in reedbeds adjoining grassland" (Bannerman 1971 in Cramp & Simmons 1980).

Sistan is located in an extremely arid region, which is entirely dependent for its water resources on rivers originating in remote tributaries. Severe water shortages have destroyed the ecological system of the wetlands which is primarily based on the inflow of the Hirmand River. The worst droughts occurred in the late 1960s, mid-1980s, and between 2000 and 2008. The last exceptionally long drought destroyed the ecological system of the wetlands and caused serious damage to wildlife populations, so that nowadays the distribution of Black Francolin is more restricted than in the past and is limited to cultivated lands and green

spaces. The race *F. f. bogdanovi* (Zarudnyi 1906) of Black Francolin occurring on the Sistan Plain, Baluchestan west to Fars Province, is smaller and paler than the other races of this species. Other races occurring in Iran are *F. f. francolinus* in north-west and northern Iran and *F. f. arabistanicus* in the Zagros range, in the south-west in Khuzestan Province and east to Fars Province (Hüe & Etchécopar 1970).

The knowledge of factors affecting the conservation of a habitat and prioritising them can help the process of conserving the environment considerably. The population trend appears to be stable, and hence the species does not approach the thresholds for Vulnerable under the population trend criterion (>30% decline over ten years or three generations) (BirdLife International 2009). By contrast, the population of Black Francolin has had fluctuations, resulting from climate changes and food resources (Arbabi 2008). Today, Black Francolins are found only in farms and more thickly vegetated areas, so they need full and urgent protection (Arbabi 2008). The present paper deals with the ecology of Black Francolin and the effect of drought on distribution and population abundance as well as the relationship between crown cover and height of vegetation and Black Francolin numbers in two different farmland and forest habitats in the eastern part of Sistan.

STUDY AREAS

The Sistan Plain with a height of 400–500 m a.s.l. and an area of about 15,200 km^2, extends from 30°05'N to 31°28'N and from 60°15'E to 61°50'E and is situated in Sistan & Baluchestan Province in south-eastern Iran. This is one of the driest regions of the world. The average annual temperature is 22.7°C; the warmest month being July and the coldest month January. The annual precipitation is 59.6 mm with maximum precipitation observed in March (14.6 mm) while the evapo-transporation is more than 4.7 m, much more than precipitation. Under such conditions, life depends on the inland delta of the Helmand River originating in the mountains of the southern Hindu Kush (Afghanistan) and the associated wetland, Hamoon. This wetland covers an extensive area but it is shallow. Shallow water (less than 3 m at the highest water levels) in a very dry region with extreme high wind speeds (above 9 m/s) makes evapo-transpiration more than 300 mm annually thus making it very vulnerable to climatic fluctuations and modifications of water inflow by humans. The agricultural area is 25,861 ha. Wheat (about 50% of the area), barley, alfalfa, watermelons, melons, and grapes are the dominant crops. Some other green areas consist of rangelands (474,595 ha), natural forests (11,000 ha), and reforestation (1,633 ha). The population of Zabol, the major city of the region, is 130,642 (Noori *et al.* 2007).

In order to study the relation between Black Francolin and plant cover, Niyatak Forest was selected as representative for forest habitats and Doost Muhammad Khan for farmland habitats; both are in the eastern part of Sistan. Niyatak Forest is located between of 61°42'E to 61°38'E and 31°07'N to 30°59'N, covering an area of *c.* 11,000 ha. Doost Muhammad Khan agricultural area is located between 61°26'E to 61°50'E and 30°56'N to 31°24'N which covers an estimated area of about 16,880 ha (Anonymous 2006).

MATERIALS AND METHODS

Field surveys for population abundance and ecology were conducted in 2007 and 2008. Eighteen nests with eggs were studied and measured. Distribution maps of Black Francolin were prepared to compare its distribution before and after the drought period. The distribution in each period was mapped for three relative ranges of high, medium and less quality of habitat based on plant cover and water resources (Ghaemi 1988). Data on population of the species were provided by the Sistan & Baluchestan Provincial Office of the Department of the Environment for the period 1995–2007.

The collection of field data on plant cover was conducted once a month in the early morning during the spring and summer seasons (late March to late September) 2008, following observation of Black Francolins in their habitats. The route selected for recording observations was based on line transects and the number of the Black Francolins was recorded by the direct observation method. The length of

each transect in the Niyatak Forest was 100 meters, and in Doost Muhammad Khan 200 meters. The selected routes in Niyatak Forest and in Doost Muhammad Khan were across the longest route of the study areas. Black Francolin observation plots were different (because of the feasibility of bird observations) and ranged from 70×70 m to 100×100 m (on average 85×85 m) in Niyatak area and from 35×35 m to 60×60 m (on average 50×50 m) in the Doost Muhammad Khan area. By following the determined route, wherever Black Francolins were found a 2×2 m square plot was sampled in connection with vegetation study and some other data such as plant species and the height of each species and the crown cover were recorded. A total of 82 sampling plots (23 plots in Niyatak Forest and 59 plots in Doost Muhammad Khan) were studied during the two seasons, of which 43 plots were studied in the spring (38 plots in Doost Muhammad Khan area and 5 plots in Niyatak Forest) and 39 plots were studied in the summer (21 plots in Doost Muhammad Khan area and 18 plots in Niyatak Forest). To identify the plant species, samples were collected to be dried and identified in the botany laboratory of Sistan & Baluchestan University, Zahedan. Tables 3–5 give information about bird numbers observed in each category of frequency percentages of plant species, the percentage of crown area projection to land area (Moqaddam 1998), and the height of the dominant species (the species which occupy the greatest space where Black Francolins were observed) measured with a measuring tape (Zarei 2005).

RESULTS

Distribution

Before the drought, Black Francolins were found in almost all villages of Sistan in suitable habitats (Fig. 1a) categorized in three groups. First, high density (more than two-thirds of the crown cover) due to having dense vegetation cover such as *Tamarix* and cultivated lands near water resources such as Chah-Nimeh (namely Ghorghori, Zabol, Emamiye, Bonjar, Niyatak forest, the border of Shirdel river and Zahak, Kohak). Second, medium density (between one-thirds and two-thirds of the crown cover) because of reed-beds and lack of suitable vegetation areas (*i..e.* Khammar village, Kaftargi, Ghalae-Now, Aliabad-e Seyyed). Third, low density (less than one-thirds of the crown cover) because of the lack of sufficient water resources and therefore, poor vegetation cover and suitable habitats (namely Hamoon-e-Sabari, Gazanguri, Adimi, Mile-e Nader, Kuh-e Khajeh mountain, Songol and Shile enterance). The population resident in higher patches of the bed of Hamoon-e Sabari is locally called *Takhtak*. This habitat was extended after evaporation of the water and fast growth of grass and foliage.

After the long drought from 1998−2005, the distribution of Black Francolin decreased markedly (Fig. 1b) and its habitats changed. Again three groups of habitats are categorised. High density due to the overflow of Hirmand River and the increase of water at Shirdel River which maintained the green cover and also the decrease in the amount of hunting because of the lack of human population in villages around Niyatak Forest and habitat security due to the lack of commuting cars for oil smuggling through the forest cover. This group consisted of Milak, the border of Shirdel Rriver, Niyatak Forest, Jahangir, Mohammad Shah Karam, Khajeh Ahmad. Medium density due to the lack of flowing water, the decrease in cultivated lands and natural plants (namely Emamiye, Bonjar, Zabol, Zhaleai and Bonjar canal, Khamak and Zahak). Low density because of the lack of precipitation and the consequent lack of vegetation cover and suitable habitats which caused a decrease in the population of Black Francolin in most of the areas (*i.e.* Doost Mohammad, Takht-e-Edalat, Ghorghori, Mirgol tower, Lotfollah, Tuti, the rangelands to the west of Varmal and Shile entrance).

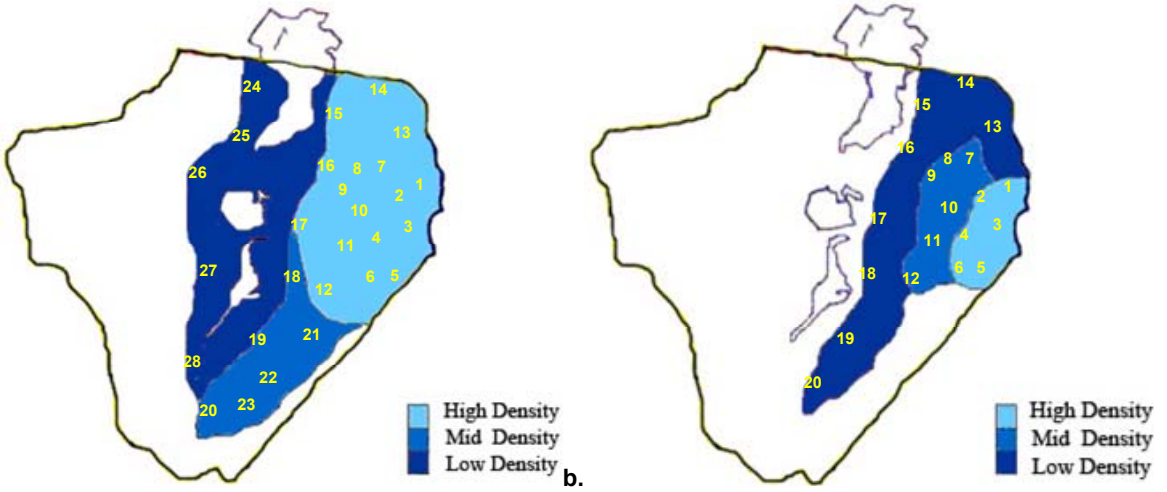

Fig. 1. Schematic distribution map of Black Francolin: **a.** Before the drought (before 2000), **b.** After the drought (2000–2008). Key to the numbers: Milak [1], the border of Shirdel River [2], Niyatak Forest [3], Jahangir [4], Mohammad Shah Karam [5], Khaje Ahmad [6], Emamiye [7], Bonjar [8], Zabol [9], Zhaleai and Bonjar canal [10], Khamak [11], Zahak [12], Doost Mohammad [13], Takht-e-Edalat [14], Ghorghori [15], Mirgol tower [16], Lotfollah [17], Tuti [18], the rangelands to the west of Varmal [19] and Shile banks [20], Kaftargi [21], Ghalaeno [22], Aliabad-e-Seyyed [23], Hamoon-e-Sabery [24], Gazanguri [25], Mile Nader [26], Songol [27] and Shile entrance [28].

Table 1. The estimated population of Black Francolin in Sistan from 1995 to 2007 (Environmental Department of Zabol)

Month Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1995	0	0	0	372	242	224	180	150	360	0	0	0
1996	180	0	78	0	0	0	0	0	0	865	85	211
1997	0	0	0	0	0	85	395	289	260	540	0	0
1998	2,117	624	897		715	178	169	185	911	1,048	0	877
1999	814	819	278	875	139	1,414	1,706	457	937	1,069	648	2,740
2000	47	100	98	267	183	85	61	54	79	98	115	52
2001	24	24	18	29	0	0	0	0	0	0	28	35
2002	0	0	17	0	0	8	0	0	26	0	0	24
2003	10	8	13	0	0	23	0	0	39	0	0	22
2004	12	10	10	32	14	18	7	0	56	20	7	8
2005	11	4	38	13	34	25	17	17	14	37	24	11
2006	64	29	35	41	33	13	0	0	0	50	47	25
2007	0	0	0	42	60	73	0	0	0	0	0	0

Table 2. Black Francolin records in different areas of Sistan from 2004 to 2007 (Sistan & Baluchestan Provincial Office of the Department of the Environment).

Area Year	2004	2005	2006	2007	Area Year	2004	2005	2006	2007
Dardedel forest	3	3	0	5	Ebrahimabad	0	6	0	4
Sadegh village	4	4	0	0	Jamalabad	0	0	4	2
Afzalabad village	2	3	4	0	Emamiyeh	0	0	2	3
Mohammadabad	2	12	5	12	Bonjar	0	0	2	2
Panjak	1	8	0	5	Seda o Sima	0	0	2	3
Shandul forest	1	4	0	13	Siahmard village	0	0	2	2
Milak	1	3	0	11	Badamak	0	0	0	4
Zurabad forest	3	9	8	18	Dashtak	0	0	0	7
Niyatak forest	4	7	3	16	Jahantigh village	0	0	0	4
Dorraji	0	15	3	25	Takht-e Edalat	0	0	0	78
Jazinak	0	5	3	4	Posht-e-ab	0	0	0	27
Sistan dam	0	4	2	3	Hamunak	0	0	0	5
Shibab	7	12	0	0	Keykha	0	0	0	7
Zarabad forest	0	15	0	0	Kolukhi	0	0	0	6
Tasfiyekhane	0	5	3	3	Lorg-e-bagh	0	0	0	4
Zhaleai	0	3	2	4	Heidarabad	0	0	0	5
Total						**28**	**118**	**49**	**298**

Population abundance

Table 1 shows the results of the monthly survey of the population of Black Francolin in Sistan from 1995 to 2007. While the period from 1998–1999 had a population over 1,000 individuals in at least three months per year, the other years in particular after 2000 had no significant population (Table1). Table 2 presents numbers of Black Francolin in 33 different areas of Sistan Plain from 2004 to 2007, respectively; among them the year 2007 had the highest numbers - 298 individuals. Among the 33 areas, Takht-e Edalat had the highest number recorded - 78 individuals.

Plant coverage

Overall, 23 plant species were observed throughout the study in the two areas of Doost Muhammad Khan and Niyatak Forest. The numbers of plant species in Niyatak Forest in the spring and summer were 9 and 24 respectively and the numbers of plant species in Doost Muhammad Khan area in the spring and summer were 18 and 10 respectively. Some of these plant species were observed in one season and some others, such as *Prosopis stephaniana*, *Salsola* sp. and *Alhaji camelorum* in both seasons and even during all four months of the study. Table 3 shows that in Niyatak Forest in the spring, *Phragmites australis, Alhaji camelorum* and *Prosopis stephaniana,* and in the summer, *Alhaji camelorum, Suaeda* sp., *Tamarix* sp. , *Salsola* sp., *Phragmites australis* and *Haloxylon persicum,* and also in Doost Muhammad Khan area in the spring, *Stuvvle* sp. and *Alhaji camelorum,* and in the summer, *Alhaji camelorum* and *Stuvvle* sp. were of the greatest importance in terms of being ideal habitats for Black Francolin.

Concerning the crown cover in Niyatak Forest (Table 4), the highest number of Black Francolin was observed in March–April in crown cover categories of 40–50%, 90–100% and included *Phragmites australis,* and *Alhaji camelorum.* In May-June this figure was most in the categories of 0–10%, 10–20%, 30–40% and included *Suaeda* sp.*, Prosopis stephaniana, Salsola* sp.*, Alhaji camelorum,* and *Phragmites australis.* In June–July this figure was recorded for the category of 10–20% and included *Tamarix* sp.*, Suaeda* sp.*, Salsola* sp.*, Alhaji camelorum, Atriplex leucoclada* and *Seiditzia* sp. The crown cover in August–September was 30–40% and included *Atriplex leucoclada*, *Salsola* sp.*, Prosopis stephaniana*, *Alhaji camelorum, Suaeda* sp.*, Aeloropus lagopoides* and *Halostachys persica*. Concerning the crown cover in Doost Muhammad Khan (Table 4), the highest number of Black Francolin was observed in March–April in crown cover categories of 30–40%, 50–60%, 90–100% and included *Carthamus oxyacantha, Prosopis stephaniana, Medicago* sp., *Alhaji camelorum, Triticum astivum, Surghum* sp. and *Hordeum* sp. In May–June this figure was most for the category of 20–30% and included *Rumex* sp., *Atriplex leucoclada*. In June–July and August–September this figure was recorded for the category of 0–10% and included *Aeloropus lagopoides.* The vegetation mentioned above had the highest number of Black Francolins observed.

Concerning vegetation height in Doost Muhammad Khan (Table 5), height in March-April was above 60–70 cm and included *Triticum astivum.* The height in May-June was 20–30 cm and included *Stuvvle* sp.*, Alhaji camelorum, Aeloropus lagopoides*, *Prosopis stephaniana*, *Carthamus oxyacantha*, *Medicago* sp. The height in June-July was 20–30 cm and included *Stuvvle* sp.*, Carthamus oxyacantha, Salsola* sp.*, Atriplex leucoclada.* The height in August-September was 40–50 cm and included *Desmosttachya bippinata*, *Prosopis stephaniana*, and *Alhaji camelorum*. The vegetation mentioned had the highest number of Black Francolins observed. Concerning the vegetation height in Niyatak Forest (Table 5), the height in March–April was 20–30 cm and 50–60 cm and included *Phragmites australis,* and *Alhaji camelorum.* The height in May–June was 30–40 cm, 40–50 cm, and 50–60 cm and included *Suaeda* sp.*, Prosopis stephaniana, Salsola* sp.*, Alhaji camelorum,* and *Phragmites australis.* The height in June–July was 50–60 cm and included *Phragmites australis, Aeloropus lagopoides, Suaeda* sp.*, Rumex* sp.*,* and *Alhaji camelorum.* The height in August–September was 0–10 cm and included *Atriplex leucoclada*, *Salsola* sp.*, Prosopis stephaniana*, *Alhaji camelorum, Suaeda* sp.*,* and *Aeloropus lagopoides*. The vegetation mentioned above had the highest number of Black Francolins observed.

Table 3. Frequency percentage of plant species in the sampling plots of Niyatak Forest and Doost Muhammad Khan areas (2008). The scientific names of the plant species have been adapted from Ghahraman (1994).

Scientific names	Niyatak forest			Doost Muhammad Khan Area		
(in alphabetic order)	Spring	Summer	Overall	Spring	Summer	Overall
Aeloropus lagopoides	-	27.77	21.73	13.15	9.52	11.86
Alhaji camelorum	40	61.11	56.52	39.47	71.42	50.84
Atriplex leucoclada	-	22.22	17.39	-	14.28	14.28
Carthamus oxyacantha	-	-	-	10.52	23.80	15.25
Citrullus colycinthus	-	5.55	4.34	-	-	-
***Convolvulus* sp.**	-	5.55	4.34	5.26	-	3.38
Cressa cretica	-	-	-	5.26	-	3.38
Cynodon dactylon	20	16.66	17.39	13.15	9.52	3.38
Desmosttachya bippinata	-	-	-	13.15	9.52	11.86
Halostachys persica	-	11.11	8.69	-	-	-
Haloxylon persicum	-	33.33	26.08	-	-	-
***Hordeum* sp.**	-	-	-	13.15	-	8.47
***Medicago* sp.**	-	-	-	13.15	-	8.47
Phragmites australis	60	33.33	39.13	-	-	-
Prosopis stephaniana	40	22,22	26.08	15.78	19.04	16.94
***Rumex* sp.**	-	5.55	4.34	5.26	-	3.38
***Salsola* sp.**	20	33.33	30.43	4.76	23.80	10.16
***Seiditzia* sp.**	-	11.11	8.69	-	-	-
***Stuvvle* sp.**	-	-	-	42.85	33.33	27.11
***Suaeda* sp.**	20	38.88	30.43	-	-	-
***Surghum* sp.**	-	-	-	-	-	13.15
***Tamarix* sp.**	20	33.33	30.43	-	-	-
Triticum astivum	-	-	-	15.78	-	10.16

Table 4. Number of Black Francolins observed in different categories of vegetation. Numbers are presented based on average 85×85 m plots in Niyatak and 50×50 m plots in Doost Muhammad Khan areas.

Area		Niyatak Forest					Doost Muhammad Khan Area				
Month		Mar-Apr	May-Jun	Jun-Jul	Aug-Sep	TOTAL	Mar-Apr	May-Jun	Jun-Jul	Aug-Sep	TOTAL
Number of plots per month		2	3	7	11	**23**	18	20	13	8	**59**
Categories of vegetation (%)	**0-10**	0	1	0	1	**2**	0	0	4	4	**8**
	10–20	0	1	3	1	**5**	0	0	2	1	**3**
	20–30	0	0	2	1	**3**	0	6	1	3	**10**
	30–40	0	1	1	4	**6**	2	3	0	0	**5**
	40–50	2	0	2	1	**5**	0	3	1	0	**4**
	50–60	0	0	0	2	**2**	2	1	1	2	**6**
	60–70	0	0	0	0	**0**	0	0	2	0	**2**
	70–80	0	0	0	1	**1**	0	0	3	0	**3**
	80–90	0	0	0	0	**0**	1	1	0	0	**2**
	90–100	2	0	0	0	**2**	2	2	0	0	**4**

Table 5. The number of Black Francolins observed in different plant height groups. Numbers are presented based on average 85×85 m plots in Niyatak and 50×50 m plots in Doost Muhammad Khan areas.

Area		Niyatak Forest					Doost Muhammad Khan				
Month		Mar-Apr	May-Jun	Jun-Jul	Aug-Sep	TOTAL	Mar-Apr	May-Jun	Jun-Jul	Aug-Sep	TOTAL
Number of plots per month		2	3	7	11	**23**	18	20	13	8	**59**
Categories of plant height (cm)	**0–10**	0	0	0	3	**3**	3	1	3	2	**9**
	10–20	0	0	2	0	**2**	1	0	0	0	**1**
	20–30	2	0	1	1	**4**	4	13	16	2	**35**
	30–40	0	1	0	1	**2**	2	5	1	0	**8**
	40–50	0	1	2	2	**5**	4	2	0	4	**10**
	50–60	2	1	3	1	**7**	0	1	0	0	**1**
	60–70	0	0	0	0	**0**	5	0	0	2	**7**
	70–80	0	0	0	0	**0**	4	3	0	0	**7**
	80–90	0	0	0	2	**2**	0	0	0	0	**0**
	90–100	0	0	0	1	**1**	0	0	0	0	**0**
	Above 100	0	0	0	2	**2**	0	0	0	0	**0**

Table 6. The collected data from 18 nests of Black Francolin in May 2008.

Clutch size	4 eggs	5 eggs	6 eggs	7 eggs	8 eggs	9 eggs	10 eggs	11 eggs	TOTAL
Number	1	1	3	4	3	2	2	2	**18**
Frequency	6	6	17	21	17	11	11	11	**100**

Breeding

In Zabol, the breeding season extends from mid-March to mid-May. The nest is merely a depression on the ground into which a few blades of dead leaves are added, usually well concealed in stands of *Tamarix*, wheat or bushes near water resources. Eggs vary greatly in colour - white, milk-white, brown and green with clear stains. Of 18 studied nests (Table 6), the clutch size varied between 4 and 11 eggs (the highest clutch size was 7 eggs, 21%). However, clutch size usually varies between 8 and 12 eggs. The hen lays one egg daily and starts incubation after laying the last egg.

DISCUSSION

Black Francolin has an extremely large distributional range, and hence does not approach the thresholds for Vulnerable under the range size criterion (Extent of Occurrence <20,000 km^2 combined with a declining or fluctuating range size, habitat extent/quality, or population size and a small number of locations or severe fragmentation) (BirdLife International 2009). In this study, Black Francolins were found near cultivation and scrub bordering wetlands. Severe water shortages have destroyed the ecological system of the wetlands and caused damage to vegetation cover in this plain, which is primarily dependent on irrigation from the Hirmand River. Additionally, serious degradation occurs when dry periods are unusually long, threatening not only the ecosystem but limiting the possibilities for human settlements and livelihoods as well. In these extreme cases, both the natural ecosystem and human society are affected adversely by dry periods. When the wetlands dry out for exceptionally long periods, waterbirds migrate elsewhere, fishing is not possible, and wetland vegetation dries up.

Changes in the distribution of Black Francolin indicated that the reduction of vegetation cover plays the most important role in decreasing its population size and range distribution. 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. Cramp & Simmons (1980) mentioned severe cold weather and snow as a limiting factor to populations of Black Francolins, and drought as another threatening factor. It is important for this study that local people reported more Black Francolins before

the drought in this area (T. Arbabi, unpubl. data). Some 50% of the clutch size in the present study was 4–7, less than the range given by Cramp & Simmons (1980; average 8–12 (ranges between 7 and 18)) suggesting the probable relationship between drought and clutch size.

According to the results, habitat preference of the Black Francolin correlates with the crown cover and the height of vegetation (Tables 4–5). The reason for this is the fact that the Black Francolin needs to be hidden from its predators among the plants as well the availability as food resources. It was also discovered that the abundance of species such as *Alhaji camelorum* and *Aeloropus lagopoides* in both Niyatak Forest and Doost Muhammad Khan areas is an indicator of the importance of these two species for providing the ideal habitat for Black Francolins. As noted above, the most ideal habitats for the Black Francolin are dense farms, which are not considered as protected areas by the DOE. In recent years, due to unprecedented drought in Sistan, the destruction of habitats has been a result of overgrazing (responsible for the destruction of at least 90% of pastures). Because Black Francolin is dependent on dense and tall vegetation, it is suggested that the vegetation of the area be conserved so that Black Francolins have a high-quality habitat. This species prefers crops, grass and bushes, tall enough to offer shelter and open beneath to provide easy escape on the ground. Tamarix which is a common tree in Sistan provides suitable cover for Black Francolins especially in hot seasons. During cold or windy days, they are absolutely quiet and hidden but in rainy days and at night they are vulnerable to predators. They are fast-runners, not easily flushed, and prefer to be hidden. The flight is a short distance of up to 200 or 300 m and they do not fly up more than 10 m. They move on the ground and fly only when they are alarmed and never stray too far from thick cover (T. Arbabi, unpubl. data).

The diet of Black Francolin is also related to plant cover. This species is omnivorous, consuming a wide variety of plants and animals, but especially seeds and insects. Plant materials include grass and weed seeds, and to a lesser extent cereal grains, fruits, berries, tubers, and leaves (Cramp & Simmons 1980). Plant materials obtained from 78 Black Francolin crops in Dez and Karkheh regions, Khuzestan Province, southwest Iran consisted of *Triticum vulgaris*, *Hordeum* sp., *Avena* sp., *Carthamus oxyacanthaa, C. glaucus, Cirsium* sp., *Carduus* sp., *Alhagi camelorum, Polygonum persica, Lagonychium farctum, Capparis spinosa, Lycium* sp., *Vitex* sp., *Citrullus vulgaris, Sesamum indicum, Salvia* sp. Major food items consumed by all birds were wheat seeds and ants. Male and female adults and juvenile females consumed seeds of the family Compositae, while adult and juvenile males consumed barley seeds (Rafiei-Tabatabaei 1977). During drought periods, they feed on *Salsola* and growing parts of *Tamarix* (T. Arbabi, unpubl. data). However animal materials mainly insect adults, pupae, and larvae, especially beetles (Coleoptera), grasshoppers and locusts (Orthoptera), ants (Formicidae) and occasionally spiders (Arachnida), small amphibians (*e.g.* toads *Bufo*), small reptiles (lizards), earthworms (Annelida), and molluscs, and, near villages in India, human excrement (Hume & Marshall 1880, Dementiev & Gladkov 1952, Bump & Bump 1964, Ali & Ripley 1969; all cited in Cramp & Simmons).

Illegal and over-hunting has had a prominent role in reducing the distribution and numbers of Black Francolin. This bird is secretive, shy and suspicious of humans, and thus hard to observe and photograph. The call of the Black Francolin, described as a loud ringing 'Shirdar Shekarak' in Sistan, can be heard in the mornings and evenings and nearly all day during the breeding season (an indicator for population estimation but also susceptible to hunting at this time). They are hunted and netted extensively using guns, night hunting and traditional nets such as *Kemmak* and *Latoo* especially during the breeding season thus resulting in a considerable decrease in the population. Similarly in India, wholescale unregulated netting is causing serious depletion in its numbers in many areas (Ali 2002). Recently, the use of combine harvesters in cultivated land has destroyed nests with their eggs. Illegal hunting (in spite of the fact that this species has been announced as 'a protected species' under the Environmental Laws of the Iran Department of the Environment) (Mansoori 2008) has caused the population of this beautiful bird to be reduced greatly.

Ghaemi (1998) also found that illegal hunting is one of the most powerful reducing factors along with habitat destruction and the use of agricultural pesticides.

Illegal hunting, overgrazing, long and unprecedented drought in Sistan, which in turn has devastated the vegetation and the natural habitats are all factors which have caused the number of Black Francolin to decrease remarkably (Einollahi & Galavi 2004). Conservation of this bird by the Department of the Environment (DOE) is not an easy task due to extensive and patchy habitats. Today, Black Francolins cannot be protected in the vast area of Sistan Plain by the Department of the Environment (DOE). In view of the vast area of the habitats, we cannot expect the DOE to be responsible for protecting the area alone. Conservation education and rearing programmes should accompany the legal plans. Therefore, one very useful method for conserving the Black Francolin is teaching local people and increasing their awareness about the consequences of the extinction of this bird. Additionally, economical conditions play a very important role in the protection of this bird. Therefore multi-disciplinary action needs to be taken to conserve this bird in the region.

Finally, the DOE can involve the people in conserving this valuable bird and gradually convince them not to hunt it. Questionnaire surveys revealed that most interviewed people had good information about this species based on their responses which were consistent with the scientific literature (Einollahi & Gelavi 2004). Therefore we hope local people awareness plays an important role in the conservation of this species in Sistan Plain. This last solution would mean that the Sistan & Baluchestan Provincial Office of the Department of the Environment (DOE) should officially control the whole area. In addition, captive breeding of Black Francolins in protected areas and returning them to their natural habitat can be another option along with the former solution.

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