

Population Biology of Black Francolin (*Francolinus francolinus*) with Reference to Lal Suhanra National Park, Pakistan*

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Abstract.- Transect data collected on black francolin, known as black partridge in Pakistan and India, (*Francolinus francolinus*) population from Lal Suhanra National Park (south Punjab, Pakistan) between 1993 and 2004 suggested that the species was present in only 6/23 stands (mainly in irrigated plantation with reed vegetation) with an average density of $8.40 \pm 1.39/\text{km}^2$; varying between 3.44 ± 0.88 and $13.28 \pm 2.25/\text{km}^2$ in different stands. Densities were lower during winter (November–March, minimum in February) and maximum during summer (May–July), explained on population recruitment cycle, mortality and local movements. Densities were not significantly different between study years, yet these were generally lower during drought years compared to better rainfall years. Sex ratio (male/ female = 1.31) was skewed towards males. There were 0.32 ± 0.09 young/adult female and 0.14 ± 0.03 young/adult birds, while 2/6 stands had no young, representing non-breeding stands. Young were not observed or could not be identified separately during October–February, and the young/adult ratio was the highest in August. Dispersion index (variance/mean) of 0.60 ± 0.09 suggests random-uniform dispersion. Group size averaged at 1.88 ± 0.15 birds/group (range 1–5), majority of individuals appeared as singles (52.39%). More uniform dispersion appeared during the evening and in winters.

Key words: Density, sex ratio, age structure, seasonal variation, annual variation, dispersion.

INTRODUCTION

Black francolin, *Francolinus francolinus* (Linnaeus 1766) known as black partridge in Pakistan and India, is a medium-sized resident game bird of the Indus Plains and associated hills up to 1,500 m above mean sea level (amsl) inhabiting thicker vegetation moving to cultivated crops and grassland to feed chiefly in the morning and the late afternoon. Species roosts on ground in thicker growth of tall grasses, though often mounts up on branches of trees for calling. Bird runs ahead of hunter/ predator for an escape, breaking cover with a loud whirl of wings, takes short, low, swift and strong flight with rapid beats of wings, punctuated with glides (Roberts, 1991; del Hoyo *et al.*, 1994). This francolin species has been providing hunting pleasure and dining table delicacy for the rich, source of bush meat for the poor, allurements for its keeper as pet, and helps the farmer in controlling insect pest infestation (Fuller *et al.*, 2000).

Global population of black francolin is generally regarded as stable, yet wildlife enthusiasts in Pakistan feel concerned over the decline in its population due to excessive hunting, habitat loss and pesticide/herbicide sprays (Mann and Chaudhry, 2000). Future management to support population build up requires conservation and sustainable utilization based upon better understanding of its biology. Studies on population biology of the species are very few, and the species is known from casual records on its distribution (Roberts, 1991). Call-counts suggested population density of 395 birds/ km^2 for irrigated tract of Faisalabad (central Punjab, Pakistan: Khan, 1989), and between 0.12 and $5.81/\text{km}^2$ for different forest plantations and sub-mountainous Punjab (Pakistan: Mann and Chaudhry, 2000). Based upon transect and call counts data, Mahmood *et al.* (2010) suggested black francolin average population density of $6/\text{km}^2$ for Lehri National Park (northern Punjab, Pakistan), and higher densities during the autumn. No study is available on covey size, dispersion, sex and age structure, annual population fluctuations, etc. A good population of black francolin is present under protection of Lal Suhanra National Park (Pakistan, LSNP). Present report presents the results of a study on different population biology variables of black

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francolin in Lal Suhanra National Park (LSNP) undertaken between 1993 and 2004 with the hypothesis that population of the species maintained under reasonable natural conditions with minimum of human caused stress can provide some basic insight into hitherto little known population biology of this francolin species.

MATERIALS AND METHODS

Study area

Lal Suhanra National Park (29° 24' N, 71° 01' E; 110-125 m amsl, northwestern Lesser Cholisthan/Greater Indian Thar Desert, southern Punjab, Pakistan; national park established in 1972) is basically a desert tract with sand dunes and interdunal flats of different sizes. Area is basically hot (average temperature: winter 3.5°C, summer 46.7°C) and arid (low precipitation and relative humidity) (Rao *et al.*, 1989). Area was under the spell of severe drought (1993-96, annual precipitation 17-51 mm), followed by high rainfall spell (1997 – 2000, 460- 569 mm) and period of moderate rainfall (2001-2004, 112-141 mm). Area witnesses two blooms, i.e. spring (February–March) and post monsoon (August–November). Bahawal Canal passes through northwestern parts of LSNP (Anonymous, 2000), supporting irrigated plantation (Khan and Mian, 2012), though the major part of the NP has general desert vegetation. Around 86% of the area has moderate sand dunes, while stabilized sand dunes, subtropical thorn forests, irrigated plantation and swamps occupy 14%.

Sampling

A total of 23 stands (stretches having reasonably uniform physico-biotic conditions) were delineated throughout LSNP and extensively searched for direct (sighting) and indirect (calls, feathers, faecal pellets) presence of black francolin during different parts of 1993. Population of black francolin was recorded in 6 of these stands which were selected for further studies.

A permanent fixed strip transect (2.5 km) was established in each of the 6 stands, using generally used walk trails, trying to maintain a straight line passing diagonally through stand area covering all possible microhabitat variation. Each transect line

was walked by 3-4 workers (hunters/wildlife staff) at a moderate speed (2–3 km/ h) talking at normal pitch in the morning (starting about half an hour before sunrise) and in the evening (starting about half an hour before dusk) sessions for two consecutive days during the second half of each calendar month between 1993 and 2004 to count sighted birds (Javed and Kaul, 2000). Data on sex (male, female) and age (young, adult) of each sighted bird, and number of birds seen together were recorded. Records on approximate distances of sighted birds from the transect line during 1993 and 1994 studies suggested that strip transect covered an average band of some 40 m on each sides, therefore a uniform transect width of 80 m (0.08 km) was adopted for analysis of strip transect data.

Analysis

Density of bird population (per km²) of each sample stand was calculated by dividing number of sighted birds by transect area (transect length × average transect width, 2.5 km × 0.08 km = 0.2 km²). Stand densities were pooled to develop average densities for different stands, calendar months and years for analysis of seasonal and annual population fluctuations. Unpaired t-test was used to determine significance of differences between samples, and Pearson coefficient of linear correlation calculated for assessing level of association of densities to different variables (Sokal and Rohlf, 2000).

Number of males and females recorded for different stands was pooled for different stands, calendar months, and overall sample for sex ratio analysis. Significance of difference was tested at 0.05 levels for 1:1 male: female sex ratio using α^2 -test. Heterogeneity α^2 -test for 1:1 sex ratio was used for judging uniformity in different sets of data.

Data on number of adult females/individuals and young recorded during transect sampling were pooled for spatial and seasonal variation in age structure (young: female ratio; young: adult ratio).

Number of birds seen together during transect sampling was regarded as a group (covey). Pooled group data collected for different calendar months and years were used to calculate mean group size and variance. Dispersion index was calculated by dividing group variance by group mean for each

category (Odum, 1971), on assumption that variance equals mean in random dispersion: values of index of <1 suggesting uniform, and >1 clumped population. Paired t-test was used for analysis of significance of difference between different sets of data.

RESULTS

Density

Black francolin population could be detected in 6/23 (26%) stands delineated in LSNP, where the population was distributed with an overall density of $8.40 \pm 1.39/ \text{ km}^2$. Densities were significantly different among study stands, ranging between 3.44 ± 0.88 and 13.28 ± 2.25 (Table I).

Table I.- Population density (mean \pm S.E., per km^2) of black francolins in different stands of LSNP having favourable francolin habitat. Number of transects (n = 160) and transect area (32 km^2) remained constant in all stands. Densities having same alphabet are not significantly different.

Stand No.	No. of francolins sighted	Density
1	186	4.84 ± 1.02 a
2	510	13.28 ± 2.25 b
3	431	11.22 ± 2.11 b
4	190	4.95 ± 1.03 a
5	487	12.68 ± 2.32 b
6	132	3.44 ± 0.88 a
Overall	1936	8.40 ± 1.39

Seasonal fluctuation

Average densities of black francolin during different calendar months suggested a marked seasonal variation (Table II). Population densities were lower during winter (November–March), the minimum appearing during February. Population densities started showing a rising trend from March onwards, the maximum densities exhibited during summer (May – July). Population densities started showing a declining trend in later part of the year, touching winter low levels in November.

Annual fluctuations

Densities of black francolins were not significantly different among the years (Table III) as judged by t-test ($P > 0.05$ between different years).

Table II.- Population density (mean \pm S.E., per km^2) of black francolins during different calendar months in LSNP. Number of transects (n = 160) and transect area (32 km^2) constant for different months.

Months	No. of francolins sighted	Density
January	115	3.59 ± 1.11
February	97	3.03 ± 1.09
March	157	4.91 ± 1.31
April	168	5.25 ± 1.09
May	195	6.09 ± 1.11
June	209	6.53 ± 1.30
July	233	7.28 ± 1.72
August	180	5.63 ± 1.11
September	167	5.22 ± 1.09
October	162	5.06 ± 1.11
November	138	4.31 ± 1.08
December	115	3.59 ± 0.78

Table III.- Black francolins densities (per $\text{km}^2 \pm$ SEM) during different years in LSNP. Number of transects (n = 160) and transect area (32 km^2) remained constant for different years. Densities between different months not significantly different at 0.05 levels.

Year	Number of francolins sighted	Density (df=318)	Precipitation (mm)
1993	139	4.34 ± 0.87	23.59
1994	129	4.03 ± 0.75	17.7
1995	137	4.28 ± 0.67	22.7
1996	142	4.44 ± 0.91	50.6
1997	154	4.81 ± 0.65	460.27
1998	191	5.97 ± 0.78	573.99
1999	210	5.56 ± 0.81	565.32
2000	204	6.38 ± 1.10	569.06
2001	187	5.84 ± 0.87	140
2002	157	4.91 ± 0.79	120.4
2003	138	4.31 ± 0.89	141.45
2004	148	4.63 ± 0.94	135.75

However, annual average densities (Table III) were maintained at relatively lower levels (4.03 – $4.44/\text{km}^2$) during 1993 and 1996, the average densities started rising gradually after 1997 up to 2001: the highest density ($6.38/\text{km}^2$) was exhibited during 1999. Population densities declined again in 2003 ($4.31/\text{km}^2$), arose slightly during 2004. Area was under the spell of low rainfall during 1993–1996 and 2001–2004 and under higher rainfall during 1997–2000. Period of higher francolin densities

considerably corresponded with period of higher precipitation.

Sex structure

Pooled data on distribution of two sexes in adult populations in different stands (Table IV) and during different calendar months (Table V) indicated a persistent preponderance of males in majority of spatial and seasonal samples, with male/female sex ratio of 1.31 ($\chi^2 = 15.42$, $df = 1$, $p < 0.001$). Despite a consistent tendency of maintaining a higher number of males in all samples, value of heterogeneity χ^2 indicated a significant level of heterogeneity between different spatial ($\chi^2 = 20.76$, $df = 5$, $p < 0.05$) and seasonal ($\chi^2 = 21.76$, $df = 10$, $p < 0.05$) samples.

Table IV.- Distribution of two sexes in the adult population of black francolins in different stands of LSNP.

Stand No.	♂	♀	♂ : ♀ ratio	$\chi^2_{(1:1)}$	P
1	101	85	1.18:1	1.38	0.24
2	232	191	1.22:1	3.97	0.05
3	205	173	1.19:1	2.71	0.10
4	113	77	1.47:1	6.82	0.01
5	243	169	1.44:1	13.29	0.0003
6	71	41	1.73:1	8.04	0.005
Overall	965	736	1.31:1	15.42	< 0.01

Table V.- Distribution of two sexes in the adult black francolins population during different Calendar months in LSNP.

Months	♂	♀	♂ : ♀ ratio	$\chi^2_{(1:1)}$	P
January	68	47	1.45:1	3.83	0.05
February	59	38	1.55:1	4.55	0.03
March	79	61	1.30:1	2.31	0.13
April	83	64	1.30:1	2.46	0.12
May	93	79	1.18:1	1.14	0.29
June	96	71	1.35:1	3.74	0.05
July	91	87	1.05:1	0.09	0.76
August	65	58	1.12:1	0.4	0.53
September	86	61	1.41:1	3.65	0.06
October	95	67	1.42:1	4.84	0.03
November	78	60	1.30:1	2.35	0.13
December	72	43	1.68:1	7.31	0.007
Overall	965	736	1.31:1	15.41	< 0.01

Age structure

Distribution of young in population (Table VI) revealed an average of 0.32 young/adult female, and 0.14 young/adult. Stand data suggested absence of young in 2 stands out of 6 (33%) in stands that had thorn forests.

Table VI.- Distribution of young in black francolins population of different stands in LSNP.

Stand (#)	Female (#)	Adult (#)	Young (#)	Young/female	Young/adult
1	85	186	0	0	0
2	191	423	87	0.46	0.21
3	173	378	53	0.31	0.14
4	77	190	0	0	0
5	169	412	75	0.44	0.18
6	41	112	20	0.51	0.18
Overall	736	1701	235	0.32±0.09	0.14±0.03

Young to female ratio varied among different calendar months (Table VII). No young were recorded during October-February. young/female ratio increased in March (0.29) and was maintained at almost the same level till May. Young/ female ratio increased gradually during subsequent months, peak level recorded in August (0.98), and a subsequent decline during September (0.33), when young were not separable from adults.

Table VII.- Distribution of young ones in the population of black francolins in different months in LSNP.

Months	Female (#)	Adult (#)	Young (#)	Young/female	Young/adult
January	47	115	0	0	0
February	38	97	0	0	0
March	61	140	17	0.29	0.12
April	64	147	21	0.33	0.14
May	79	172	23	0.29	0.13
June	71	167	42	0.59	0.25
July	87	178	55	0.63	0.31
August	58	123	57	0.98	0.46
September	61	147	20	0.33	0.14
October	67	163	0	0	0
November	60	138	0	0	0
December	43	115	0	0	0

Dispersion

Overall dispersion index (0.60±0.09) suggests that the species in general maintained a random dispersion, tending towards some degree of uniform dispersion. This trend persisted in all seasonal (Table VIII) and annual (Table IX) samples.

Table VIII.- Dispersion index (variance/mean) of black francolin population in LSNP during different calendar months

Months	Morning				Evening				Overall			
	n	Mean	Variance	Index	n	Mean	Variance	Index	n	Mean	Variance	Index
January	80	1	0	0	40	1	0	0	120	1	0	0
February	69	1.25	0.2	0.16	40	1	0	0	109	1.17	0.15	0.12
March	64	1.81	0.36	0.19	32	1.33	0.33	0.24	96	1.71	0.37	0.21
April	48	2.14	0.81	0.37	32	1.33	0.33	0.24	80	1.9	0.76	0.4
May	48	2.14	1.81	0.84	36	2	0.66	0.33	84	2.09	1.29	0.61
June	52	3.5	0.28	0.08	40	2	1.5	0.75	92	2.92	1.41	0.48
July	84	2.14	1.97	0.92	40	2.25	2.25	1	124	2.16	1.91	0.88
August	72	2.3	1.56	0.67	28	2.5	4.5	1.8	100	2.33	1.66	0.71
September	68	1.16	1.5	1.2	28	2	4	2	96	1.28	0.22	0.17
October	64	1.09	0.09	0.08	36	1	0	0	100	1.06	0.06	0.05
November	56	1.02	0.07	0.07	42	1.33	0.33	0.24	98	1.08	0.08	0.07
December	70	1	0	0	41	1	0	0	111	1	0	0
Overall	775	1.63	1.04	0.63±0.12	435	1.51	0.79	0.52±0.20	1210	1.6	0.97	0.60±0.09

Table IX.- Dispersion index (variance/mean) of black francolin population in LSNP during different years

Months	Morning				Evening				Overall			
	n	Mean	Variance	Index	n	Mean	Variance	Index	n	Mean	Variance	Index
1993	50	1.14	0.13	0.09	27	1.33	0.33	0.24	77	1.17	0.25	0.21
1994	48	1.5	0.5	0.33	25	2	0.85	0.42	73	1.9	0.76	0.4
1995	72	1	0	0	32	1.58	0.99	0.62	104	1.5	0.88	0.58
1996	60	3	0	0	25	1.7	1.12	0.65	85	1.81	1.16	0.64
1997	78	1	0	0	35	1.53	0.93	0.6	113	1.38	0.72	0.52
1998	90	2.06	2.21	1.07	62	2.06	2.21	1.07	152	2.11	1.93	0.91
1999	82	1.58	0.99	0.62	42	1.57	1.28	0.81	124	1.57	1.03	0.65
2000	72	1.83	1.42	0.77	50	2	1.5	0.75	122	1.88	1.36	0.72
2001	75	1.3	0.23	0.17	42	1.28	0.23	0.17	117	1.3	0.22	0.16
2002	48	1.37	1.12	0.81	38	2	3	1.5	86	1.54	1.47	0.95
2003	52	2	1	0.5	32	2.14	1.47	0.68	84	2.11	1.36	0.64
2004	48	1.62	1.12	0.24	25	1.62	1.12	0.69	73	1.54	0.87	0.56
Overall	775	1.63	1.04	0.63±0.12	435	1.51	0.79	0.52±0.20	1210	1.6	0.97	0.60±0.09

Table X.- Frequencies of coveys of different sizes in black francolin population in LSNP, during morning and evening sessions

Covey size	Morning		Evening		Overall	
	n	%	n	%	n	%
1	395	50.97	239	54.94	634	52.39
2	181	23.35	120	27.58	301	25.08
3	82	10.58	26	5.98	108	9
4	91	11.74	34	7.82	125	10.41
5	26	3.35	16	3.67	42	3.5

Such a dispersion pattern was equally reflected in the size of coveys (group of individuals seen together). Average covey size was 1.88 ± 0.15 /covey (range: 1-5). Majority of individuals appeared as singles (52.39%). Frequency of groups having larger covey size gradually decreased (Table X).

Population dispersion varied between morning and evening sessions, and seasons (Table VIII) and years (Table IX). Dispersion indices for morning and evening samples were not significantly different ($t = 0.4707$, $df = 11$, $p > 0.05$), yet there was more uniform dispersion during evenings (mornings = 0.63 ± 0.12 , evenings = 0.52 ± 0.20). This was

equally reflected in mean covey size, which were not significantly different ($t = 0.77$, $df = 1218$, $p > 0.05$), yet average covey size was smaller during evenings (1.77 ± 0.12) compared to morning (1.93 ± 0.17) samples.

Dispersion also varied with seasons (Table VIII). There was more uniform dispersion during winter (October-February, index < 0.12), gradually tending towards more random dispersion during summer, almost uniform dispersion (0.88) during July.

DISCUSSION

Population distribution and density

LSNP is basically a desert tract. The dense vegetation, that constitutes the habitat of black francolins, occurs only in the limited tract that is canal irrigated. Therefore, the absence of this francolin from major part of LSNP was expected. Mian and Ghani (2007), in a study designed to evaluate effect of increasing protection on biodiversity under desert conditions of LSNP, did not record black francolin (irrigated tract not included in their study design). Black francolin has not been recorded with reference to LSNP or Bahawalpur in the Fauna of British India (Baker, 1921) when canal irrigation was not introduced in the area. Ali (1941) reported this species from Bahawalpur, without pointing specific area. It appears that black francolin is an invasive species in Bahawalpur and LSNP, extending its distribution range with introduction of canal irrigation and subsequent development of thicker vegetation. Overall population densities in different stands recorded under present study (8.40 ± 1.39 ; range: 3 – 13 birds/ km²), 6.09 ± 1.11 in May and 6.53 ± 1.30 in June are closer to that recorded for LSNP (5.8 birds/km² in May-June, 1999; Mann and Chaudhry, 2000). Densities (2-12/ km²) have been reported for Lehri National Park (Punjab, Pakistan) by Mahmood *et al.* (2010). High density figures of black francolin (375 birds per km², Khan, 1989) have been reported for Faisalabad (Pakistan; arid with perennial irrigation and high energy subsidy). Higher level of food energy available in cultivated fields of Faisalabad can support higher populations of black francolin, especially during non-breeding season.

Seasonal fluctuation

Patterns of seasonal fluctuation in population densities can be partially explained under population recruitment and chick loss pattern. Population density started rising with addition of newly recruited chicks in March, the density continued increasing gradually till July, when recruitment for the season/year was complete. An associated study on breeding biology suggested that 70-80% of egg laying occurred during February-April, though some low level of breeding continued till August (Khan, 2010). Higher expected mortality of newborn chicks and young ones, without population recruitment may explain the rapid decline in population between July and November.

Stable winter population densities suggest absence of significant winter caused mortalities. Low winter mortalities have been reported for grey partridge (*Perdix perdix*) (Penrod and Hill, 1985) and ring-neck pheasant (*Phasianus colchicus*; Homan *et al.*, 2000) in USA, though they face harsh winter temperatures. Low winter mortality can be expected under relatively milder winter temperatures and low population of raptors in LSNP (Mian and Ghani, 2007).

Low winter population densities also indicate possible local population movements to adjacent agricultural fields, where food energy subsidies are available. As general ecological principle, ecological amplitude of a species is wider during non-breeding season as compared to that during breeding season (Odum, 1971). Wider ecological amplitude permits the species to exploit associated tracts. Further studies on monitoring the movement of tagged birds are required to know levels of such seasonal movements. Local movements in recently introduced populations of black francolin in Hawaii Island (USA; 15-64 km) and Oklahoma (USA; up to 81 km) have been reported (del Hoyo *et al.*, 1994).

Higher summer densities can also be expected as an artifact under increased activity of birds, rendering them prone to appear in transect-sampling. Scarce literature is available to support this possibility, hence requiring further studies. Higher summer male mortalities, as reflected by lowered proportion of males during summers under present study, may indicate some degree of

increased male activity and thence higher predation, selective hunting/capture or migration.

Annual fluctuation

Rainfall, especially under arid conditions, directly impacts growth of annual ephemerals (Mian, 1985) ensuring food energy and shelter for animal species, including francolins which are predominantly herbivores (Khan and Mian, 2011) and cursorial depending upon vegetative cover for their defense against predators (Ali and Ripley, 1969; Roberts, 1991). Calculated value of correlation coefficient between annual rainfall and population densities ($r = 0.6529$, $df = 10$, $P < 0.05$) suggests a significant positive correlation between these variables. This indicates that rainfall strongly impacts annual population level of this francolin species. Irrigation provided some support to vegetation in stands holding Black Francolin population, which may reduce direct effect of drought. Studies carried out in Sistan Plains (Iran) suggested a serious decline in the population of Black Francolin as a result of prolonged drought (Heidari *et al.*, 2009).

There are reports of illegal hunting/ trapping of birds in LSNP (Anonymous, 1997). No reliable estimates are available on such hunting/trapping losses, however it appears that human predation is fully sustained by population of this species. It is difficult to conclude whether stable populations are being maintained at carrying capacity levels of habitat, changing with change in vegetative cover, and illegal hunting is harvesting the population falling above carrying capacity or whether hunting is checking population increase. Fact that population fluctuations were reasonably following rainfall pattern may give an indirect indication that population of this francolin species was maintained at carrying capacity levels of habitat, amicably sustaining the natural predation. If this logic proves true then hunting is claiming the part of the population that is above the carrying capacity level.

Sex ratio

Sex ratio is skewed towards males in phasianids (Islam and Crawford, 1993; Donald, 2007) and black francolin appears no exception.

This tendency is more pronounced in medium-sized phasianids (58-67 males: 6 – 10 females, Djibouti francolin, *Francolinus ochropectus*, Bealey *et al.*, 2004; 19 males : 5 females, grey partridge, *Perdix perdix*, Novoa *et al.*, 2002) as compared with larger species (1 male : 1.42 females in grey jungle fowl, *Gallus sonneratii*, Sathyanarayana, 2007). Reflecting a similar tendency, Islam (1999) suggested that some 10–11% of black francolin males failed to secure a female in the population introduced in Molokai Island, USA. Male biased sex ratio is attributed to a higher mortality of the females of the grey partridge (*Perdix perdix*) during incubation (Hupp, 1980). A higher natural female mortality can be expected for heterogametic (ZW) female (Bealey *et al.*, 2004). This may allow males to offer sacrifice to save females, which has responsibility of rearing the brood. This may give special protection to adult females and hence has special value for species survival, compensating earlier loss of females.

Age structure

Pattern of seasonal variation in age structure follows the population recruitments. Under field conditions, young ones and adults are hard to be differentiated after September, when chicks are more than two months old (Baker, 1932).

Dispersion

No direct study on quantification of population dispersion is available for this or any other francolin or partridge species. Average group size of 3.77 (protected areas) and 2.96 (grazed/ burnt grassland) have been reported for redwing francolin (*F. levaillantii*) in South Africa (Jensen *et al.*, 2000), indicating different levels of clumping. Dispersion pattern has a value in species survival. Increasing uniform dispersion decreases intraspecific competition and group protection from biotic/abiotic environmental hazards (Odum, 1971). Black francolin, surviving under thicker vegetative cover, can find protection of vegetative cover and hence is exposed to lower level of environmental hazards, therefore exhibits tendency towards a uniform dispersion. No explanation is available on a difference in dispersion levels in morning and evening samples, which appears to be species

specific behaviour.

Breeding activities, pair bonds and development of family groups during summer are collectively responsible for increased size of the covey and a lower level of uniform distribution. More uniform dispersion during low rainfall years compared with higher rainfall years can be expected under better availability of food with increasing rainfall, consequently lowering intra-specific competition for food and shelter. Increased aggregation may also be a character of higher population levels especially when food and shelter are not the limiting factor and population remains below carrying capacity of the habitat.

Different variables, like group size, distance between sighted animal/bird and constancy of appearance in different samples have been used in different animal groups to judge dispersion, but none of these provides a comparable index of dispersion. General statistical property of a random population distribution, i.e., variance equals the mean; provides a valuable index of dispersion. If variance equals mean (dispersion index = 1) population has a random dispersion, and if it is larger (dispersion index >1) population is clumped and if smaller (index <1) dispersion is uniform (Odum, 1971; Mian, 1985). Dispersion index provided a quantified parameter in the present studies on Black Francolin, measuring changes in dispersion pattern at different times, seasons and years.

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