

Research Article

Population Estimation of Grey Francolin (*Francolinus pondicerianus*) in Salt Range, Punjab, Pakistan

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Abstract

The genus *Francolinus* belongs to Order Galliformes and Family Phasianidae and is diverse genus of game birds. Grey francolin (*Francolinus pondicerianus*) belongs to this genus and is a medium size game bird, serving as an operator of biological control. Population of grey francolin has declined over the time mainly due to excessive hunting and habitat destruction. Research studies have not been carried out on Grey francolin in the Salt Range and data on their biological and ecological aspects is lacking. The current study was conducted in two protected areas i.e. Chumbi Surla Wildlife Sanctuary (CSWS) and Diljabba Domeli Game Resrve (DDGR) to generate information about population density and distribution pattern of Grey francolin in the Salt Range. For population estimation, 40 transects were laid in the both areas and Grey francolin population were recorded both by direct sighting and calls and data was analyzes by DISTANCE Software 6.0. Significant difference was recorded in population densities among different sites both by sighting and calls method. In CSWS, population density by sighting was the highest at Open land habitat (3.23 individual ha⁻¹) while lowest at cultivated habitat (1.58 individual ha⁻¹) and by calls was the highest at (2.87 individual ha⁻¹) from natural forest habitat, while lowest at (1.59 individual ha⁻¹) from cultivated habitat. In DDGR population density by sighting was highest from wetland (2.47 individual ha⁻¹) and lowest at (2.09 individual ha⁻¹) from natural forest habitat, by calls highest from open land habitat (2.45 individual ha⁻¹) and lowest from wetland habitat (1.10 individual ha⁻¹). This study would provide essential scientific base about population and distribution patterns of grey francolin in the study area that is required for the conservation of grey francolin, ultimately helping in sustaining the population of this important game bird in the Salt Range.

Key words: Chumbi Surla; Density; Diljabba Domeli; Distance software 6.0; *Francolinus*; Game bird.

Introduction

Pakistan has variety of ecosystems with diverse avifauna [1]. More than 650 bird species have been reported in the country

and their occurrence is unique in the world as diversity of habitat found here [2, 3]. Grey francolin (*Francolinus pondicerianus*), formerly called grey partridge [4] is a

medium-sized game bird of Family Phasianidae and is found in open, dry and arid parts of the Asia [4, 5]; Pakistan, south-eastern Iran, India, Bangladesh and northern Sri Lanka. Its origin allowed it to live easily in cultivated areas where it can find cover, food, and ground for nesting [6, 7]. Grey francolin is native bird of Pakistan [8, 4, 9], however, under different environmental conditions shows local migration. In Pakistan, Grey francolin is widely distributed from the west of Indus valley to south of the foothills of Himalayas [4]. It is rarely found above an elevation of 1200 m in Pakistan and usually found feeding on bare soil or low grass cover in open and scrub country [10].

This species is considered “friend of the farmers” as it consumes variety of invertebrates including, insects, their eggs, larvae and pupa, which are harmful to crops and, therefore, work as effective bio-controlling agent [11, 12]. It is an excellent game and table bird, also used as a cage and fighting bird [13].

They may roost at night on low thorny branches of trees or shrubs in pairs or family groups called “coveys” and have camouflaging plumage to live in vegetation that is not so dense [14, 4]. Grey francolin is an indicator species for farmland ecosystems and decline in its population has been reported in the past [15, 9]. Increased use of pesticides due to agriculture expansion and habitat degradation can be cited as main causes behind its decline. A rapid decline in its natural habitat has been reported by [4], through its food loss, excessive predation, habitat destruction, intensification of agricultural practices and pressure on scrub forests for use as fodder, timber wood and fire wood needs. It is listed Least Concern on IUCN Red List, one of the reasons behind this is that it has a wider distribution range [16].

Unfortunately, in the past very few studies addressed grey francolin found in different parts of Pakistan. None of those was carried out in Salt Range of the Punjab, one of the major areas of its distribution in Pakistan. Keeping in view the declining trend in population of grey francolin, current study was conducted to generate information about population density, distribution pattern of grey francolin in different habitat types in the study area.

Materials and Methods

Study area

The study was conducted at Chumbi Surla Wildlife Sanctuary (CSWS) and Diljabba-Domeli Game Reserve (DDGR) located in Salt Range, Pakistan (Figure 1). The Salt Range is an east-west turning point of communication about 175 km long in the northern Punjab consisting of Khushab, Mianwali, Jhelum and Chakwal districts [17]. It extends between 32°41' - 32°56' N and 71°50' - 74°E, elevation 250 m-1520 m and forms an impressive scarp. Sakesar top is the highest point in Salt Range with an elevation of 1524 m [18].

Chumbi Surla Wildlife Sanctuary is situated at 20 km south- west of Chakwal Town at 32° 47' N & 67° 42' E and 460 m – 1050 m elevation . Total area of CSWS is 55,987 ha [19]. The sanctuary contains different habitat types including; wetlands, torrents, farm lands and hills, due to which good diversity of wild animals exist here. Climate of CSWS is dry sub-tropical with cool winters and hot summers. Temperature ranges from 10°C to 41 °C and average annual rainfall is 500 mm [20]. The sanctuary has mixture of sub-tropical semi-evergreen and tropical thorn forest [19]. Diljabba- Domeli Game Reserve is located in district Jhelum at 32° 54' N - 73° 09' E and 600 m elevation. Total area of the game reserve is 118,106 ha [18].

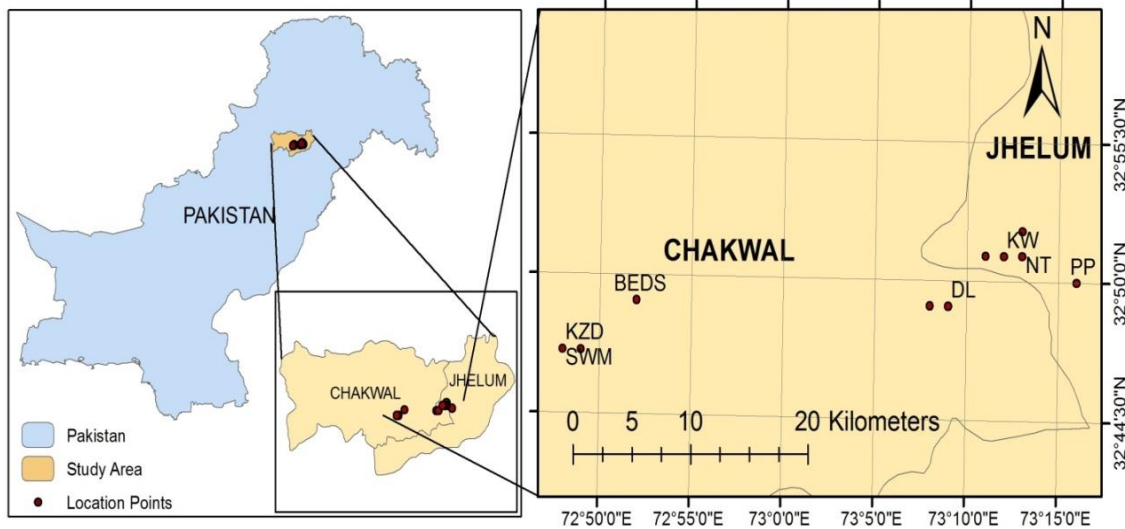


Figure 1. Map showing study area and sites selected for data collection within Salt Range.

Methodology

A reconnaissance survey was conducted to select the study sites for data collection within two study areas i.e. Chumbi Surla Wildlife Sanctuary and Diljabba- Domeli Game Reserve as representatives of Salt Range. Study sites were selected for data collection, on the basis of occurrence of grey francolin and accessibility of the area. Study area was divided into different habitat types as potential sites for the grey francolin. Different types of potential habitats of grey francolin found in the study area were randomly selected for collecting data including; I) cultivated crop fields and associated natural vegetation on field boundaries, II) natural forest and associated grassland, III) open lands, and IV) wetlands and associated natural vegetation.

Population estimation in selected habitats

For population estimation of Grey francolin, direct sightings of the birds using “Visual Encounter Method (VEM)” and call counts were used in four selected habitat types. Five permanent transects of 0.5 km to 3km in length and 100 m (50 m on each side) in width were established, adjusting length and orientation of transect based on terrain of the site. Transects were taken between 539 m

(Bella), 687 m (Khokhar Zer Dam), 697 m (Dhok Sehla) and 708 m (SubedaraWali Mori) in CSWS and between 395 m (Pathial Pahar), 460 m (Kalewali), 463 m (Nathoot) and 505 m (Dhial) in DDGR. Transects were walked slowly by single observer in every month for four successive days, both in the morning (from 5 am to 8 am during April to September in summer and from 6 am to 10 am during October to March in winter) and the evening (from 5 pm to 8 pm during April to September in summer and from 2 pm to 5 pm during October to March in winter) to record direct sighting or calls of grey francolin depending on topography of land and nature of vegetation [21]. Population density for each site was calculated separately using by the sightings and call counts data. During breeding season calls were more prominent than direct sighting, so call counts method was also used for population estimation.

Estimation from direct Sighting

Estimation of Grey francolin population was carried out by direct sighting of the birds along the transects. For every observation, sighting angle (perpendicular distance from observer to bird) was recorded and distance

from observer to the francolin was measured.

Estimation from call count method

For estimation of Grey francolin population call counts method [22] was used. Calls of Grey francolin were counted in each sample area early in the morning and evening. Grey francolin was assumed to have pairing for mating during spring season. Each call was recorded individually by assuming that male grey francolin produced calls especially during breeding season. During observations utmost care was taken in data recording to avoid overlapping as only those birds on transect were recorded who fall under transect line.

Both sighting and call count methods of population assessment were used to compare the effectiveness of methods under CSWS and DDGR conditions. Forty permanent line transect of 0.5- 3 km length was used. Transect line was walked with uniform speed for four successive days during different month of study period in the morning hours from 5 am to 8 am and the evening hours from 5 pm to 8 pm. Numbers of grey francolin for each transect walk were recorded from sighting and calls. To work out the total number of calls and sightings for each month and for each time period (morning / evening), respective data for different transects were averaged / combined. Transect length being variable, frequencies obtained from sighting and calls

for different time periods and months were directly compared to observe the differences in population of grey francolin between different sites/habitats by ANOVA at 0.05 level of significance as used by [23].

For population estimation, DISTANCE version 6.0 was used [24, 25, 26]. The priori models (Key function/ sries expansion) used to arrive at density estimates included; Uniform - cosine, Half normal-Hermite polynomial and Hazard rate - Simple polynomial. Model selection was at the minimum of Akaike information criterion (AIC). As AIC provides a relative measure of fit. Distance also provides the ΔAIC values, with the AIC of best fitted model which are the values of AIC subtraction. Thus change in AIC is equal to zero for the best model [26]. The density estimation was made by pooled data of over all individuals encountered at transects.

Results and Discussion

Population estimation of Grey francolin

Area of Grey francolin habitat in scrub forest considered for distance sampling extended from Dhok Shela (32° 47.869" N, 72°48.659 "E) to Khokhar Zer Dam (32° 49.591 "N, 72°52 .023 "E), in CSWS and from Pathial Pahar (32° 50.131 N, 73° 16.053 E) to Kalewali (32° 51.544" N, 73° 12.651" E) in DDGR (Table 1). Total 40 transects were laid in both areas and Grey francolin population were recorded both by direct sighting and calls counts.

Table 1. Selected study sites for Grey Francolin population estimation in Salt Range.

Study Area	Location	Habitat Type	Elevation	Coordinates	
CSWS	Dhok Sehla	Natural Forest	697m	32° 47.869 N	72°48.659 E
	SubedaraWali Mori	Cultivated Field	708m	32° 47.775 N	72° 48.582 E
	Bella	Open land	539m	32° 49.595 N	72° 52.127 E
	Khokhar Zer Dam	Wetland	687m	32° 49.591N	72°52 .023 E
DDGR	Pathial Pahar	Natural Forest	395m	32° 50.131 N	73°16.053 E
	Nathoot	Cultivated Field	463m	32° 51.761 N	73° 11.941 E
	Dhial	Open land	505m	32° 49.883 N	73° 09.406 E
	Kalewali	Wetland	460m	32° 51.544N	73°12 .651 E

Population density in salt range by direct sighting

Estimated population density by direct sighting was 3.07 individual ha⁻¹ (95% CI: 0.47 and 0.72) from Dhok Shela, 1.85 individual ha⁻¹ (95% CI: 0.48 and 0.82) from Subedarawali Mori, 3.23 individual ha⁻¹ (95% CI: 0.45 and 0.71) from Bella, 3.19 individual ha⁻¹ (95% CI: 0.45 and 0.65) from Khokhar Zer Dam. Population were recorded through sighting in DDGR; 2.09 individual ha⁻¹ (95% CI: 0.50 and 0.90) from Pathial Pahar, from Nathoot 2.51 individual ha⁻¹ (95% CI: 0.45 and 0.68), from Dhial 2.45 individual ha⁻¹ (95% CI: 0.44 and 0.70)

and from Kalewali 2.47 individual ha⁻¹ (95% CI: 0.45 and 0.68). Population density by sighting was the highest (3.23 individual ha⁻¹) at Bella while lowest at Subedarawali Mori (1.58 individual ha⁻¹). In DDGR by sighting population was highest from Kalewali 2.47 individual ha⁻¹ and lowest at 2.09 individual ha⁻¹ from Pathial Pahar. Effective width of transect for sighting in CSWS was 41.12 (Dhok Shela), 44.38 (Subedarawali Mori) 25.67 (Bella), and 24.69 (Khokhar Zer Dam). In DDGR, effective width of transect for sighting was 43.74 (Pathial Pahar), 25.13 (Nathoot), 25.37 (Dhial), 25.05 (Kalewali) (Table 2).

Table 2. Summary of model used and fit in line transect analysis of Grey Francolin by sighting.

Name of Sites	Location	Population Estimation Model	AIC	ESW/EDR	D/Hac
CSWS	Dhok Sehla	Uniform / cosine	289.58	41.12	3.074
	Subedara Wali Mori	Uniform / cosine	259.67	44.38	1.856
	Bella	Uniform / cosine	221.54	25.67	3.231
	Khokhar Zer Dam	Uniform / cosine	211.89	24.69	3.199
DDGR	Pathial Pahar	Uniform / cosine	306.80	43.74	2.097
	Nathoot	Uniform / cosine	168.63	25.13	2.516
	Dhial	Uniform / cosine	161.96	25.37	2.458
	Kalewali	Uniform / cosine	198.59	25.05	2.476

Population density in salt range by calls

By calls population estimation from CSWS was 2.87 individual ha⁻¹ (95% CI: 0.56 and 1.00) from Dhok shela, 1.59 individual ha⁻¹ (95% CI: 0.51 and 0.88) from Subedarawali Mori, 2.17 individual ha⁻¹ (95% CI: 0.50 and 0.96) from Bella, 1.88 individual ha⁻¹ (95% CI: 0.44 and 0.69) from Khokhar Zer Dam . In DDGR, by calls 1.99 individual ha⁻¹ (95% CI: 0.50 and 0.90) from Pathial Pahar, from Nathoot 1.25 individual ha⁻¹ (95% CI: 0.45 and 0.92), from Dhial 2.45 individual ha⁻¹ (95% CI: 0.43 and 0.75) and from Kalewali 1.10 individual ha⁻¹ (95% CI: 0.42 and 0.79). By calls highest population was

recorded from Dhial 2.45 individual ha⁻¹ and lowest from Kalewali 1.10 individual ha⁻¹ in DDGR. By call count method, population was the highest at Dhok sehla (2.87 individual ha⁻¹) while lowest at (95% CI: 0.51 and 0.88) at Subedarawali Mori (1.59 individual ha⁻¹) in CSWS. For calls effective width of transect was 45.92 (Dhok Shela), 47 was at (Subedarawali Mori), 48.54 (Bella), and 33.54 (Khokhar Zer Dam) in CSWS. In DDGR, effective width of transect for calls was 43.74 (Pathial Pahar), 45.69 (Nathoot), 34.35 (Dhial) and 35.0 (Kalewali) (Table 3).

Table 3. Summary of model used and fit in line transect analysis of Grey Francolin by calls.

Name of Sites	Location	Population Estimation Model	AIC	ESW/EDR	D/Hac
CSWS	Dhok Sehla	Uniform / cosine	409.11	45.92	2.879
	Subedara wali		337.05	47.14	1.599
	Mori	Uniform / cosine	262.25	48.54	2.179
	Bella		183.02	33.54	1.885
	Khokhar Zer		306.80	43.74	1.997
	Dam		194.06	45.69	1.619
DDGR	Pathial Pahar	Uniform / cosine	168.44	34.35	1.259
	Nathoot		161.32	35.00	1.101
	Dhial				
	Kalewali				

There was significant difference in population densities among different sites and habitat types in both study area of CSWS (ANOVA: $F = 6.59$; $df = 3$; $P = 0.008$) and DDGR (ANOVA: $F = 6.59$; $df = 3$; $P = 0.042$) (Table 4). The conventional distance sampling analysis engine was used which models possibility to detect as a distance function from transect line. Distance sampling (Buckland et al., 2001) is an addition in sampling of an area, in which estimation of the birds are made inside fixed range. The expansion in distance sampling gives the chance that some of the birds are not counted present in the area. The detection probability of an animal decreases

with increasing distance from transect line (Thomas et al., 2010).

Highest detection probabilities by sighting were 0.71 at Dhok sehla (Figure 2), 0.63 Subedarawali Mori 0.57 at Bella and 0.54 at Khokhar Zer Dam. Probability of detection by calls was 0.76 at Dhok sehla (Figure 3), 0.67 at Subedarawali Mori, 0.69 at Bella, 0.55 Khokhar Zer Dam. In DDGR detection probabilities by sighting were 0.67 at Pathial Pahar (Figure 4), 0.55 at Nathoot 0.56 at Dhial and 0.55 at Kalewali , while by calls were 0.67 at Pathial Pahar (Figure 5), 0.65 at Nathoot , 0.57 at Dhial and 0.58 at Kalewali.

Table 4. ANOVA table showing difference in population density of Grey Francolin between study sites.

Study Site	ANOVA-Single Factor							
	Groups	Count	Sum	Average	df	P-value	F-critical	Level of Sig.
CSWS	Subedarawali Mori	2	252	126	3	0.008	6.59	0.05%
	Dhok Sehla	2	400	200				
	Bella	2	250	125				
	Khokhar Zer Dam	2	207	103.5				
DDGR	Pathial Pahar	2	180	90	3	0.042	6.59	
	Nathoot	2	248	124				
	Dhial	2	155	77.5				
	Kalewali	2	151	75.5				

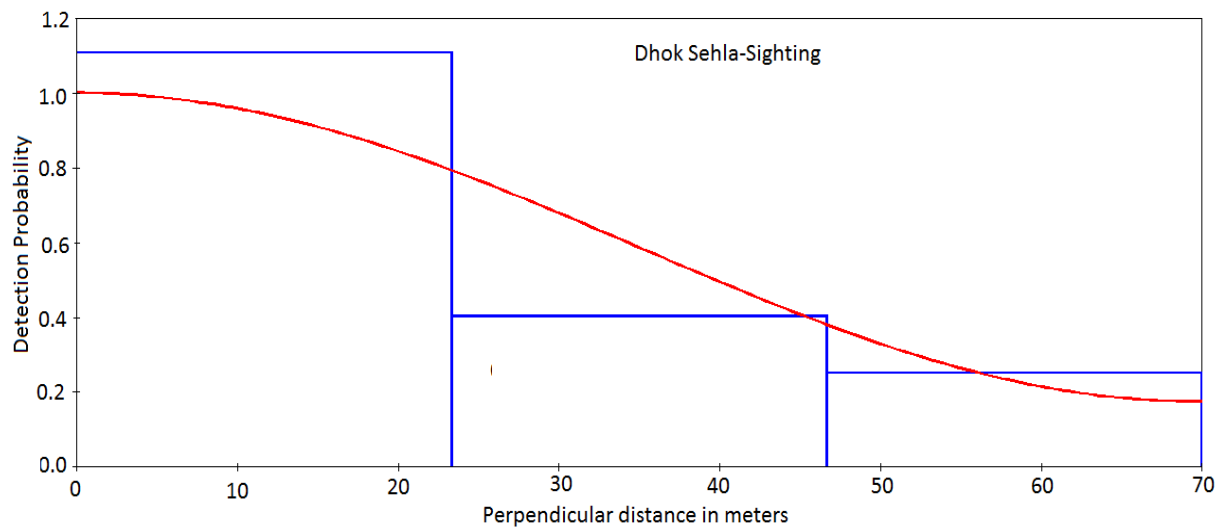


Figure 2. Distance function curve for Grey Francolin sightings in natural forest habitat in Chumbi Surla Wildlife Sanctuary.

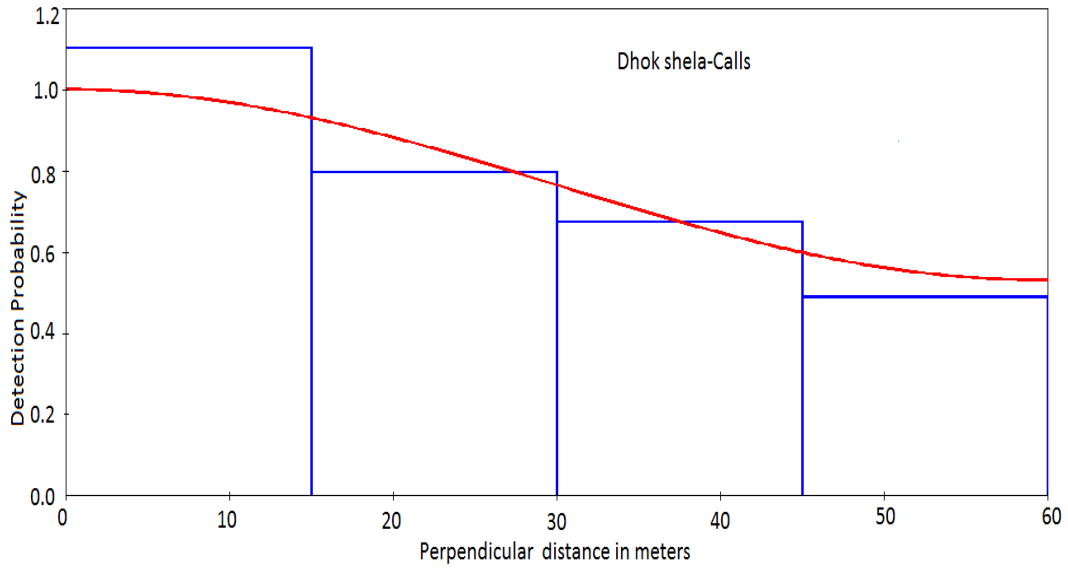


Figure 3. Distance function curve for Grey Francolin calls in natural forest habitat.

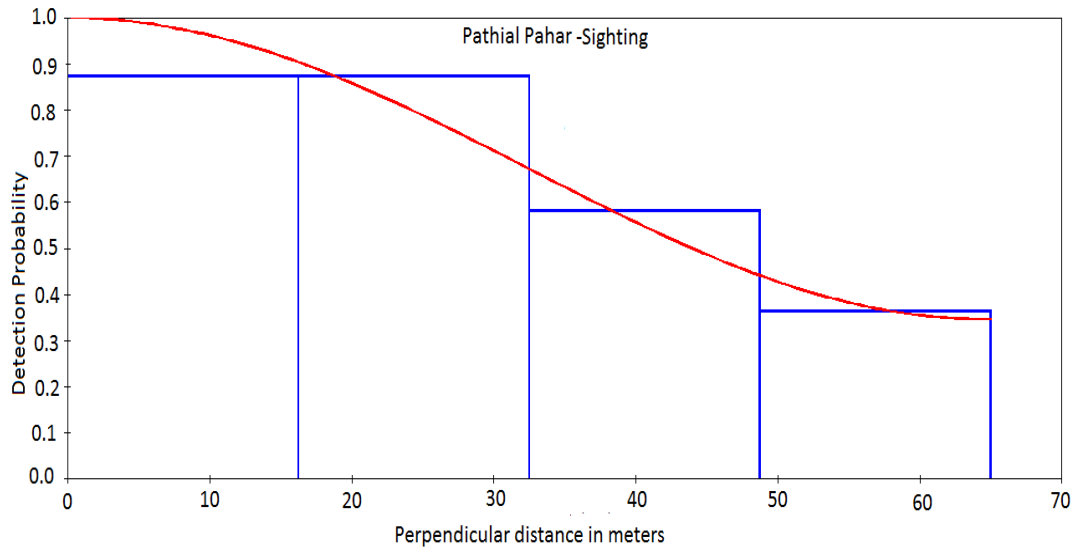


Figure 4. Distance function curve for Grey Francolin sightings in natural forest habitat in Diljappa Domeli Game Reserve.

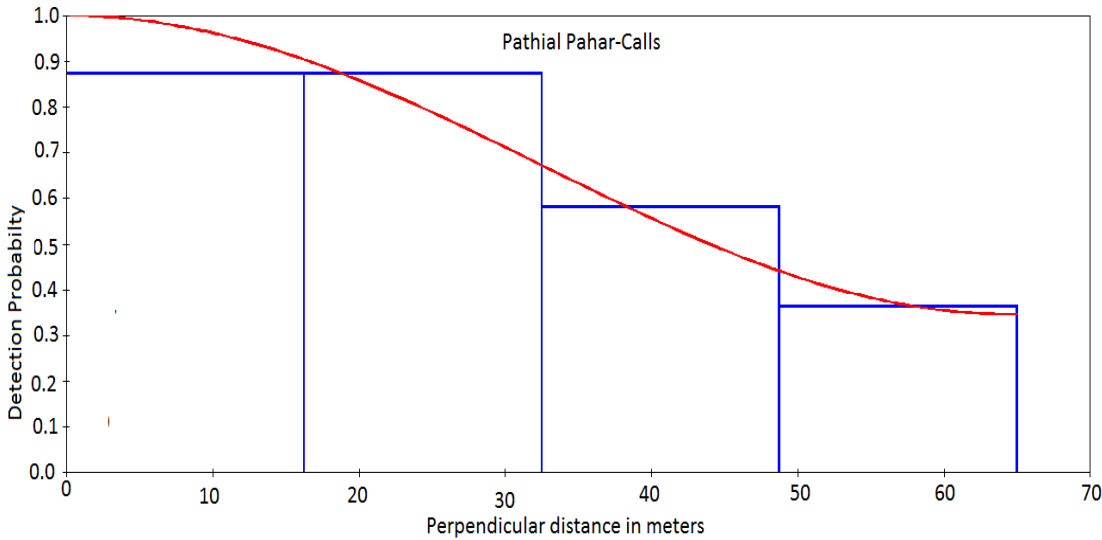


Figure 5. Distance function curve for Grey Francolin calls in natural forest habitat, Diljabba Domeli Game Reserve.

Discussion

The data collected on the population distribution of Grey francolin revealed that this species was not evenly distributed in different sites of the study area having different elevations and vegetation which is evident from difference in its population density at different locations and habitats of both study areas. Highest population density recorded by sighting in CSWS was at Bella (3.23 individual ha⁻¹) that was an open land with sparse vegetation in the middle of the area, which increased visibility of birds during daily activities and thick vegetation on its boundaries provides cover for them to live in open land habitat.

Lowest population in CSWS was at Subedarawali Mori (1.58 individual ha⁻¹) that was cultivated cropland having different cropping pattern during year. In a study conducted in Lal Suhanra National Park (LSNP) [27], reported very low densities of Grey francolin i.e. 0.83 and 0.60 individuals / km² in intensively protective desert tracts. [28] estimated 7.44 birds / km² in LSNP under same desert conditions. According to this study variation in frequencies of calls were prominent as compared to sighting in same area. The difference in population

density figures of Grey francolin in this study and that reported previously for LSNP can be associated to variation in sampling designs of both studies. [29] has been reported for the Mannar, Sri Lanka, a relatively low density of population of 3.5 / km² birds for the Grey francolin. Temperature is considered to be an important factor in deciding the populations of francolins. However new brooders are also matured in summer and ready for calls which causes increase in the population density. Sufficient amount of food also play critical role, besides these factor. For decrease in population of grey francolin, the possible reason seems to be illegal hunting, netting, grazing, industrialization and urbanization. Seasonal fluctuations also affect the population of francolin species. Overall species maintain low population during winter. But the population density of grey francolin starts rising gradually in summer.

By calls method, the highest density was found at Dhok Sehla (2.87 individual ha⁻¹ (95% CI: 0.56 and 1.00), that was natural forest while again lowest density was in Subedarawali Mori at 1.59 individual ha⁻¹ shows that Grey francolin has low

preference for this type of habitat that has only cultivated crops without water source and scarce natural vegetation in CSWS.

In DDGR by sighting, highest density was estimated for Kalewali (2.47 individual ha⁻¹) which was a wetland area with thick natural vegetation on its boundaries. This indicates that species prefers the habitat having water and thick vegetation, which provides cover for them. Lowest record was (2.09 individual ha⁻¹) from Pathial Pahar that was a pure natural forest but have disturbance because of road construction around it during the study period. By calls method, highest density was at Dhial (2.45 individual ha⁻¹) that was an open land with natural vegetation around it while lowest calls was recorded from Kalewali (1.10 individual ha⁻¹). Population density recorded by sighting and by calls show difference among different sites. A similar study carried in the agricultural land and wetland in the Faisalabad (Central Punjab, Pakistan) utilizing call count method, suggested average densities of 395 birds/ km² having range from 90 – 655 birds for the Grey francolin did not tried to give density values [30].

The results indicated that Grey francolin prefers areas with vegetation cover and water source which provide better habitat to live in a particular place. These findings are supported by [31] proposed that high density of wild Grey Partridge (*Perdix perdix*) were related with the presence of herbaceous land, unmanaged wild areas and farm land around it in Prague, the Czech Republic. Moreover, estimations of density, analysis of home range, sampling of weed seed and study of plant structure factors affect the francolin's habitat preference.

Transect sampling and call counts have been utilized for population studies in different francolin species [32, 33, 34, 28, 35] to reach at some reliable estimates on the populations. Call counts in spring season

were considered as more dependable sign to record the breeding pairs/ birds in population of Grey partridge (*Perdix perdix*) [36], though such estimates were not considered reliable for other parts of the year due to different climatic conditions. The technique of counting the birds through call affected by changes in season, temperatures, conditions of availability of habitat and food, male activity of reproduction as well as density of males [37, 38]. Such problems have been addressed earlier in call count method as relevant to pheasants [36, 37, 39]. The number of the calling birds has been reflected by call counts, and therefore stated as the frequency of calling males [40, 41] or birds in pair form [42, 43], of distinct bird species. However, under the conditions of Salt Range, in CSWS and DDGR, in scrub forest the sighting on the transect line for estimations of population seems to be a more reliable method particularly, when the width of the transect belt is limited. Results obtained by calls count are different from the results of direct sightings. This difference may be due to camouflage ability of the grey francolin in different conditions. [7] concluded that sightings of the francolins species, living under thick cover of plants, mainly based upon searching a shelter along some vegetation for its protection, and possessing shy behavior under a higher level of disturbance adds difficulties in the transect sightings. During the study, groups of 4 to 12 francolins were observed in CSWS and DDGR, particularly shortly before breeding season. [3, 29] also reported that during non-breeding season, Grey francolins are mostly found in coveys form of 4-8 birds or family groups were also known, which during breeding season makes pairing. Populations of Grey francolin recorded from CSWS were found higher as compared to DDGR, probably because of more protection of the area as sanctuary,

where grey francolin assumed more protected.

According to present study, being an important habitat of Grey francolin, Salt Range (CSWS and DDGR), needs more attention through formulation of an effective conservation plan for the species. Habitat degradation activities as agricultural intensification/fuel wood collection should be controlled in its habitat. Land encroachment and clearing for the purpose of commercial poultry farming, housing schemes, and other business oriented disturbances must be checked and prohibited. Illegal hunting of the species must be strictly prevented through public awareness and also by observing and implementing the Punjab Wildlife Act and Rules 1974. Shooting needs to be regulated by an official body to ensure sustainable harvests of grey francolin in CSWS and DDGR, Salt Range. Wildlife staff should make more efficient and effective efforts for the protection of wildlife in general and Grey francolin in particular to conserve this precious game bird, sustaining its healthy population in this region.

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Authors' contribution

Conceived and designed the experiments: S Khalil. Performed the experiments: S Khalil & M Anwar. Analyzed the data: S Khalil & M Anwar. Contributed reagents/materials/analysis tools: S Khalil, M Anwar & I Hussain. Wrote the paper: S Khalil.

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