



Threats Affecting Grey Francolin (*Francolinus pondicerianus*) Population in Salt Range, Punjab, Pakistan

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Abstract

Grey francolin (*Francolinus pondicerianus*) is a medium size game bird, also serving as biological control agent. 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 major threats affecting Grey francolin population in the Salt Range. Data was collected through questionnaire survey (n=100) from hunters, local people and wildlife staffs. Major threat reported in CSWS included; 38% by illegal hunting , 18 % by agriculture activities, 18% by land clearing, 06% by trade, 06% by habitat destruction, 04% by predation, 04 % by live stock pressure, 04% by fuel wood collection, and 02% by stone crushing. Similarly major threat reported in DDGR were; 46% by illegal hunting , 18 % by agriculture, 16% by fuel wood collection, 04% by trade, 04% by predation, 04 % by live stock pressure, 04% land clearing, 02% by habitat destruction, and 2% by stone crushing. Among all these threats, illegal hunting was found to be major threat in both study sites, followed by agriculture practices, fuel wood collection and predation. Results would help in conservation of Grey francolin, ultimately helping in sustaining its population in the Salt Range.

Key words: Grey francolin; Habitat; Human Activities; Population; Salt Range; Threats.

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1. Introduction

Grey francolin (*Francolinus pondicerianus*), formerly called grey partridge, is found in the open and arid parts of the Asia [22, 39] as in Pakistan, southeastern Iran, India, Bangladesh and northern Sri Lanka. It is a typical grassland game bird, found in the plain, largely treeless area. Its origin allowed it to live easily in cultivation, where it can find cover, food, and ground for nesting [14,19, 47].

Grey francolin is native bird of Pakistan [4, 21, 39] but under different environmental conditions also show some local movements upto 81 km seasonally. Grey francolin is somewhat larger than black francolin in size about 33-36 cm [13]. In grey francolin both sexes are alike in plumage, upper parts of the body are grayish-brown, boldly streaked with pale buff and finely barred with black and chestnut. Under parts are buff, prominently barred with black; outer rectrices chestnut. Throat is buff, outlined by a narrow black band, creating a gorget. The outer tail feathers are crossed barred brown and pale - buff. The bill dark gray, iris hazel, legs and feet dull red and its wingspan is 48-52 cm [39]. Juveniles are without black necklace and head pattern is less conspicuous in them. The immature birds have paler throat-patch, totally enclosing black border and are minor rufous on forehead. Chicks in coloration are light grey [17]. Sexes are indistinguishable in coloration in the field and but males can be distinguished from the females by the presence of metatarsal spur and larger mass [21]. Grey francolin has played a prominent part in shooting and hunting from past [10]. This species is also considered as friend of the farmers as it is believed to consume a variety of invertebrates including, insects, their eggs, larvae and pupa, which are harmful to crops and, therefore, work as effective bio controlling operator [7, 29]. According to Khan [23] it is an excellent game and delicious table bird, also used as a cage and fighting bird. They are generally found in open farmlands as well as in small woodland forest where shrubs are dominant and based on their calls their common name are teetar [8, 22). Generally found below 610 m but occasionally as high as 1400 m [39]. It is also reported that grey francolin inhabits wide array of arid habitats from semi desert grasslands and thorny scrub to tropical thorn forests and sometimes also found in frequents cultivation areas and villages [13].

In Pakistan, Grey francolin avoids intensively cultivated and heavily populated areas and is most plentiful in undisturbed tropical thorn forest habitat. It is much better adapted to arid conditions than the black francolin and it is a widespread game bird of agro-silvicultural systems of Pakistan [39]. The grey francolin plays a significant role in natural food web. Foxes and crows predate on this species at adult and eggs or juveniles, respectively [43]. According to [49], raptors are the main predators of adult francolins, although red fox, coyotes and weasels also prey on adults. Since insect based food constitutes a significant part of the diet of the francolin species [21, 29], therefore, they play a role of biological control agent of insect pests in agro-ecosystems.

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 [39, 40]. Grey francolin forms a monogamous pair bond, but the female does all the incubation. Nesting is mostly in spring, eggs being found in March and April, but a few pairs nest in September and October after the monsoon rains. The eggs are glossy, pointed at one end and vary from pale brownish to pale buff unmarked. Incubation takes 18 to 19 days and the chicks hatch synchronously. Both parents tend the young chicks after hatching [39].

Grey francolin is found to western Asia, across Europe and in some parts of northern United States of America and in south part of Canada [8, 14, 15, 22]. It has a vast distribution range thought to be around 10,000,000 km² [8, 22]. In 1970's it was introduced in United Arab Emirate and in twentieth century it was introduced in Oman. Now, it is successfully established there due to its prolific breeding potential [18, 24].

In Pakistan, Grey francolin is widely distributed from the Indus valley in the west to the foothills of the Himalayas in the south. It occurs throughout the Lasbela and the lower hills of Makran districts in Balochistan, Thar desert of Sindh, Salt Range, Pothwar Plateau and Thal desert of the Punjab and around Cherat and in parts of Kohat districts of Khyber Pakhtun Kwa. They avoid higher hills and are absent around Quetta, but share the same habitat with the See-see francolin in Kohat, Cherat and the Salt Range. They share the same habitat with black francolin in irrigated plantations and the outer slopes of the Margalla hills [39]. The presence of grey francolin is also reported around Mangla Reservoir in Azad Jammu & Kashmir [26]. Grey francolin is rarely found above an altitude of 1200 m above sea level in Pakistan and usually found feeding on bare soil or low grass cover in open and scrub country [38].

The decline of grey francolin has been reported in the past, with the species as an indicator species for farmland ecosystems and as a game bird. Increased use of pesticides caused by the agricultural expansion and habitat degradation can be cited as the main causes behind its decline ([13]. A rapid decline in its natural habitat has been reported by Roberts [39], through its food loss, excessive predation, habitat destruction, intensification of agricultural practices and other pressures on scrub forests for their use in fodder, timber wood and fire wood needs. The grey francolin has seen an overall decline in its population in last 10 years as high as 79%, but has a status as Least Concern on the Red List. However, whilst the species has faced declines, on the IUCN Red List of threatened species, it is not listed yet. One of the reasons behind this is that, it has a broad area of distribution [8].

Unfortunately, very few studies exist which address the grey francolins found in different parts of the Pakistan. None of those carried out in Salt Range, one of the major areas of gray francolin distribution in Pakistan. Keeping in view the declining trend in population of grey francolin, the current study was conducted in Salt Range, Punjab Pakistan. This study generated information about preferred habitat, population density, distribution pattern in different habitat types and breeding aspects including; breeding season, clutch size, incubation period and hatching success of grey francolin in the study area. It would provide essential scientific data required for the conservation of grey francolin, ultimately helping in sustaining the population of this important game bird in the Salt Range. The study was conducted with the objective; identify the natural as well as anthropogenic factors that affect the habitat and population of this bird in the Salt Range.

2. Materials and Methods

2.1. Study Site

The study was conducted at Chumbi Surla Wildlife Sanctuary (CSWS) and Diljabba- Domeli Game Reserve (DDGR) located in the Salt Range (Figure 1). The Salt Range is an east-west turning point of communication

about 175 km long in north Punjab consisting of Khushab, Mianwali, Jhelum and Chakwal districts [25]. It extends between 32°41' - 32°56' N and 71°50' to 74°E and forms an impressive scarp, from 250m-1520m in elevation. Sakesar top is the highest point in the Salt range with an altitude of 1524 m [5].

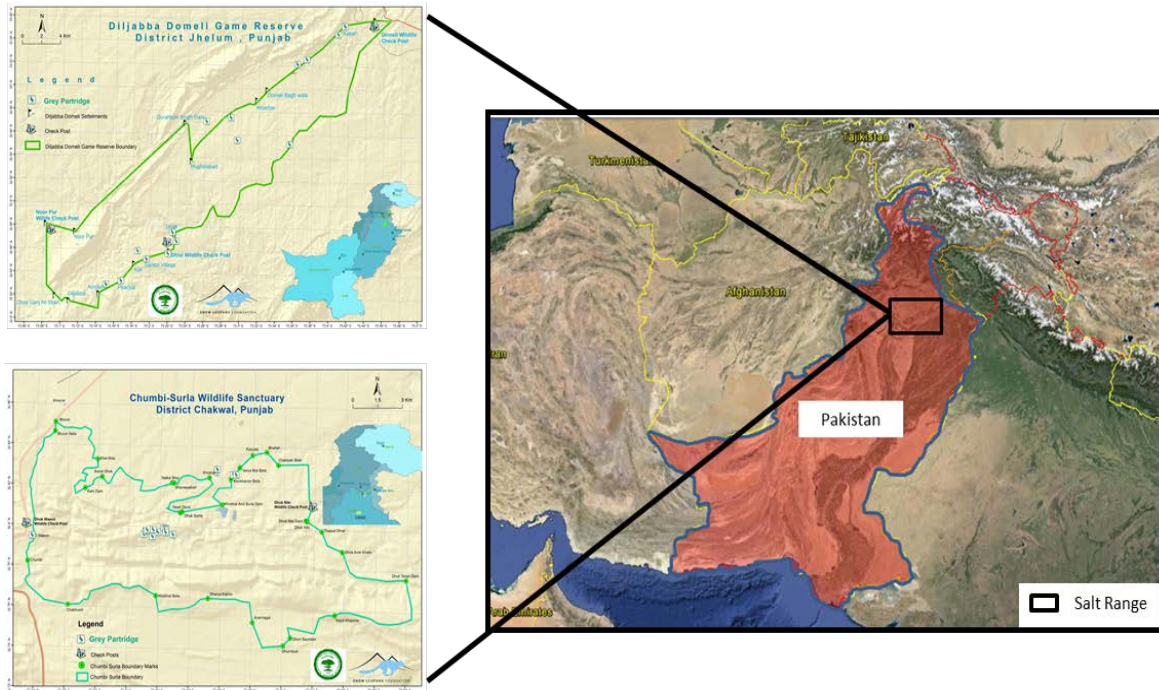


Figure 1: Map showing study area and sites selected for data collection within Salt Range, Punjab, Pakistan.

Major habitat type in the area is arid sub-tropical, semi-evergreen scrub forest [39]. The climate of the area is continental type as sub-tropical and sub-humid. Thirty year average precipitation was 853 mm. There are two rainy seasons: the monsoon rains start by about mid July and end until the mid of September or summer season. During July and August most of the precipitation is received. In January, winter rains begin and continue up to beginning of March. January being the coldest and June the hottest month of the year with mean monthly temperature ranges from 5.9° C to 38.4 ° C. During winters usually in December and January the temperature often drops to below zero degree [5].

Overgrazing, extraction of heavy firewood and past abuse, have removed many of the forests and most of the existing ones degraded. People have rights to collect firewood (dead and dry), and graze their cattle. Grass cutting is also mostly allowed. Lopping is not allowed anywhere. However, felling and illegal cutting of tree are common [41].

Cultivation for livelihood is the main occupation of the people of the Salt Range. Land ownerships are small and production of crop depends on rainfall. Major crops are lentils, groundnut, grams and wheat. Rearing of cattles

is also common [20].

Chumbi Surla Wildlife Sanctuary is situated in Chakwal Town about 20km south west at 32° 47' N, 67° 42' E which is heart of the Salt Range at elevation of about 460-1050m. Total area of Chumbi Surla Wildlife Sanctuary is about 55,987 ha [6]. The sanctuary has importance due to having different habitat types including; wetlands, torrents, farm lands and hills. Presence of these various ecological regions allowed the sanctuary to hold a variety of wild animals. The sanctuary has climate, which is dry sub-tropical with cool winters and hot summers. Diljabba- Domeli Game Reserve is located in Jhelum district at 32° 54'N and 73° 09'E. Total area of the game reserve is 118,106 ha with 600 m elevation and also part of Salt Range [5].

2.2. Threat Survey

This study was based on questionnaire survey. Primary and secondary sources of data were used to collect information about threats affecting grey francolin's population and its habitat in CSWS and DDGR. Primary data sources were the field observations, formal and informal interviews with the local people and focus group discussions. The sources of secondary data were hunters and Wildlife staff. Questionnaires were given to the literate people to solve and illiterate people were interviewed. The surveys were conducted in randomly selected area in both CSWS and DDGR. In total 100 questionnaires were filled from CSWS and DDGR, during which different questions were asked from the peoples, whose age were divided into the categories; 15-25, 25-35, 35-45, 45-55, 55-65 and 65-75 years and had different occupation in the study area. Questionnaire was consisted of two parts. First part of questionnaire was designed to collect information about age and occupation of the respondent (Person who interviewed or filled the questioner) who lived within and outside of the protected areas of CSWS and DDGR. Second part was about population trend, major threats, hunting methods, trade life stage and predator of the grey francolin in study area. Conservation measures suggested on the basis of results obtained.

2.3. Data analysis

Data was statistically analyzed by using SPSS 16 software to test the hypothesis that all threats e.g., hunting, trade, habitat degradation, predation, livestock pressure, agriculture, fuel wood collection, land clearing and stone crushing, contributed equally or not. Chi square test was used [36] in which, null hypothesis was that, population of Grey francolin is effected by different threats equally in the study areas (CSWS and DDGR), while alternative hypothesis was, that population of grey francolin is not affected by different threats equally. All other calculations were represented in percentage. Level of significance was 0.05.

3. Results

3.1. Threat identification of Grey francolin in Chumbi Surla Wildlife Sanctuary (CSWS) and Diljabba Domeli Game Reserve (DDGR)

This study was based on questionnaire survey where information about various threats to population and habitat of Grey francolin was collected in both study sites.

Table 1: Threat assessment of Grey francolin in Chumbi Surla Wildlife Sanctuary.

S.No.	Questions for Threat Assessment	Number of respondents	Percentage (%)
1	Age of Respondents		
	15-25	10	20
	25-35	7	14
	35-45	7	14
	45-55	13	26
	55-65	5	10
	65-75	8	16
2	Occupation		
	Farmer	17	34
	ShopKeeper	7	14
	Live Stock Owner	6	12
	Hunter	11	22
	Job	5	10
	Wildlife Watcher	4	8
3	Population Trend of Grey francolin		
	Increasing	18	36
	Decreasing	19	38
	Stable	7	14
	Unknown	6	12
4	Hunting Methods		
	Shooting	27	54
	Netting	8	16
	Trapping	15	30
5	Trade Life Stage		
	Egg	11	22
	Chick	21	42
	Sub-Adult	13	26
	Adult	5	10
6	Predator of Grey francolin		
	<i>Canis aureus</i>	2	4
	<i>Accipiter nisus</i>	18	36
	<i>Herpestes edwardsii</i>	14	28
	<i>Echis carinatus</i>	3	6
	<i>Vulpus vulpus</i>	10	20
	<i>Felis chaus</i>	1	2
	<i>Varanus indicus</i>	2	4

3.1.1. Age:

For the survey, respondents were categorized into six age group i.e. 15-25, 25-35, 35-45, 45-55, 55-65 and 65-75 years. In Chumbi Surla Wildlife Sanctuary 20% respondents belonged to age group of 15-25, 14% of 25-35, 14% of 35-45, 26 % of 45-55, 10% of 55-65 and 16 % of 65-75 (Table 1). In Diljabba Domeli Game Reserve, 14 % respondents were of age group of 15-25, 24% of 25-35, 28% of 35-45, 18 % of 45-55, 10% of 55-65 and 6 % of 65-75 (Table 2).

3.1.2. Occupation

In both protected areas, most of the respondents were engaged in agriculture, livestock rearing, government jobs and shopkeeper. In Chumbi Surla Wildlife Sanctuary, 34% respondents were farmers, 14% shopkeepers, 12% livestock owners, 22% hunters, 10% Government employees and 8 % were in Fisheries and Wildlife Department. In Diljabba Domeli Game Reserve, 18 % were farmers, 22% shopkeepers, 36% livestock owners, 8% hunters, 8% Government employees and 8 % engaged in Fisheries and Wildlife Department .

3.1.3. Population trend of Grey francolin

In Chumbi Surla Wildlife Sanctuary, 36% respondents were of the view that population of grey francolin is increasing after designation of the area as sanctuary, while 38% said that population is declining and, 14 % said that population is stable in sanctuary areas due to control hunting, especially in core zone where all such activities are prohibited. In Diljabba Domeli Game Reserve, 30% respondents said that population is increasing, according to. 44% population is decreasing, 16 % people said that population is stable in reserve due to controlled hunting and 10% people were unaware.

3.1.4. Major Threats to Gray francolin population and its habitat in the study area

Keeping in view the declining trend of grey francolin in the study area, major threats affecting grey francolin in both CSWS and DDGR were identified as hunting, trade, habitat destruction, predation, livestock pressure, agriculture, collection of fuel wood, land clearing and stone crushing. Major threat in Chumbi Surla Wildlife Sanctuary included; 38% by illegal hunting , 06% by trade, 06% by habitat destruction, 04% by predation, 04 % by live stock pressure, 04% by fuel wood collection, 18% by land clearing, 02% by stone crushing and 18 % by agriculture in the protected areas. Similarly, these threat in Diljabba Domeli Game Reserve were; 46% by illegal hunting , 04% by trade, 02% by habitat destruction, 04% by predation, 04 % by livestock pressure, 18 % by agriculture, 16% by fuel wood collection, 04% land clearing and 2% by stone crushing (Figure 2).

Chi square test was used to find out whether all threats contributed equally or not in both CSWS and DDGR. Level of significance was 0.05 % with 8 degree of freedom. The Chi-square value is a single number that adds up all the differences between actual data and the data expected if there is no difference. Greater differences between expected and actual data produce a larger Chi-square value. The larger the Chi-square value, the greater the probability that there really is a significant difference [36].

Table 2: Threat assessment of Grey francolin in Diljabba Domeli Game Reserve.

S.No.	Questions for Threat Assessment	Number of respondents	Percentage (%)
1	Age of Respondents		
	15-25	7	14
	25-35	12	24
	35-45	14	28
	45-55	9	18
	55-65	5	10
	65-75	3	6
2	Occupation		
	Farmer	9	18
	ShopKeeper	11	22
	Live Stock Owner	18	36
	Hunter	4	8
	Job	4	8
	Wildlife Watcher	4	8
3	Population Trend of Grey francolin		
	Increasing	15	30
	Decreasing	22	44
	Stable	8	16
	Unknown	5	10
4	Hunting Methods		
	Shooting	29	58
	Netting	14	28
	Trapping	7	14
5	Trade Life Stage		
	Egg	5	10
	Chick	30	60
	Sub-Adult	5	10
	Adult	10	20
6	Predator of Grey francolin		
	<i>Accipiter nisus</i>	37	74
	<i>Herpestes edwardsii</i>	5	10
	<i>Echis carinatus</i>	2	4
	<i>Varanus indicaus</i>	6	12

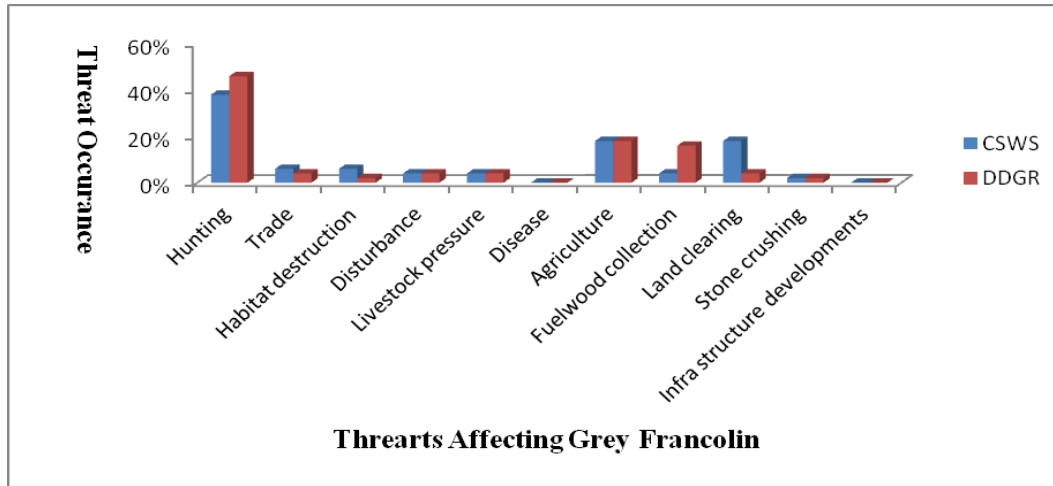


Figure 2: Threats faced by Grey Francolin in study area of CSWS and DDGR.

In present study, actual values recorded in CSWS for various categories of threats; 19(hunting), 3 (trade), 3 (habitat destruction), 2 (predation), 2 (livestock pressure), 9(agriculture), 2 (fuelwood collection), 9 (land clearing) and 1(stone crushing). Similarly, actual values of threat in DDGR were; 23 (hunting), 2 (trade), 1 (habitat destruction), 2 (predation), 2 (livestock pressure), 9 (agriculture), 8 (fuel wood collection), 2 (land clearing) and 1(stone crushing). (Table 3). Value of Chi-square for the different threats in CSWS and DDGR indicating that all threats are significantly different from each other and did not contribute equally. Pearson Chi square value $X^2=0.292$ is greater than 0.05. So, we accept our null hypothesis that threats and location are independent of each other and there is no significant difference between threats with respect to area. Different threats effect differently on grey partridge population in the study area (Table 4).

3.1.5. *Hunting methods*

Different hunting methods used for Grey francolin in the study area included; shooting with bore guns, trapping by setting traps in potential feeding sites of grey francolin, hunting with trained dogs and use of nets. In Chumbi Surla Wildlife Sanctuary, major hunting method as told by respondents was: 54% shooting, 16% major hunting practice, followed by 28% netting and 14 % trapping.

3.1.6. *Predators of Grey Francolin*

Predation of Grey francolin by different groups of animals was commonly reported in the area. Major predators reported during study period included; jackal (*Canis aureus*), Hawk (*Accipiter nisus*), Mongoose (*Herpestes edwardsii*), Jungle cat (*Felis chaus*) Snake (*Echis carinatus*), Red fox (*Vulpus vulpus*) and Monitor lizard (*Varanus indicus*).

According to local people and wildlife staff different predator affect grey francolin population during different period of the year. Some species like monitor lizard, snake and red fox prey upon grey francolin during breeding season as they feed on the eggs by jackal, mongoose, jungle cat and hawk was common after breeding season of Grey francolin. In Chumbi Surla Wildlife Sanctuary, predation caused by different animals by people opinion

was: 4% by jackal, 36% by hawk, 28% by mongoose, 6% by snake, 20% by red fox, 2% by jungle cat and 4% by monitor lizard. In Diljabba Domeli Game Reserve, 74% by hawk, 10% by mongoose, 4% by snake, and 12% by monitor lizard.

Table 3: Threats to Grey francolin population in Chumbi Surla Wildlife Sanctuary and Diljabba Domeli Game Reserve.

Location		CSWS		DDGR	
S. NO.	Threats Categories	Observed N	Percentage (%)	Observed N	Percentage (%)
1	Hunting	19	38	23	46
2	Trade	3	6	2	4
3	Habitat destruction	3	6	1	2
4	Predation	2	4	2	4
5	Livestock pressure	2	4	2	4
6	Agriculture	9	18	9	18
7	Fuelwood collection	2	4	8	16
8	Land clearing	9	18	2	4
9	Stone crushing	1	2	1	2

Table 4: Test statistics showing results of Chi-Square in CSWS and DDGR.

	N	Pearson Chi-Square	df	Asymp.Sig.
Threats	100	9.635	8	0.292

4. Discussion

Present study revealed that illegal hunting is one of the major threats in both study sites which accounts for decline of Grey francolin by 38% in CSWS and 46% in DDGR. Similarly, an earlier study reported illegal hunting as major factor affecting francolin’s population in irrigated forest plantations and sub-mountainous tract

of the Punjab [27]. Among different hunting methods used for Grey francolin, shooting with bore gun was common method of francolin hunting as it accounts 54% hunting in CSWS and 58% in DDGR. Shooting considered an indirect cause of the decline in grey francolin *Perdix perdix* in Europe and in the last few years farming incomes have fallen which has driven some farms to change in land used for hunting and shooting game birds. This has led to the concern that shooting is damaging the remaining stocks of wild grey francolins which may inadvertently be shot when hunting pheasants and red-legged francolins [1]. In Italy, population of the francolin was falling dramatically since the change in agriculture but there was little to no change in the amount of shooting [46].

In France, where francolin shooting is popular as they were abundant especially where bag count as high as 5000 were recorded, breeding pair densities have been maintained only through a drastic reduction of shooting bags [11]. In the UK, at the turn of the century as many as 2 million birds were shot annually [1]. Because of its importance as a hunting bird there have been records kept about numbers for hundreds of years, for example spring counts to assess stocks were carried out in Austria since 1695. Commercial shooting often results in unintentional density-independent mortality of wild grey francolins because the number of shoot days depends on the number of game birds released, irrespective of wild grey francolin density. Considerable effort has been made to impose restrictions on shooting of grey francolin at low densities [44].

Second highest threat causing decline of grey francolin in study area was agriculture practices which contribute 18% in both CSWS and DDGR. As due to agricultural intensification, natural land is converted into farmland, decreasing habitat of Grey francolin in the study area. Efficient farming practices caused more than 80% decline of francolin population in the UK since 1950's [2, 42] due to reduced chick survival caused by agricultural intensification and use of insecticides and herbicides In Europe, the problem is more severe due to long history of farming [9,11]. Overall farmland birds in Europe have suffered larger decline than almost any other group. There has been an average decline of 44% from 1985 - 2005, compared to forest birds which have seen declines of roughly 9% [33]. The future fate of Grey francolin in the UK rests on the balance between the economics of agricultural production, agri-environment measures and shooting [3]. There was little to no use of machines in farming in past and the most of the work was carried out by hand or beast.

The introduction of mechanization into agriculture advances the industry, ploughing, sowing and reaping could all be done by one person in a much shorter time span. However, to accommodate the large machines and to give them room to manoeuvre fields were enlarged and vital francolin habitat went with it [14]. Hedgerows were removed along with permanent vegetative cover which francolins would use for nesting [2, 11]. The permanent vegetative cover is also an important source of food (e.g. insects and seeds) for francolin chicks and this has an impact on chick survival [30]. This is also linked to predation; francolin predation rates are naturally high throughout the year and therefore the availability of cover is a key factor for francolin survival [12]. Francolin nests were and continue to be directly destroyed by farm machinery [11, 14].

Trade of grey francolin at different life stages was common in both protected area of CSWS and DDGR causing decline of the species as 6% decline in CSWS and 4% decline in DDGR was recorded. It was recorded that mostly trade occurs at the chick stage (42% in CSWS and 60% DDGR) than eggs, sub-adult or adult stage.

There is no such evidence provided by previous studies that trade of species outside its home range causing decline of the species. Six percent decline in CSWS and 2% in DDGR reported by habitat destruction of the grey francolin due to urban expansion or increase in human population around both areas with the passage of time. Although this is not a main factor contributing to the population decline in Grey francolin but it still plays a role. This aspect is more common in Eastern Europe where there has been more intensive rural-urban migration [1].

Fuel wood collection is another cause of grey francolin habitat degradation in both protected areas. Collection of wood is mainly done for fire and cooking purposes and trees are cut which ultimately destroyed vegetation cover for the species available as roosting sites in night time, it accounts 4% in CSWS and 6% in DDGR. Through food loss, excessive predation, habitat destruction, intensification of agricultural practices and other pressures on scrub forests for their use in fodder, timber wood and fire wood needs, a drastic decline in the natural habitat of grey francolin has been reported by author [39].

Some other factors recorded under current study were livestock grazing pressure, predation and stone crushing activity in the habitat of Grey francolin which indirectly cause decline in its population as 6% decline in both areas by live stock pressure and predation while 2% decline by stone crush has been identified during study from CSWS and DDGR. Livestock grazing indirectly affects the francolin habitat by disturbing it and by putting pressure on the vegetation which is utilized by Grey francolin as its breeding ground. Major plant species affected due to livestock grazing in both areas were *Acacia modesta*, *Zizyphus nummularia*, *Dalbergia sissoo*, *Prosopis glandulosa*, *Justicia adhatoda*, *Calotropis procera*, *Cynodon dactylon* and *Saccharum bengalensis*. [45] reported that climate and change in landscape structure along with agricultural practices and predation have driven Grey francolin (*Perdix perdix*) decline.

Among all these threats, predation causes major decline in Grey francolin population in the study area. Predation by hawk was reported prominent; 36% in CSWS and 74% in DDGR during study period. As Grey francolin construct its nest on the ground, so there is more chance of predation as compared to other birds which have their nest on trees or vegetation above ground. Ground nesting birds face more predation especially those living in shrub and grassland habitat [28, 50]. Author [34, 35] diagnosed that Grey francolin affected by nest predation and shooting, as the abundance of sparrow hawks (*Accipiter nisus* L.) and Common buzzard (*Buteo buteo* L.) has increased in the United Kingdom which causes the francolin decline. Other studies from European countries have shown that the main reasons behind the decline have been a decrease in chick survival through the indirect effects of herbicides decreasing habitat at different stages of the life cycle [35, 37], and increased predation rates. Predation is a major factor of francolin mortality in the breeding season in spring/summer especially in areas where there is little predation control [11]. A study reported that reduction in predation pressure increased the breeding success and population density of grey francolin (*Perdix perdix*) in Salisbury Plain, England [43]. Foxes and francolins had various structural elements at their disposal, in a differentiated landscape which causes partial separation of the predator and its prey in the space [32] while low density of grey francolins coincided with areas of high raptor density [48]. By controlling predators, providing nesting cover, sufficient insect food for chicks and appropriate rates of shooting [16] can also play an important role in grey francolin conservation.

5. Conclusion

According to present study, being an important habitat of grey francolin, CSWS and DDGR, Salt Range, needs more attention through formulation of an effective conservation plan for the species. This study emphasizes the need for further research into the aspect of long term monitoring of declines at different scales, so, that it would be helpful in conservation of this precious bird in Salt Range. The study made following recommendation for conservation of Grey francolin in both protected areas.

1. Illegal hunting and trade should be strictly controlled through strict implementation of the Punjab Wildlife protection Act 1974.
2. Habitat degradation activities as agricultural intensification/fuel wood collection should be controlled in its habitat.
3. Hunting needs to be regulated by the Punjab Wildlife and Parks Department to ensure sustainable harvests of Grey francolin in the Salt Range.
4. Land encroachment and clearing for the purpose of commercial poultry farming, housing schemes, and other business oriented disturbances must be checked and prohibited.
5. Public awareness must be created among the peoples living in the vicinity of protected areas about the importance / benefits of Grey francolin to communities and threats affecting its populations, which should be ceased.
6. The Salt Range Protection Force in the area should be further strengthened for efficient and effective protection of wildlife in the Salt Range.

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References

- [1] N. J. Aebischer and Ewald. Managing the UK Grey Partridge *Perdix perdix* recovery: population change, reproduction, habitat and shooting. *Ibis*, 2004, 146 (2): 181 – 191.
- [2] N. J. Aebischer, and G. R. Potts. Population dynamics of the Grey Partridge *Perdix perdix* 1793–1993: monitoring, modelling and management. *Ibis*, 1995, 137 (1): 29 – 37.
- [3] N. J. Aebischer and J. A. Ewald . The grey partridge in the UK: population status, research, policy and prospects. *Animal Biodiversity and Conservation*, 2012. 35(2) : 353–362.
- [4] S. Ali and S. D. Ripley. Handbook of the Birds of India and Pakistan. Oxford Univ. Press, Delhi, India. 1983.
- [5] G. A. Awan. Ecology of Punjab Urial (*Ovis vaginei Punjabiensis*) in the Salt Range, Punjab. (Unpublished) M. Phil. Thesis. Quaid-i-Azam Univ. Islamabad, Pakistan: 1998, 78 pp.
- [6] M. M. Azam, A. Q. Nazar and N. Abbas . Some observations on the population Status of Punjab Urial

- (*Ovis vignei punjabiensis*) in district Chakwal. *Rec. Zool. Surv. Pak.*, 2008, 18: 1-3.
- [7] M. A. Beg and J. I. Qureshi.. Birds and their habitats in the cultivated areas of Lyallpur district and vicinity. *Pak. J. Agric. Sci.*, 1972, 9: 161-166.
- [8] BirdLife International . *Francolinus pondicerianus*. In: *The IUCN Red List of Threatened Species*. Version 2014. 2. www.iucnredlist.org. 2012. [14 September 2014].
- [9] BirdLife International *Birds in the European Union: a status assessment*. Wageningen, The Netherlands: BirdLife International. 2004.
- [10] E. Bro, F. Sarrazin, J. Clobert and F. Reitz. (Demography and decline of the grey partridge *Perdix perdix* in France. *J. Appli. Ecol.*, 2000, 37: 432 – 448.
- [11] E. Bro, F. Reitz, J. Clobert, P. Migot and M. Massot Diagnosing the environmental causes of the decline in Grey Partridge *Perdix perdix* survival in France. *Ibis*, 2001, 143: 120 – 132.
- [12] F. Buner, M. Jenny, N. Zbinden and B. Naef-Daenzer . Ecologically enhanced areas – a key habitat structure for re-introduced grey partridges *Perdix perdix*. *Biological Conservation*, 2005, 124 (3): 373 – 381.
- [13] Del Hoyo, J. A. Elliot. and J. Sargatal . *Handbook of the birds of the world*. In *Lynx (ed.)*, New world Vultures to Guinea fowl. Barcelona, 1994. p. 412-567.
- [14] De Leo, G. A. S. Focardi, M. Gatto and I. M. Cattadori . The decline of the grey partridge in Europe: comparing demographies in traditional and modern agricultural landscapes. *Ecological Modelling*. 2004, 117: 313 – 335.
- [15] R. T. Dumke, R. B. Dahlgren, S. R. Peterson, J. W. Schulz, J. P Weigand and W. Wishart. The Gray Partridge Management/Research Plan for North America. Proceedings of the Perdix II Grey Partridge Workshop. Forest, Wildlife and Range Experiment Station, 1980, 211: 165 – 198.
- [16] J. A. Ewald, G. R. Potts and N. J. Aebischer . Restoration of a wild grey partridge shoot: a major development in the Sussex study, UK. *Animal Biodiversity and Conservation*, 2012, 35 (2): 363–369.
- [17] A. R. Fuller, P. J. Carroll and McGown. Partridges, Quails, Francolins, Snowcocks, Guinea fowl and Turkeys. Status survey and conservation action plan 2000-2004. WPA/BirdLife/SSC Partridges, Quails and Francolin Specialist Group. IUCN. The World Conservation Union, Gland, Switzerland. 2000, 63pp.
- [18] M. Gallagher and M. W. Woodcock The Birds of Oman. Quarter Books Ltd., New York, USA, 1980.
- [19] GCT. Conserving the grey partridge: A practical guide produced by The Game Conservancy Trust for farmers, landowners and local Biodiversity Action Plan Groups. GCT, Hampshire, 2006.
- [20] GOP. Government of Pakistan. District census report of Khushab, 1998. Census publication No. 64. Population census organization, Islamabad, 2000.
- [21] K. Islam. Erckel's Francolin (*Francolinus erckelii*), Black Francolin (*Francolinus francolinus*), Grey Francolin (*Francolinus pondicerianus*). *Birds of North America*, 1999, 23 pp.
- [22] IUCN. Red List of Threatened Species. Downloaded September, 18, 2014 at <http://www.iucnredlist.org>. 2013.
- [23] R. A . Khan. Status and ecology of Black and Grey Francolin in agricultural land in the Punjab, Pakistan, WPA News, 1997, 52: 30-34.
- [24] S. B. Khan, S. Javed and J. N. Shah. Distribution and status of Galliformes in the United Arab

- Emirates. *Internat. J. Galliformes Conser.*, 2009,1: 58 – 62.
- [25] J. King and D. St. Vincent. Pakistan a Travel Survival Kit. 4th ed. Lonely Planet Publications. Hawthorn. Australia, 1993.
- [26] K. Mahmood, T. Ahmad, A. Khan, A. Mahmood and W. Mahmood. Some Notes on Avifauna of Mangla Reservoir. *AJ & K, Pak. J. Ornith*, 1997, 1:1-2.
- [27] M. A. Mann and A. A. Chaudhry. Francolins in irrigated forest plantations and sub-mountainous tract of the Punjab, Pakistan. *J. Pak. Veter.*, 2000. 20 (3):118–122.
- [28] T. E Martin. Nest predation among vegetation layer and habitat types. Revising the dogmas. *Am. Nat.* 1993. 141:897-913.
- [29] A. Mian. Grey partridge demands intensive study. WPA News, 1995, No.1:2.
- [30] M. Panek. The effect of agricultural landscape structure on food resources and survival of grey partridge *Perdix perdix* chicks in Poland. *J. Appl. Ecol.*, 1997. 34: 787 – 792.
- [31] M. Panek and R. Kamieinarz. Effect of landscape structure on nest site selection and nesting success of Grey Partridge (*Perdix perdix*) in western Poland, *Polish J. Eco.* 2000, 48: 239-247.
- [32] M. Panek. Demography of Grey Partridge (*Perdix perdix*) in Poland in the years 1991 – 2004: Reasons of population decline. *Eur. J. Wildl. Res.*, 2005, 51: 14–18.
- [33] PECBMS. State of Europe's Common Birds, 2007. CSO/RSPB, Prague, Czech Republic. (2007).
- [34] G.R. Potts. Studies on the changing role of weeds of the genus *Polygonum* in the diet of the Partridge *Perdix perdix* L. *J. Appl. Eco.*, 1980. 7:567–576.
- [35] G.R. Potts. The partridges: pesticides, predation, and conservation. Collins Sons and Co., Ltd., London, U.K., 1986.
- [36] Random.ORG, True Random Number Service, October ,1998. <http://www.random.org>.
- [37] M. R. Rands. Effect of hedgerow characteristics on Partridge breeding densities. *J. Appl. Eco.*, 1986, 23: 479 - 487.
- [38] P. C. Rasmussen and J. C. Anderton. Birds of South Asia: the Ripley Guide. Smithsonian Institution and Lynx Editions, 2005. 121 pp.
- [39] T. J. Roberts. The birds of Pakistan. Non -Passeriformes. Vol. I. Oxford University Press, Karachi, 1991, p. 232-233.
- [40] I. K. Sharma. The Grey Partridge (*Francolinus pondicerianus*) in the Rajasthan desert. *Annals of Arid Zones*, 1983, 22 (2): 117-120.
- [41] M. I. Sheikh. Forests and Forestry in Pakistan. Pakistan Forest Institute Peshawar, Pakistan, 1987.
- [42] N. W. Sotherton, N. J. Aebischer and J. A. Ewald. The conservation of the Grey Partridge. In: Maclean, N. (ed.) *Silent Summer: The State of Wildlife in Britain and Ireland* Cambridge University Press, Cambridge: 2010. 319-336.
- [43] S. C. Tapper, G. R. Potts and M. Brockless. The effect of an experimental reduction in predation pressure on the breeding success and population density of grey partridge. *J. Appl. Ecol.*, 1996. 33: 965-78.
- [44] S. C. Tapper. Conserving the Grey Partridge. Game Conservancy Trust, Fordingbridge. 2001.
- [45] C. J. Topping, T. T. Hoyer, P. Odderskaer and N. J. Aebischer. A pattern-oriented modelling approach to simulating populations of grey partridge. *Ecological Modelling*, 2010. 221: 729-737.

- [46] P. Tout and F. Perco. The grey partridge (*Perdix perdix*) in the region Friuli-Venezia, Giulia, NE Italy its recent history and current conservation efforts. In: *Perdix VIII Proceedings of an International Symposium on Partridges, Quails and Pheasants in the Western Palearctic and Nearctic. Hungarian Game Bulletin*, 2000, 5: 229 – 240.
- [47] L. Uimaniemi, J. Lumme, A. Putaala and R. Hissa. Conservation of the Finnish Grey partridge (*Perdix perdix lucida*). In: *Perdix VIII Proceedings of an International Symposium on Partridges, Quails and Pheasants in the Western Palearctic and Nearctic. Hungarian Game Bulletin*, 2000. 5: 165 – 170.
- [48] M. Watson, N. J. Aebischer, G. R. Potts and J. A. Ewald. The relative effects of raptor predation and shooting on overwinter mortality of grey partridges in the United Kingdom. *J. Appl. Eco.*, 2007, 44: 972-982.
- [49] J. P. Weigand. Hungarian Partridge in north central Montana. P-R Projects W-91-R-12 and W-120 -R-1-8, Montana Dept. of Game and Fish, 1977, 361 pp.
- [50] M. Yanes and F. Suarez. Nest predation patterns in ground nesting passerines on the Iberian Peninsula. *Ecography*, 1995, 18: 423-428.