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Food Composition of the Grey Francolin *Francolinus pondicerianus* in the Salt Range, Punjab, Pakistan

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Abstract
This study was conducted to investigate food habits of the Grey Francolin in the Salt Range (Chumbi Surla Wildlife Sanctuary and Diljabba Domeli Game Reserve). For this purpose, 28 crop and gizzard samples of the Grey Francolin were collected from local hunters/poachers. These samples were collected in different seasons; spring (n=6), summer (n=4), autumn (n=7) and winter (n= 11) and during the morning and evening hours. In total, twelve food items were recovered from 28 samples. Eight food items consisted of plant materials (leaves and seeds) were identified as *Brassica rapa, Pennisetum typhoideum, Carthemus oxycantha, Eruca sativa, Triticum aestivum, Vigna radiata, Oxalis corniculata* and *Sorghum bicolor*. Three food items belong to animal parts were from three different orders of insects; *Formica rufa* (Hymenoptera), *Coptotermes formosanus* (Isoptera) and *Tribolium castaneum* (Coleoptera). The total weight of their gut with food contents was 147.1 gm (10.50±1.26) in the morning while in the evening, the weight of their gut with food contents was 115.86 gm (8.27±0.53). The consumption of plant materials was high in spring (2.33+0.89) and summer (2.59+0.67) compared with autumn (1.23+0.48) and winter (1.47+0.65). The consumption of insects as compared with plant materials showed seasonal variation as it was higher in summer (4.15+1.93) and winter (2.5+1.44) as compared to spring (1.56+0.88) and autumn (2.38+1.03). Comparison of the weight of different food items collected during the morning and evening times using student's paired t-test in QI Macros-2014 showed that there was significant difference between the weight of contents of the morning and evening and the selection of plant and animal species during the time of the day.

1. Introduction

The Grey Francolin *Francolinus pondicerianus* is a native bird of Pakistan (Ali & Ripley 1983; Roberts 1991; Islam 1999); however, under different environmental conditions, it shows seasonal and local movements up to 81 km. It is somewhat larger than the Black Francolin *Francolinus francolinus* in size, having 33–35cm body length (Roberts 1991; Islam 1999). Sexes have similar coloration, which makes distinction in the field difficult. Males can be told apart from females by the presence of metatarsal spurs and larger mass (Islam 1999).

The Grey Francolin is generally found in open farmlands as well as in sparse woodland

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where shrubs are dominant. The common name of the bird, based on its calls, is 'teetar'. This species has a large distribution range estimated to be around 10,000,000 km² (BirdLife International 2012; IUCN 2013). In the 1970s, the Grey Francolin was introduced to the United Arab Emirates and sometime during the twentieth century to Oman. Now, it is successfully established there due to its great breeding potential (Khan *et al.* 2009; Gallagher & Woodcock 1980). It is also successfully established in the Hawaiian Islands, USA (Islam 1999).

In Pakistan, the Grey Francolin is widely distributed from the Indus valley in the west to the foothills of the Himalayas in the south (Roberts 1991). The Grey Francolin is rarely found above an elevation of 1,200 m in Pakistan and is usually observed feeding on sparsely covered ground or low grass cover in open and scrub country (Rasmussen & Anderton 2005).

The Grey Francolin is omnivorous (Chaudhry & Bhatti 1992). The analysis of 36 crops in Khanewal (Pakistan) found they utilize both plants and insects (Chaudary & Bhatti 1992). Crops of ten Grey Francolins taken between March and July at Faisalabad area contained grains, seeds, other vegetable matter, locusts or grasshoppers, ants, termites and beetle grubs (Roberts 1991). Hussain *et al.* (2012) reported that in Pothwar area the Grey Francolin eats seeds, grains, ants and termites in cultivated fields and croplands. Similarly, Mian & Wajid (1994) concluded that in Layyah district of Punjab (Pakistan) in winter, the Grey Francolin was dependent upon insects (9.8 %), mature seeds of at least 16 plant species (69.6 %; mainly *Potamogeton filiformis, Vigna radiata, Asphodelus tenuifolius, Triticum aestivum*) and leaves (21.3 %). Non-significant differences in food composition were recorded between sexes. Similarly analyses of 31 crop contents of Grey Partridge collected from Lal Suhanra National Park (Punjab, Pakistan) in different seasons contained 51 taxa (35 plants, 16 insects), suggesting that this species omnivorous and a food generalist (Khan & Mian 2012). Since insect-based food constitutes a significant part of the diet of the Grey Francolin (Faruqi *et al.* 1960; Mian & Wajid 1994), it plays a role as a biological control agent of insect pests in agro-ecosystems.

Grey Francolins may roost at night on low thorny branches of trees or shrubs in pairs or family groups called "coveys" and are camouflaged as an adaptation for life in relatively sparse vegetation (Sharma 1983; Roberts 1991). Grey Francolins bond as monogamous pairs, but females do all the incubation. Nesting is mostly in spring, eggs being found in March and April, but some pairs nest in September and October after the monsoon rains. The eggs are glossy, pointed at one end and unmarked, varying from pale brownish to pale buff. The incubation takes 18–19 days and chicks hatch synchronously. Both parents care for their chicks after hatching (Roberts 1991).

The decline of the Grey Francolin population has been reported on in the past, with the species as an indicator of changes in farmland ecosystems and also as a game bird (Chaudhary & Bhatti 1992; Islam 1999). A rapid population decline in its natural habitat has been reported by Roberts (1991), attributed to loss of food resources, excessive hunting and habitat destruction, mainly because of overharvest of scrub forests for fodder, timber and firewood as well as the intensification of agricultural practices. Grey Francolin population has seen an overall decline as high as 79% during the last 10 years in Europe (del Hoyo *et al.* 1994). It is listed as Least Concern on IUCN Red List, primarily because it has a wide distribution range (Birdlife International 2012; del Hoyo *et al.*1994).

There is little literature on the Grey Francolin in different parts of Pakistan, and none of those focused on the Salt Range of the Punjab, one of the major areas of Grey Francolin distribution in Pakistan. The current study was therefore conducted in the Salt Range to determine feeding habits of the Grey Francolin and to find out the relative consumption of plant and animal materials and seasonal variation in the selection of food items. The outcomes will provide essential scientific base required for the conservation of the Grey Francolin.

2. Materials and Methods

2.1. Study area

This study was conducted at Chumbi Surla Wildlife Sanctuary (CSWS) and Diljabba-Domeli Game Reserve (DDGR) located in the Salt Range, Pakistan between 32º41'−32º56'N and 71º50'−74ºE and 250–1,520 m a.s.l. (Awan 1998) (Fig.1). CSWS has an area of 55,987 ha and is located at 32º47'N, 67º42'E and 460–1,050 m a.s.l. (Azam *et al.* 2008). The climate of CSWS is dry sub-tropical with cool winters and hot summers. The temperature ranges from 10°C to 41°C and the average annual rainfall is 500 mm (Chaudhry *et al.* 1997). It has a mixed habitat types of sub-tropical semi-evergreen and tropical thorn forest. This sanctuary has wetlands, torrent streams, farmlands and hills, and therefore a high diversity of wild animals. Diljabba-Domeli Game Reserve, having an area of 118,106 ha, is located at 32°54'N, 73°09'E and around 600 m a.s.l. (Awan 1998; Anwar & Goursi 2012).

2.2. Methodology

A total of 28 crop and gizzard samples of adult Grey Francolins were collected in study areas of the Salt Range, Chumbi Surla Wildlife Sanctuary and Diljabba Domeli Game Reserve, during spring (March-May); summer (June-August); autumn (September-November) and winter (December-February), particularly during the hunting season of the species with the help local hunters and poachers. Each crop and gizzard was weighed in the field using a digital scale (SF-820) with accuracy of 0.1 mg to 300 g. Each gizzard and crop was placed in a plastic bag with a label summarizing all possible information including location, date of collection and time of the day of that sample. These samples were then brought to the laboratory at the Department of Wildlife Management, Pir Mehr Ali Shah (PMAS) Arid Agriculture University, Rawalpindi for further analysis. The samples were kept in a freezer or stored in 10% formalin solution for preservation. Then, crops and gizzards were dissected and their contents were observed to identify their composition. The empty crop and gizzard were weighed again with the digital scale and the difference weight between fresh and emptied crops and gizzards was noted as the weight of the contents. Contents were transferred to a petri dish and examined with the help of a magnifying lens (10x magnifications). Seeds were sorted out and mounted on cardboard sheets. Seed specimens were identified by the Weed Management Programme of the National Agricultural Research Center (NARC), Islamabad. The insect samples were identified with technical assistance of the Biosystematics Laboratory, Department of Entomology, PMAS Arid Agriculture University Rawalpindi and the National Insect Museum, NARC, Islamabad.

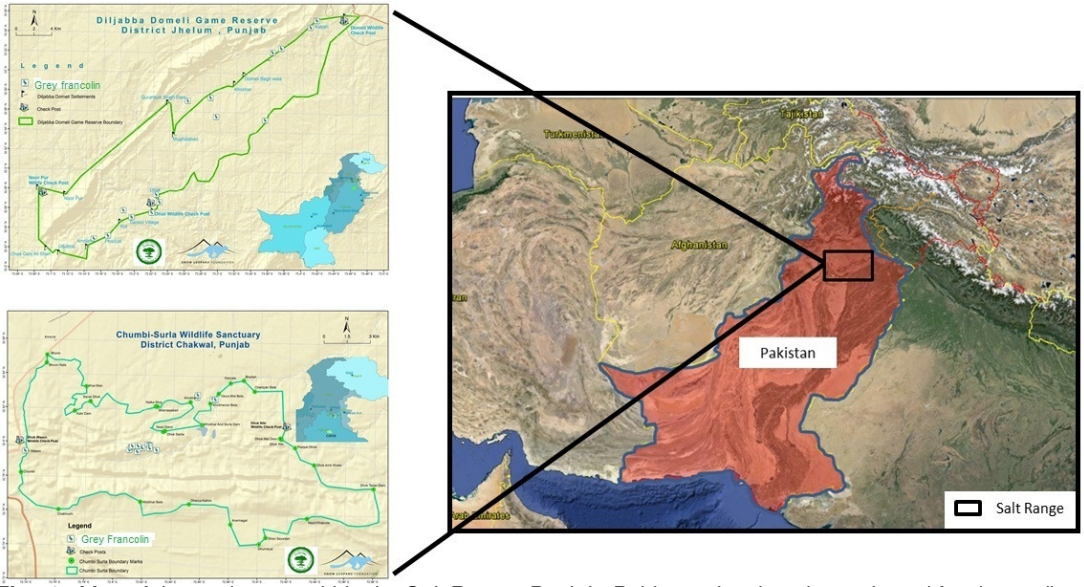

Fig. 1. Map of the study area within the Salt Range, Punjab, Pakistan showing sites selected for data collection of Grey Francolin.

After identification, the seeds and insects were preserved for future reference. Each constituent of the contents was weighed separately. For this purpose, each part was placed in a separate petri dish and air dried by placing at room temperature for 24 hours. The dried samples were weighed with the digital scale.

2.3. Statistical analysis

Seasonal food preference was statistically analyzed by calculating the weight and percentage of different food contents recovered from crops and gizzards of the Grey Francolins hunted during different seasons. The weight of food contents in the morning and evening were compared using student's t-test in QI Macros-2014. The percentages of occurrence of different food items were calculated by the following formula: Percentage = No. of birds with food contents x100 / Total No. of birds.

3. Results

The crop and gizzard samples were collected in different seasons: spring (n=6), summer (n=4), autumn (n=7) and winter (n= 11). Data are presented as mean ± 1 S.E. In the samples collected on mornings, the total weight of the guts with food contents was 147.1 gm (10.50$\pm$1.26) and weight of empty gizzards was 86.65 gm (6.18 $\pm$0.89). Therefore the weight of consumed food in the morning can be calculated to be 59.88gm (4.27$\pm$0.57). In the evening, the weight of the gut with food contents was 115.86 gm (8.27$\pm$0.53) and the weight of empty gizzards was 68.25 gm (4.87$\pm$0.38), hence 46.87gm (3.34$\pm$0.28) of food had been consumed in the evening (Table 1). In total, 12 different food items were recovered from these 28 samples. Plant materials (leaves and seeds) of eight species were identified: *Brassica campestris, Pennisetum typhoideum, Carthemus oxycantha, Eruca sativa, Triticum aestivum, Vigna radiata, Oxalis corniculata* and *Sorghum bicolor*. Body parts of three species of insects were also observed: *Formica rufa* (Hymenoptera), *Coptotermes formosanus* (Isoptera) and *Tribolium castaneum* (Coleoptera). There were also some grit and unidentified materials present.

Analysis of samples indicated some variation in the ratios of different types of food items in different season (Table 2). The consumption of plant materials was high in spring (2.33+0.89) and summer (2.59+0.67) as compared with autumn (1.23+0.48) and winter (1.47+0.65). Insects in the diet compared to plant materials were higher in the summer (4.15+1.93) and winter (2.5+1.44).

The relative abundance of plant matter was determined as follows: *Vigna radiata* (12.17 %), *Brassica rapa* (11.16 %), *Pennisetum typhoideum* (10.14 %) and *Triticum aestivum* (9.13%). The relative abundance of insects was: *Coptotermes formosanus* (11.16 %), *Formica rufa* (7.10 %) and *Tribolium castaneum* (3.04 %). Grit was present in 60.7% and unidentified material in 32.1% of all samples (Fig. 2).

Comparison of the weight of different food items collected in the morning and evening showed that amount and species in the selection of food did not differ significantly based on time of day ($P \geq 0.05$; 3.87$\pm$0.54 g in the morning and 3.75$\pm$0.38 g in the evening).

4. Discussion

During the study, Grey Francolins were directly observed feeding in cultivated fields of *Brassica rapa* leaves and also observed feeding on Bajra cones *Pennisetum typhoideum,* termites *Coptotermes formosanus* and red ants *Formica rufa.* They were also observed feeding on fresh dung of cow as well as on old cow dung as a source of termites.

Table 1. Weight (g) of food contents of the Grey Francolin in the Salt Range, Pakistan.

Specimen No.	Sex	Time of Hunt	Total Weight (Gut portion with food contents)	Weight of empty gizzard	Weight of food contents
1	Male	Morning	8.42	5.68	2.70
2	Female	Morning	15.08	9.21	5.87
3	Male	Morning	7.64	5.20	2.31
4	Male	Morning	8	5.21	2.69
5	Female	Morning	17.67	11.69	5.98
6	Male	Morning	17.97	11.44	6.50
7	Female	Morning	18.13	11.47	6.63
8	Female	Morning	6.88	2.54	4.34
9	Male	Morning	10.97	3.76	7.21
10	Male	Morning	9.97	3.0	6.97
11	Female	Morning	8.15	5.08	3.05
12	Male	Morning	6.65	4.42	2.23
13	Female	Morning	4.05	2.56	1.37
14	Female	Morning	7.52	5.39	2.03
Total			**147.1**	**86.65**	**59.88**
Mean ± S.E			**10.50±1.26**	**6.18 ±0.89**	**4.27±0.57**
S.D			**4.71**	**3.33**	**2.14**
15	Female	Evening	11.32	6.64	4.63
16	Female	Evening	9.75	7.21	2.25
17	Female	Evening	11.21	5.23	5.90
18	Male	Evening	7.51	4.93	2.56
19	Male	Evening	9.31	5.81	3.40
20	Male	Evening	7.64	5.37	2.24
21	Male	Evening	5.04	2.23	2.81
22	Male	Evening	7.27	3.69	3.56
23	Male	Evening	7.42	4.21	3.09
24	Male	Evening	5.62	3.30	2.29
25	Male	Evening	6.93	4.19	2.74
26	Male	Evening	8.34	3.87	4.47
27	Female	Evening	7.40	4.51	2.89
28	Male	Evening	11.10	7.06	4.04
Total			**115.86**	**68.25**	**46.87**
Mean ± S.E			**8.27±0.53**	**4.87±0.38**	**3.34±0.28**
S.D			**1.99**	**1.45**	**1.07**

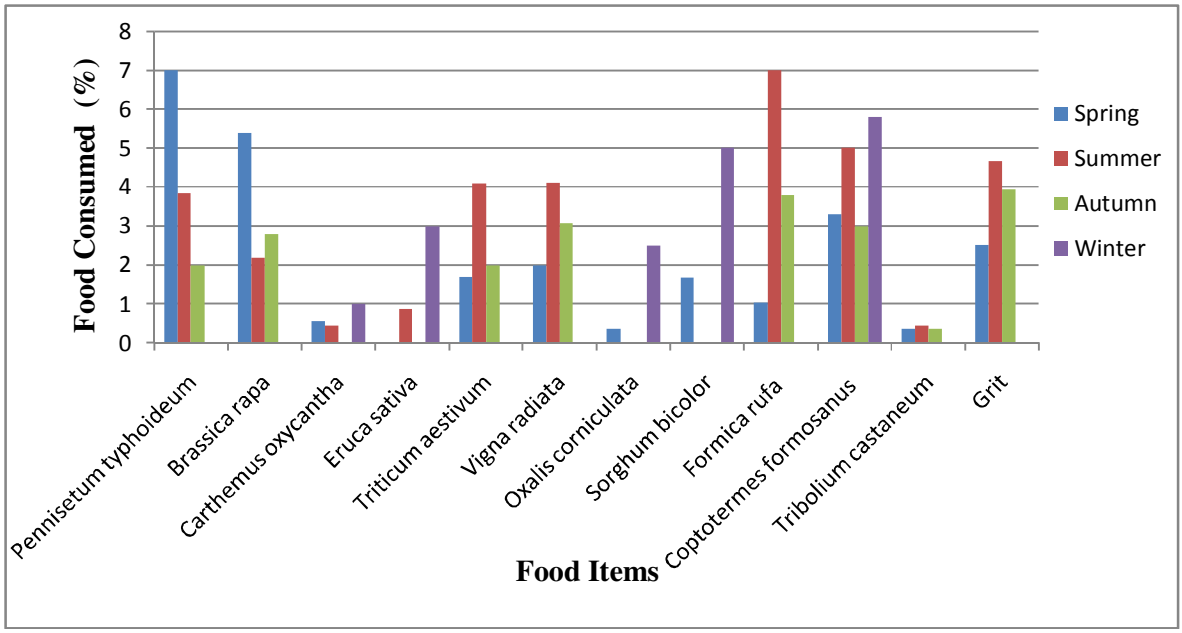

Fig. 2. Relative consumption of different food items by the Grey Francolin in different seasons in Salt Range.

Table 2. Occurrence of food contents (g) in crop/ gizzard samples of Grey Francolin in different seasons in the Salt Range, Pakistan.

Food items	Common Name	Seasons				Total (N=28)	Percent occurrence
		Spring (n=6)	Summer (n=4)	Autumn (n=7)	Winter (n=11)		
Vigna radiata	Mung Bean	1.0 ±0.33	1.02± 0.55	0.76± 0.19	1.5 ±0.5	3.04± 0.43	12.17
Brassica campestris	Mustard	1.34 ±0.23	1.09± 0.09	1.39 ±0.60	1.58 ±0.55	3.78± 0.76	11.16
Pennisetum typhoideum	Millet	2.33± 0.33	1.91±0.08	0.66 ±0.22	1.5± 0.5	3.96± 1.08	10.14
Triticum aestivum	Wheat	0.5± 0.27	1.36 ±0.35	0.5± 0.16	0.85± 0.15	2.19± 0.66	9.13
Carthemus oxyacantha	Wild safflower or pholi	0.13± 0.13	0.11± 0.11	0.0±0.0	0.0±0.0	0.25± 0.14	7.14
Eruca sativa	Taramera, aragula	0.0	0.43± 0.36	0.0	0.0	0.21± 0.21	1.01
Oxalis corniculata	Wood sorrel	0.36±0.0	0.0	0.0	0.0	0.09± 0.09	1.01
Sorghum bicolor	Jowar	1.68±0.0	0.0	0.0	0.0	0.42± 0.42	1.01
Mean (of plants) ± S.E.		**2.33±0.89**	**2.59±0.67**	**1.23±0.48**	**1.47±0.65**	**6.98±2.39**	
Coptotermes formosanus	Termite	0.60± 0.14	2.5 ±1.44	1.5 ±1.17	2.5± 1.44	4.07±0.53	11.16
Formica rufa	Red Ant	0.51± 0.47	2.33± 0.33	1.26 ±0.99	1.25±1.25	3.58± 1.27	7.10
Tribolium castaneum	Flour Beetle	0.36±0.0	0.45±0.0	0.36±0.0	0.0	0.29± 0.09	3.04
Mean (of insects) ± S.E.		**1.56±0.88**	**4.15±1.93**	**2.38±1.03**	**2.5±1.44**	**10.6± 4.74**	
Grit	Stone	0.62± 0.17	1.16 ±0.55	0.98± 0.34	1.15 ±0.44	4.22± 0.68	17.24
Unidentified mixture		0.17± 0.06	0.12± 0.02	0.49 ±0.49	1.10±1.10	0.55± 0.18	9.13

The occurrence of 11 food species (8 plants, 3 insects) suggest that the Grey Francolin feed on relatively few plants and animals in the study area. Overall, this species is considered to be omnivorous. This statement is supported by earlier findings of Hussain *et al.* (2012) in agro-ecosystems of Pothwar Plateau, where there were nine identifiable food items in the diet of the species, consisting of seven plant species (*Pennisetum typhoideum*, *Sorghum bicolor*, *Sorghum halepense*, *Prosopis juliflora*, *Phaseolus radiatus*, *Carthemus oxycantha* and *Acacia* sp.) and two insect species (*Coptotermes formosanus* and *Formica rufa*). However, the number of identifiable food species in the present study was less than that reported from the Lal Suhanra National Park (LSNP) (35 plant species and 16 animal species), located in a desert ecosystem in Bahawalpur, Pakistan (Khan & Mian 2012) and other studies (Faruqui *et al.* 1960; Ullah 1991; Chaudhry & Bhatti 1992; Mian & Wajid 1994). The present study suggested that insects constituted 21.3 % of the diet. The occurrence of insects was previously reported by Mian & Wajid (1994). However, Ali & Ripley (1983), Roberts (1991) and Chaudhry & Bhatti (1992) have reported the presence of reptiles and earthworms along with insects in the diet of this Grey Francolins.

Our study also indicated that the Grey Francolin consumes plants based on their seasonal availability. Potts (1980) suggested that young Grey Partridges *Perdix perdix* require a diet with high protein from insects for their growth in summer as they are unable to (effectively) digest plant matter. According to Kobriger (1977) and Hupp (1980), in South and North Dakota, Grey Partridges consume small grains in late summer and fall and insects were the major source of food for juveniles during summer. Our results are in contrast to the findings of Khan & Mian (2012) who studied Grey Francolin in Lal Suhanra National Park and found that seeds were dominant during autumn and winter

while insects were higher in spring and summer.

Grey Francolins were found feeding on crops during spring and winter seasons. Adults and chicks also observed feeding on cow dung, which harbours termites, a source of protein for chicks. It was earlier reported that in the first weeks of life, Grey Partridge *Perdix perdix* feed almost exclusively on insects to obtain the proteins needed for rapid growth (Ewald *et al*. 2010). The diet of the Grey Francolin during the winter months has reportedly been dominated by mustard *Brassica sp.* seeds and leaves in Layyah, Punjab (Mian & Wajid 1994). These findings are also supported by Kaiser (1998), who stated that Grey Partridges occur in large numbers on farmlands and fields with a high diversity of crops. Similarly, Bro *et al*. (2004) reported maize or oil seeds, winter cereals and beans as preferred food of the Grey Partridge in Europe.

Grit found in crops along with other food items, suggested that the Grey Francolin requires grit for digestion of food materials. The presence of grit had been reported in the gizzard/crop contents of Grey Francolin (Faruqi *et al*. 1960; Ullah 1991; Mian & Wajid 1994). A positive regression of the proportion of grit in crop contents was found with the quantity of seeds and a negative association with softer food items, *i.e.* leaves and insects, in Lal Suhanra National Park (Mian 1995; Khan & Mian 2012).

The Grey Francolin, being an omnivore, utilizes both plants and insects inhabiting the Salt Range area. Therefore, this habitat provides a suitable site for a sustainable population of the Grey Francolin.

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