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Breeding Biology of Grey Francolin (*Francolinus pondicerianus*) in Salt Range, Pakistan

Sangam Khalil,* Maqsood Anwar and Iftikhar Hussain
Department of Wildlife Management, Faculty of Forestry, Range Management and Wildlife, Pir Mehr Ali Shah Arid Agriculture University, Murree Road, Rawalpindi 46000, Pakistan

ABSTRACT

Present study documented some aspects of breeding biology of grey francolin (*Francolinus pondicerianus*) such as breeding season, nest structure, clutch size, incubation period and hatching success in the Salt Range of Punjab, one of important area of grey francolin distribution in Pakistan. Breeding season of grey francolin in the study area extended from mid March to end of July. All of its nests located during the study were found on the ground in natural vegetation consisting of *Acacia modesta*, *Acacia nilotica*, *Ziziphus mauritiana*, *Dalbergia sissoo*, *Desmostachia bipinnata* and *Cynodon dactylon*. Egg laying occurred mainly in the months of April and May, having mean egg laying span of 12.1±1.20 days (range 7-18 days) and a mean clutch size of 6.8±0.78 eggs per nest (range 4-12). Mean incubation period was 15.7±1.86 days (range 13-20 days). Out of a total of 68 eggs located in various nests, 53 hatched (74.80%) with a mean hatching rate of 5.3±0.85 eggs per clutch. The fledging success was estimated at 4.6±0.81 per clutch (77%). No difference was found between forest and cultivated habitats with respect to diameter and shape of nest, egg laying period, clutch size, egg weight, and incubation period, however, volume of the eggs was significantly more in cultivated habitat (ANOVA: F = 4.09; df = 1; P = 0.01) as compared to the natural forest habitat. Study suggested that grey francolin's successful breeding in Salt Range is mainly associated with natural vegetation and crop cultivated fields around natural vegetation, which supports its healthy population.

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Authors' Contributions
SK, MA, IH conceived and designed the experiment. SK, MA performed the experiments and analyzed the data. SK wrote the article.

Key words
Grey francolin, breeding season, clutch size, hatching success, salt range.

INTRODUCTION

Pakistan has a variety of ecosystems with diverse avifauna to exploit their resources (Khan *et al*., 1996). A total of 669 bird species have been reported in the country and their occurrence is unique in the world (Grimmett *et al*., 2008; Mirza and Wasiq, 2007). Grey francolin (*Francolinus pondicerianus*) belongs to order Galliformes and family Phasianidae which is distributed in the plains and drier parts of South Asia (IUCN, 2013; Birdlife International, 2012). In Pakistan, it is distributed from the Indus valley (south-central part of the country around River Indus) to Himalayan foothills in open cultivated lands as well as scrub forests (del Hoyo *et al*., 1994). Grey francolin has remained a favorite game bird in the sub-continent and has been hunted for food as it is considered an economical source of meat by local inhabitants (Long, 1981). This species is an effective bio-control agent as it is known to feed on insects, their eggs and larvae (Beg and Qureshi, 1972; Mian and Wajid, 1994). Both the sexes have same coloration but males can be distinguished from the females by the presence of metatarsal spur and larger mass (Islam, 1999).

Both male and female grey francolins breed during the first year after hatching, but pairs are established when female chooses a male (Potts, 1980), and these pairs remain together for life. Both the sexes readily mate again in case of mortality (Carroll, 1993). The monogamous grey francolin forms a pair before the breeding season. In Pakistan, nesting occurs mostly in spring, eggs are laid in March and April, however a few pairs also nest in September and October after monsoon rains (Roberts, 1991).

The nest of grey fracolin is always well concealed inside a clump of grass growing up through a thorny bush, in a depression on the ground having few blades of grass or dead leaves (Roberts, 1991), a simple grass lined with scrapes in grassland, standing crops, ploughed fields, or scrub forest (Ali, 1945; Sharma, 1983; Bro *et al*., 2004). Eggs are mostly laid on the bare ground; cryptic coloration of hen helps provide protection to the eggs while she incubates them (Hosking and Newberry, 1944). Clutch size depends on food availability and is generally larger at agricultural farms with abundant grain and insects, than in scrub jungle and possibly three clutches per season have been reported (Bump and Bump, 1964).

Incubation takes 18 to 19 days, solely done by the female and chicks hatch synchronously, however, during incubation, male remains in the neighborhood and gives alarming calls during danger (Johns, 1980). According to

* Corresponding author: sangamuaar@gmail.com
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Layard (1854) the female lays 9-16 olive-green eggs in one clutch, robust at one end and sharp at the other. If eggs are destroyed, the hen will lay eggs again and a late brood is reared. If female flees the nest even once, the incubation does not continue, and the nest is ultimately destroyed by the predators. The higher rate of egg production is believed to be an adaptation to compensate for high rate of eggs and chick predation as the species builds their nests on ground (Potts, 1980; Novoa *et al.*, 2002; Putaala and Hissa, 1998; Wijeyamohan *et al*., 2003). Female mortality is the highest during incubation, whereas nestlings face high mortality during the first three weeks of their life (Bro *et al*., 2005). Both parents attend the young chicks after hatching (Roberts, 1991).

Population decline of grey francolin has been well documented. Habitat destruction and increased use of pesticides caused by intensification of agriculture can be cited as main causes of the falling numbers (Roberts, 1991). Grey francolin has undergone an overall population decline as high as 79% in the last decade, but is listed as Least Concern in IUCN Red List (IUCN, 2015). Its current status might be due to its wide distribution range (Birdlife International, 2015). Only a few research studies have been carried out on grey francolin in Pakistan. Khan (2010) while studying grey francolin in Lal Suhanra National Park, Pakistan, documented different aspects of its breeding but did not show comparison between different types of habitat preferred by the bird during breeding season. The study in agro-ecosystem of Pothwar Plateau by Hussain *et al.* (2012) revealed population density as 0.87±0.14 birds per ha in forested tracts and 1.59±0.39 birds per ha in crop fields and 76.19% breeding success with a mean hatching rate of 5.33±1.22 eggs per clutch. Even Hussain *et al.* (2012) did not correlate the habitat type (cultivated land, natural vegetation) with breeding success of the grey francolin. The present study was, therefore, undertaken with the specific objectives of gathering information on i) breeding season, ii) nest structure, iii) clutch size, iv) incubation period, and v) hatching success of grey francolin in the natural and cultivated habitats in the Salt Range of Pakistan.

MATERIALS AND METHODS

Study area

The study was conducted at Chumbi Surla Wildlife Sanctuary (CSWS) and Diljabba- Domeli Game Reserve (DDGR) located in the Salt Range (32º41-32º56 N and 71º50-74º E). CSWS is located at 32º 47 N, 67º 42 E, elevation ranging between 460-1050 m with an area of 55,987 ha (Azam *et al.*, 2008). Diverse habitat types including hills, torrents, wetlands and agriculture lands support a rich diversity of flora and fauna (Chaudhry *et al*., 1997). DDGR is located at 32° 54 N and 73°09 E having an area of 118,106 ha with 365-600 m elevation (Anwar and Mehmood, 2010) (Fig. 1). CSWS (IUCN category IV) is protected under Punjab Wildlife (Protection, Preservation, Conservation and Management) Act, 1974 while limited hunting is allowed through permits in DDGR under this law. Livestock rearing and crop cultivation are the two main land uses of the study area.

Main plant species in the study area include: *Acacia modesta, Olea ferruginea, Salvadora alights, Ziziphus nummularia, Prosopis glandulosa, Justicia adhatoda, Calotropis procera, Dodonaea viscosa* and grasses like *Eleusine compressa, Heteropogon contortus, Desmostachia bipinnata* and *Cyonodon dactylon.* The climate of the area is sub-humid sub-tropical continental type. An average precipitation recorded in the last 30 years was 853 mm. There are two distinct rainy seasons: the summer season or the monsoon rains which start by about mid July and last until mid September. Most of the precipitation is received during July and August. The winter rains begin in January and persist up to the beginning of March. The mean monthly temperature ranges from 5.9º C to 38.4º C, January being the coldest and June the hottest month of the year. During winters the temperature often drops below zero, usually in December and January (Awan, 1998).

Past abuse, overgrazing and heavy firewood extraction have eliminated many of the forests and degraded most of the existing ones. The requirements of the people which include grazing for their cattle, sheep, goats and camels; firewood for heating and cooking; small timber for agricultural implements and for building purposes are met from these forests. People have rights to graze their livestock and collect firewood (dry and dead). Grass cutting is also generally allowed. Lopping is not permitted anywhere. However, illicit lopping and felling are common (Sheikh, 1987).

Study design

A reconnaissance survey of both the study areas was conducted to select study sites in different habitat types including natural vegetation (as given above), cultivated crops *Brassica rapa* (Field mustard), *Eruca sativa* (Salad rocket), *Sorghum bicolor* (Jawar), *Triticum aestivum* (Wheat), *Vigna radiate* (Moong bean), permanent wetlands with associated vegetation and open grassland with scattered trees within natural forest area. Field observations were taken in the selected study sites during breeding season twice a week to record data on breeding aspects of grey francolin which included the onset of breeding season, nest size and structure,

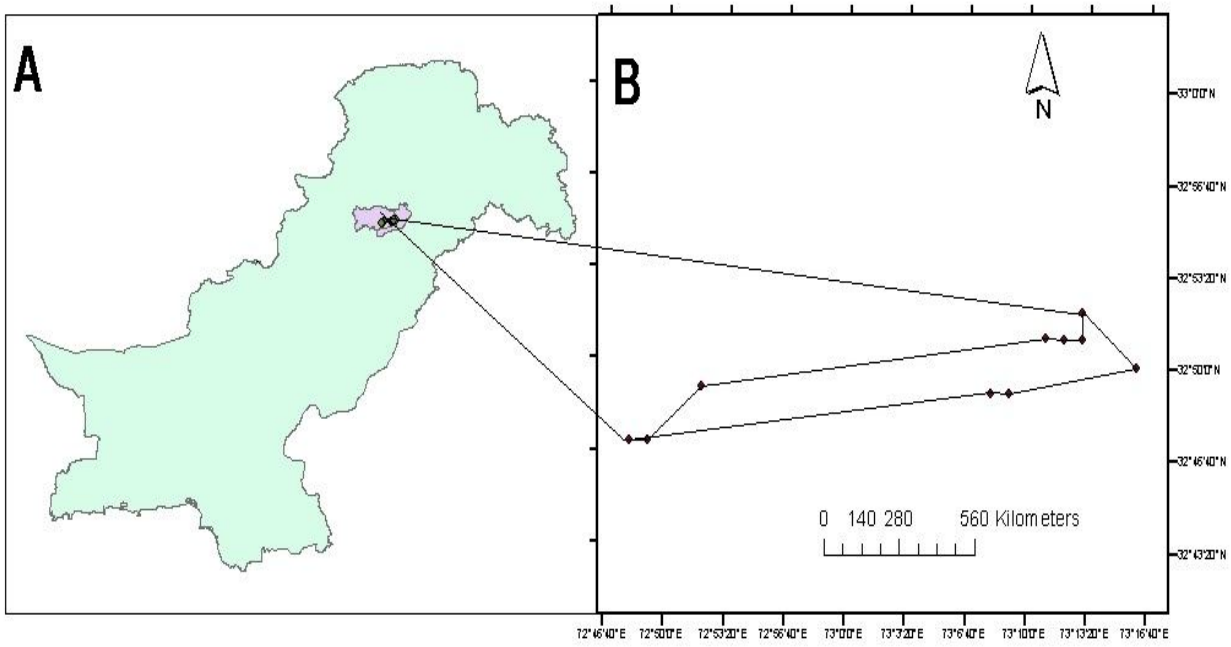

Fig. 1. A. Map of the study area within Salt Range, Punjab, Pakistan and B: sites selected for data collection on breeding biology of grey francolin.

vegetation at nest site, clutch size, incubation period and hatching success. Line transect surveys were started before the onset of breeding season during March 2011-July 2013 to record the data on different breeding aspects of grey francolin.

Nests were located by following the individual francolins carrying nesting material or food to the nests, or based on behavior cues. Standard protocols were followed during nest monitoring to minimize disturbance to birds, and habitat, and prevent observer-induced nest predation (Martin and Geupel, 1993). After locating an active nest (nest with a female or eggs), it was marked by GPS navigator and allotted a specific number. Marked nests were visited regularly by a group of four persons, two to three times in a week during early mornings and late evenings from March to July, and after short intervals, from egg laying till fledging; nest was visited on daily basis.

Data sheets were used to record information such as dates of laying first and the last egg, number of eggs, shape, color and surface texture of eggs, date of hatching, number of hatched eggs, length and width of eggs, nest location and general appearance or structure of the nest including inner and external diameter. Nest height, plant species and height of nest substrate were recorded immediately after fledging of the young or their predation (Soler *et al*., 1998). Bushnell 7X35 mm binocular was used to locate and record observations on grey francolin, Nest height from ground by using trigonometry scale, Sony DSC-HX 10V digital camera to take photographs of nests, eggs and francolins, Garmin eTerex 10 GPS navigator to take geo reference of francolin nests, Electronic LCD digital vernier caliper to measure length and width of eggs and a digital scale (SF-820) having range of 0.1 mg to 300 g were used to weigh the eggs.

Statistical analysis

Prior to the analysis, we tested for normality of the data using the Shapiro-Wilk test (Shapiro and Wilk, 1965). As the data were not normally distributed, a logarithm transformation log (x+1) was used. One way Analysis of Variance (ANOVA) (Clark, 2007) was used by software R 3.0.1 to test whether there were significant differences in the following features: i) outer diameter of the nest; ii) inner diameter of the nest; iii) egg weight; iv) egg length; v) egg width; vi) egg laying period; vii) clutch size; viii) incubation period; ix) hatching success and x) fledging success, between forest and cultivated habitats ($\alpha = 0.05$).

RESULTS

Ten nests of grey francolin; six in natural forest and four in crop cultivated fields were located during the

study. All nests were found on the ground in the vegetation which mainly comprised of *Desmostachia bipinnata, Cynodon dactylon, Ziziphus mauritiana, Dalbergia sissoo, Acacia modesta* and *Acacia nilotica* (Table I). Shape of the nest varied from round to oblong in both cultivated and forest habitats. For natural forest habitats, mean outer diameter of the nests was 17. 54±1.04 cm (range 15. 24-21.18 cm) while inner diameter was 13.09±1.20 cm (range 10.16-17.78 cm) and for cultivated fields, outer diameter was 19.97±2.08 cm (range 15.21-25.34 cm) and inner diameter was 17.41±2.37 cm (range 13.23 - 22.86 cm). However, when compared no significant difference between the two habitats was found (outer diameter, ANOVA: F = 1.34; Df = 1; P = 0.27; inner diameter, ANOVA: F = 3.22; Df = 1; P = 0.11) (Table II).

Color of eggs was dusty white to pink with white spots on it, and texture was somewhat rough and smooth, while shape of eggs was oval. There is no difference in the shape of nest and color and surface texture of the egg between the two habitats (cultivated and natural forest; (χ^2= 0.28, Df = 2; P = 0.87) (Fig 2). Mean weight of eggs was 10.39±0.87 g (range 8 - 14 g) in forest habitat and 13.06±1.80 g (range 8 - 15 g) in cultivated habitat; mean length was 29.39±0.93 mm (range 25-32 mm) in forest habitat and in cultivated habitat 41.05±3.7 mm (range 30 - 46 mm); mean width was 21.75±1.27 mm (range 16 - 25 mm) in natural forest habitat and 31.38±3.33 mm in cultivated habitat (range 21-35 mm) and mean volume in natural forest habitat was 645.63±55.24 (425-805 mm^3) and in cultivated habitat was 1339.95±233.27 (653-1671 mm^3). The weight of eggs (ANOVA: F = 2.21; Df = 1; P = 0.17) was the same between the habitats; however, egg length (ANOVA: F = 14.439; Df = 1; P = 0.005238), egg width (ANOVA: F= 9.7207; Df = 1; P = 0.01428) and volume of the eggs (ANOVA: F = 4.09; df = 1; P = 0.01) had bigger values in the cultivated habitat as $P \leq 0.05$ (α= 0.05) (Table II).

The mean egg laying period was 12.1±1.20 days (range 7 - 18 days) and was similar between the habitats (ANOVA: F= 1.2878; Df = 1; P = 0.2893). The mean clutch size was 6.8±0.78 (range 4 - 12 eggs) indicating that this population probably laid eggs on alternate days, with no difference in number of eggs between the habitats (ANOVA: F = 0.4994; Df =1; P = 0.4998). A nest with four eggs without female was found, which might have been killed during incubation and as a result all eggs were destroyed. The average incubation period recorded in the present study was 15.7±1.86 days (range 13-20 days), similar in both habitats (ANOVA: F = 0.7072; Df = 1; P = 0.4248); and both sexes were observed taking part in incubation.

Out of a total of 68 eggs recorded in various nests, 38 eggs were observed in nests located in natural forest habitat and 30 eggs in nests found in cultivated habitat, 53 hatched (74.80% success), 31 in natural forest (81 % success) and 22 from cultivated habitat (73 % success), with a mean hatching rate of 5.1±0.65 eggs per clutch in forest habitat and 5.5±2.10 eggs per clutch in cultivated habitat with different success (ANOVA: F = 0.0324; Df = 1; P = 0.8616). The fledging success was estimated at 4.3±0.66 per clutch in natural forest habitat and 5±1.95 per clutch in cultivated habitat indicating an overall success of 68% and 67%, showing non significant difference for both habitat types (ANOVA: F = 0.1438; Df = 1; P = 0.7144; Table III, Fig. 3). Some additional observations suggested that grey francolins always changed their nest sites in each breeding season. Female gives its egg membrane as first feed to her chicks. Grey

Fig. 2. Nest with eggs of grey francolin found in forest habitat of salt range, Pakistan.

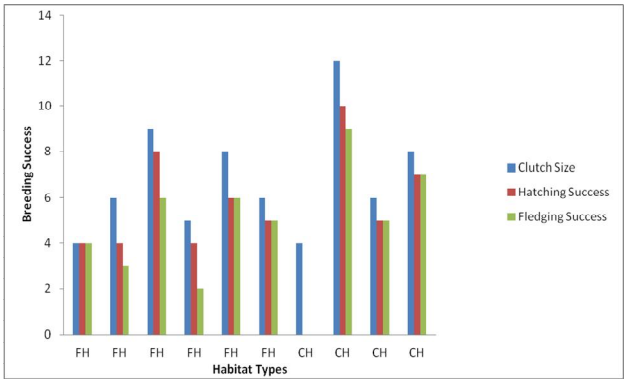

Fig. 3. Breeding success (clutch size, hatching and fledging success) of grey francolin in forest habitat (FH) and cultivated habitat (CH), in Salt Range, Pakistan.

Table I.- Location and constituents of nesting material of grey francolin in the study area in Salt Range, Pakistan during the period 2011-2013.

Nest No.	Habitat type	Elevation (m)	Coordinates	Nest material	Vegetation around nest location
1	Natural Forest	523	32 º 49. 739 N 73 º 08.657 E	*Desmostachia bipinnata,*	*Acacia nilotica*
2	Natural Forest	655	32 º 47.913 N 72 º 48.953 E	*Cynodon dactylon, Desmostachia bipinnata*	*Ziziphus mauritiana*
3	Natural Forest	398	32 º52.073 N 73 º13.744 E	*Desmostachia bipinnata, Acacia nilotica*	*Acacia nilotica, Ziziphus mauritiana*
4	Natural Forest	677	32 º 47.941 N 72 º 49.458 E	*Desmostachia bipinnata, Cynodon dactylon*	*Ziziphus mauritiana*
5	Cultivated field	539	32° 49.595 N 72° 52.127 E°	On ground in soil with *Dalbegia sissoo* leaves	*Dalbergia sissoo, Ziziphus mauritiana* on field edge
6	Cultivated field	704	32 º 47.869 N 72 º 48.659 E	*Desmostachia bipinnata*	*Ziziphus mauritiana*
7	Natural Forest	367	32 º 50.131 N 73 º 16.053 E	*Desmostachia bipinnata, Acacia modesta*	*Acacia modesta, Ziziphus mauritiana*
8	Cultivated field	417	32 º51.982 N 73 º13.575 E	*Desmostachia bipinnata*	*Ziziphus mauritiana*
9	Natural Forest	707	32 º 47.874 N 72 º 48.690 E	*Desmostachia bipinnata*	*Ziziphus mauritiana, Acacia nilotica*
10	Cultivated field	463	32° 51.761 N 73° 11.941 E	*Desmostachia bipinnata*	*Ziziphus mauritiana, Acacia modesta* on field edge

francolin chicks feed on termites and black ants from their hatching up to four weeks of age and avoid drinking water as it is considered harmful for their survival. Sparrow hawk *Accipiter nisus* and saw-scaled viper *Echis carinatus* were found among top predators of grey francolin.

DISCUSSION

Present study revealed that all nests of grey francolin were located on the ground in natural vegetation having the main species *Ziziphus mauritiana, Dalbergia sissoo, Acacia modesta, Acacia nilotica, Desmostachia bipinnata* and *Cynodon dactylon.* These findings are in agreement with Hussain *et al.* (2012) who reported that nests of grey francolin were mostly made with *Desmostachia bipinnata, Acacia modesta, Ziziphus mauritiana, Euphorbia* spp. and *Imperata cylindrica* in agro-ecosystem of Pothwar Plateau, Punjab. Bro *et al.* (2004) concluded that grasslands were selected as the nest site by grey partridge during breeding season which shows contradiction with the present study.

Out of ten nests, six were found in natural forest, which indicated the positive association of species with natural vegetation to build its nest as compared to cultivated vegetation. Selecting the natural forest during breeding season may be due to the reason that it provided cover and escape to the species from its predators better than the cultivated fields in addition to providing food resources as it has different types of seasonal crops on which grey francolin feeds. Results of previous studies on grey francolin suggested that the hatching success was positively correlated with the vegetative cover as preferred sites for nesting were in permanent plant cover and orchards; Use of crops was less frequent than expected. The present study recorded the egg laying span from 13 April to 24 June which coincides with earlier observations in this regard i.e. from March to June (Trippenses, 1948) in London and from March to May in Pothwar Plateau (Hussain *et al.*, 2012). In agriculture fields (Faisalabad, Pakistan) egg laying extended from March to September with peak from March to June and maximum number of fledglings was observed from April to June (Ullah, 1991). The mean egg laying period of 12.1±1.20 days and average clutch size of 6.8±0.78 eggs in present study, suggest that this population probably laid eggs with one day interval. Study of breeding behavior of this species in desert areas of Pakistan by Khan (2010) supports the data that grey francolin did not lay eggs daily and required double duration than its clutch size to complete it.

Shape of the nest varied from round to elongate and color of the egg was dusty white to pink with white

Table II.- Measurements of nests and eggs of grey francolin in natural forest and crop cultivated habitat of Salt Range, Pakistan during the period 2011-2013.

Nest No. (Habitat type)	Shape of nest	Outer diameter of nest (cm)	Inner diameter of nest (cm)	Shape of eggs	Color of eggs	Surface texture	Weight of egg (g)	Length of egg (mm)	Width of egg (mm^2)	Volume of egg (mm^3)
1 (Forest)	Oblong	20.32	10.16	Oval	Pink with white spot	Somewhat rough	14.45	25.4	16.77	425.95
2 (Forest)	Partial round	16.51	11.91	Oval	Pink with white spot	Somewhat rough	8.67	28.54	20	570.80
33 (Forest)	True round	15.24	11.07	Oval	Dusty white	Smooth	9.79	30.24	24.65	745.41
4 (Forest)	Partial round	21.18	15.57	Oval	Pinky white	Smooth	9.29	29.87	21.23	634.14
5 (Forest)	True round	15.51	12.09	Oval	Pink with white spot	Somewhat rough	9.11	30.11	23	692.53
6 (Forest)	Oblong	16.51	17.78	Oval	Dusty	Smooth	11.03	32.20	25	805.00
Mean±S.E		17.54±1.04	13.09±1.20				10.39±0.87	29.39±0.93	21.75±1.27	645.63±55.24
7 (Cultivated)	Oblong	19.30	13.23	Oval	Pink with white spot	Somewhat rough	16.89	46.88	35.65	1671.27
8 (Cultivated)	True round	25.34	19.93	Oval	white	Smooth	8.72	30.48	21.45	653.79
9 (Cultivated)	Oblong	15.21	13.63	Oval	white	Smooth	11.66	43.18	33.55	1448.68
10 (Cultivated)	Partial round	20.06	22.86	Oval	Dusty white	Smooth	15	45.46	34.89	1586.09
Mean±S.E	(χ^2= 0.28, df = 2, P = 0.87).	19.97±2.08 (F = 1.34, df = 1, P = 0.28).	17.41±2.37 (F = 3.22, df = 1, P = 0.11).		(χ^2= 4.09, df = 3, P = 0.25).	(χ^2= 0.623, df = 1. P = 0.43).	13.06±1.80 (F = 2.21, df = 1, P = 0.17).	41.05±3.75 (F = 14.44, df = 1, P = 0.05).	31.38±3.33 (F = 1.34, df = 1; P = 0.28).	1339.95±233.27 (F = 4.09, df = 1; P = 0.18).

Table III.- Breeding pattern of grey francolin in different habitats of Salt Range, Pakistan during the period 2011-2013.

Nest No. (Habitat type)	Egg laying period (days)	Clutch size	Incubation period	Hatching success	Fledging success
1 (Forest)	7	4	15	4(100%)	4 (66%)
2 (Forest)	9	6	19	4 (66%)	3 (66%)
3 (Forest)	15	9	18	8 (66.66%)	6 (66%)
4 (Forest)	9	5	17	4 (66.66%)	2 (66%)
5 (Forest)	15	8	20	6 (75%)	6(100%)
6 (Forest)	11	6	13	5(83.33%)	5 (100%)
Mean±S.E	11±1.36	6.3±0.76	17±1.06	5.1±0.65 (81%)	4.3±0.66 (68%)
7 (Cultivated)*	8	4	0	0 (0%)	0 (0%)
8 (Cultivated)	16	12	18	10 (83.33%)	9 (90%)
9 (Cultivated)	13	6	19	5 (83.33%)	4 (80%)
10 (Cultivated)	18	8	18	7 (87.5%)	7 (100%)
Mean±S.E	13.75±2.17	7.5±1.70	13.75± 4.58	5.5± 2.10 (73%)	5± 1.95 (67%)
Over all Mean±S.E	**12.1±1.20**	**6.8±0.78**	**15.7±1.86**	**5.3±0.85 (74.80%)**	**4.6±0.81 (77%)**

*The female left the nest during incubation period

spots on it; texture observed was somewhat rough and smooth, while shape of the egg was oval. Hussain *et al.* (2012) observed that eggs were oval in shape and pale brown in color. In both, cultivated fields and natural forest, shape, inner and outer diameter of the nest, color, shape, texture, and weight of the eggs was almost the same, however egg length, width and egg volume were different in both the natural and cultivated habitats. Clutch size (4-12 eggs) recorded in the present study is in accordance with the observation of Baker (1921) 4-10 eggs while Clark (1901) reported 8-10 eggs, Hussain *et al*. (2012) 6-8 eggs, Sharma (1983) 6-7 eggs, and Khan (2010) 2-13 eggs. Maximum number of 12 eggs was recorded in a nest situated in a cultivated field having natural boundary vegetation. These data are also in conformity with that of Hussain *et al*. (2012) where the nest located in cultivated habitat had maximum number of eggs *i.e.* 8 eggs. Average incubation period 15.7±1.86 days (range 13-20 days) recorded during present study is different from the earlier findings by Khan (2010) in desert population of grey francolin, which is 16-21 days. It also varies from the value 18-21 days recorded by Bump and Bump (1964), Ali and Ripley (1969), Roberts (1991), and Hussain *et al.* (2012) which are in the range of 19-22 days.

The hatching success (74.80%) recorded in this study with a mean hatching rate of 5.3±0.85 eggs per clutch is higher than that reported by Khan (2010) *i.e.* 4.40±3.36 (4.76±0.97). However, it was similar to that reported by Hussain *et al*. (2012) with a mean hatching rate of 5.33±1.22 eggs per clutch (76.19% success). Similarly, fledging success (77%) estimated at 4.6±0.81 per clutch in this study is also a little higher than that reported by Panek (2005); 31 to 56% and Khan (2010) who reported 37.0±3.25 % and Hussain *et al*. (2012) who estimated at 3.83±0.83 per clutch (63.08%). According to Khan (2010) average clutch size and number of nestlings and fledglings increases with higher rainfall. Higher reproduction success in the Salt Range may be due to higher mean annual rainfall than that of the desert habitat.

Present study revealed that grey francolin is mainly associated with natural vegetation and crop cultivated fields situated around natural vegetation for breeding in the Salt Range. Hence, its population can be maintained by maintaining the natural vegetation cover in its habitat. Being an important habitat of this species, Salt Range needs more attention through formulation of an effective conservation plan for this and the associated species in this area. 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, so that a healthy population is sustained in this region.

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