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Food of Grey Francolin (*Francolinus pondicerianus interpositus*) with Remarks on Competition with Black Francolin (*Francolinus francolinus henrici*) in Lal Suhanra National Park (Pakistan)*

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Abstract.- Analyses of 31 crop contents of grey francolin (*Francolinus pondicerianus interpositus*) collected from Lal Suhanra National Park (Punjab, Pakistan) during different seasons (spring 7, summer 9, autumn 7, winter 8) contained 51 (35 plants, 16 insects) taxa, demonstrating the omnivorous and food generalist character of this species. The food was comprised of seeds (44%), leaves (7%), insects (34%), grit (11%) and unidentified material (5%). Relative representation of all food taxa remained low (>7%). Seeds were more frequent in autumn (49%) and winter (51 %) compared to spring (37%) and summer 40%), insects were in lower proportions in autumn (27%) and winter (28%) than in spring (40%) and summer (38%), and leaves were slightly higher in spring (9%) and summer (10%) than in autumn (5%) and winter (4%). Grit formed 11% of average content and exhibited significant positive regression with seed and significant negative regression with leaves and insects. Comparison of food of grey and black (*F. francolinus henrici)* francolins suggested similarity in types of food consumed with a group of 29 (22 plant, 7 animal) taxa consumed by both. However, 17 taxa (12 plants, 5 animals) were consumed exclusively by black francolin; and 23 (14 plants, 9 animals) were exclusively consumed by grey francolin, suggesting that these sympatric species avoid food competition under the Gause Principle.

Key words: Seasonal variation, food taxa, food type, seeds, leaves, insects, grit, food competition, grey francolin black francolin.

INTRODUCTION

The northern grey francolin **(***Francolinus pondicerianus interpositus;* Order: Galliformes; Family: Phasianidae) is distributed in arid conditions in open grasses and thorn scrub at altitude below 900 m above sea level (asl), over a wide range extending from Pakistan through Indian Peninsula to Bangladesh and Sri Lanka (Ali and Ripley, 1983; Lever, 1987; Roberts, 1991; Fuller *et al*., 2000). The southern Persian black francolin (*F. francolinus henrici*) is present in Indus Plains and associated hills in Pakistan up to an altitude of 1,550 m asl (Roberts, 1991). Both of these species are considered as friends of farmers (Kelso, 1932; Qureshi, 1972), controlling the harmful pests of crops and are good game birds. Global populations of these species are reported to be stable (del Hoyo *et al*., 1994, IUCN, 2007), yet hunters and wildlife enthusiasts believe that there is a decline in indigenous populations of these species, surviving under the territorial limits in Pakistan (Roberts, 1991). Analysis of food requirements can help with the proper management of their populations and enhance their future survival in the area. The grey francolin is adapted to better survive arid conditions than the black francolin, which is more adapted to subtropical habitat (Roberts, 1991). Substantial populations of both these species are surviving together under reasonable protection in the Lal Suhanra National Park, Pakistan (LSNP; Khan, 2010).

The black francolin has been observed digging/ scratching at the ground (Wijeyamohan *et al.*, 2003), tearing at anthills (Johns, 1980) and pecking cattle dung (Ali and Ripley, 1969) possibly searching for ants and insects, which constitute its food. This species has been regarded as omnivores, consuming seeds of cultivated crops [wheat (*Triticum aestivum*), mustard (*Brassica compestris*), maize (*Zea mays*), millet (*Pennisetum typhoideum*), and barley (*Hordeum* sp.)], weeds, green leaves of wild grasses, insects (ground beetles, mole cricket,

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grubs, and insect larvae/pupae) and snails (Manson and Lefroy, 1912, Ali and Ripley, 1969; Roberts, 1991; Chaudhry and Bhatti, 1992; Wijeyamohan *et al*., 2003). Sharma (1983) reported that adults preferred larger insects (grasshoppers), while younger birds preferred smaller insects (ants, including larvae/pupae). Raw data on individual crops contents collected from irrigated tracts (Faisalabad, central Punjab, Pakistan) suggested that 28% of diet of grey francolins came from animal sources (Ullah, 1991). Mian and Wajid (1994) reported that during winter 9.8% of food of this species came from insects in Layyah (Pakistan), which was attributed to lower availability of insects at low temperature. The black francolin has been reported to feed on wide variety of food, including seeds and foliage of different plants species along with insects, lizards, snails, etc. (Faruqi *et al.*, 1960; Bump and Bump, 1964, Roberts, 1991; Chaudhry and Bhatti, 1992; Khan, 1989; Khan and Mian, 2011).

Food of an animal species in an area depends upon a compromise between range of tolerance of the species and availability of food items. Two or more species adopting same trophic level try to avoid inter-specific competition by selecting different food items under Gause's Principle, which is in the interest of both the species (Odum, 1971). Examining the available literature suggests that both grey and black Francolins are omnivorous and food generalist, depending upon seeds, insects and foliage from a number of different taxa. No study has examined the possible feeding competition which may exist between two species, which are sympatric along the range of their distribution.

Present study has been designed to test the hypothesis that the northern grey francolin maintains its omnivorous nature under the desert conditions of the LSNP with some degree of seasonal adjustment to the seasonal variation in availability of different food items and the physiological requirements of the animals. The specific objectives of the study, therefore, included: (a) relative consumption of animal and plant matter, (b) relative consumption of different food species and/or their parts, (c) seasonal variation in food selection, and (d) association of grit with major categories of food ingested by grey francolin. Presence of both black and grey francolins in LSNP provides the opportunity to simultaneously study feeding preferences (results on food of black francolin reported; Khan and Mian, 2011) of both the species and to develop an insight into possible feeding competition between these two species.

MATERIALS AND METHODS

A total of 31 crops of humanely killed and freshly dissected grey francolin were used for this study. The birds were collected from LSNP (29^o 12' - 29^o 78' NL, 71^o 48' - 72^o 08' E; northwestern Cholistan Desert, northwestern part of the Thar Desert; high summer temperature and mild winters, low relative humidity, sporadic rainfall mainly in July-August; most plant species bloom in autumn though some bloom in March-April; grey francolin distributed in non-irrigated desert tracts: Khan, 2010; Khan and Mian, 2011) and its adjacent areas during spring (February - April, n = 7), summer (May – July, n = 9), autumn (August- October, n = 7) and winter (November – January, n = 8). Each crop was weighed in the field (Sartorius, top loading) to the nearest 0.1 g, then preserved separately in plastic bags containing 7% formalin (commercial grade), assigned a field number.

Each crop was dissected to expose its content which was gently teased into a petri dish with a fine brush. The empty crop was weighed (Sartorius, top loading) and difference between fresh and emptied crop weights was taken as weight of crop content. Content of the petri dish was later sorted into plant and animal materials. Plant materials were identified to the lowest possible taxa by morphological comparison with reference drawings of plant species collected from the field, and confirmed (doubtful cases) by histological examination of temporary mounts of grinded pieces compared with drawings of similarly prepared reference materials under light microscope (400 X, Olympus, Japan). Animal parts were directly identified to the lowest possible taxa, using taxonomic characters microscopically. Unidentified materials were regarded as unidentified plant or animal or general food. Grit appearing in each crop was weighed separately. Thereafter, each class of the food item was separately weighed and expressed as percentile of total weight of the crop

content.

Data on different classes of food contents were appropriately pooled to calculate mean and standard errors of mean (SEM) of each food item present in seasonal and overall samples. Associations of grit with different broad types of food items were examined using a linear regression model (Sokal and Rohf, 2000).

Available data on composition of 28 crop contents of black francolins, collected from LSNP (Khan and Mian, 2011) were used for analysis of feeding competition.

RESULTS

General food

The mean weight of the crop content of grey francolins was 14.45±3.17 gm. Relative distribution of different food items (Table I) suggests that this francolin utilizes a minimum of 35 plant and 16 animal species (all insects) in LSNP. All the crop contents examined had food of both plant and animal origin (100% constancy of presence for both, Table II).

Plants provide dominant part (51.4±6.3%) of overall food, animals contributing relatively smaller part (29.5±6.3%). Seeds of different plants constituted 43.3±7.3% of overall diet, while leaves represented 10% of average crop content. Ten plant taxa were represented by both seeds and foliage, while 24 others were represented by seeds only and one (*Zizyphus* sp.) by foliage only.

Contribution of individual food species in average crop content was low, *Neotermes* sp. and an unidentified species of the order Homoptera having higher contributions (6.7%, each) and the majority (22: plants 16, animals 6) contributing <1.0%. This is despite the fact that some of the contents had a very high representation of certain food item. Constancy of presence of different food items were, however, relatively high (>80% for 2 animal species; 61-80% for 9 species, 6 plants and 3 animals; 41-60% for 9 species, 8 plants, 1 animal).

Seasonal variation

Seasonal samples of the stomach contents (Table I, Fig. 1) suggest significant seasonal variation (F, 4.704, df 3, 27, $p < 0.05$) in composition of food items in grey francolin. Proportionate consumption (LSD = 8.51) of seeds was relatively higher in autumn (48.6±12.15 %) and winter (50.5±9.87%) in comparison to spring (37.2±2.13%) and summer (39.8±1.11%). Seeds consumed during autumn and winter is significantly different from those of spring and summer. Conversely, proportionate consumption of insect part was lower in autumn (27.2±1.69%) and winter (28.1±3.29%) as compared with spring (40.2±6.27%) and summer (38.4±4.74%). Proportionate representation of leaves was also slightly higher in spring (9.0±2.24%) and summer (10.1±3.85%), compared to autumn (6.3±2.15%) and winter 4.0±1.45%). A majority of the taxa were consumed in all seasons, though their proportionate consumption varied with the season. Overall diversity of plant taxa in seasonal samples of crop remained relatively constant (autumn = 28, winter = 29, spring = 31 summer = 30), however the number of taxa represented by seeds (autumn = 23, winter = 27, spring = 25, summer = 27), differed from leaves (autumn = 5, winter = 3, spring = 15, summer = 12). The diversity of insects taxa was similar in all seasons (autumn = 10, winter = 12, spring = 15, summer = 12).

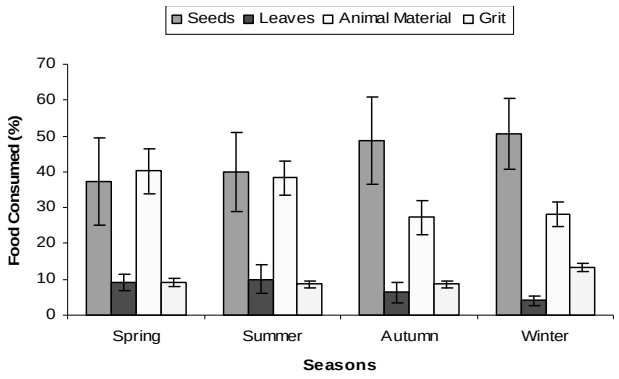

Fig. 1. Comparison of food material consumed by grey francolin in different seasons in Lal Suhanra National Park.

Grit

Grit formed some 11.0±0.15% (CV = 7.59%; 95% CL = 10.7 -11.3%) of the overall sample. Autumn (12.2±0.2%) and winter (13.3±0.2%)

Table I.- Relative frequencies (%) of different items of food recovered from the crops of the grey francolin, killed during different seasons from Lal Suhanra National Park during 1998.

Food species	Spring (n=7)			Summer (n=9)			Autumn (n=7)			Winter (n=8)			Total (n=31)		
	Seeds	Leaves	Total	Seeds	Leaves	Total	Seeds	Leaves	Total	Seeds	Leaves	Total	Seeds	Leaves	G. Total
Plants															
Cenchrus sp.	2.91± 0.12	1.07± 0.10	3.98± 0.22	3.12± 0.22	-	3.12± 0.22	4.31± 0.32	-	4.31± 0.32	4.04± 0.42	-	4.04± 0.42	3.62± 0.22	0.31± 0.08	3.93± 0.30
Eleusine sp.	3.06± 0.32	0.77± 0.18	3.83± 0.50	2.82± 0.14	0.74± 0.11	3.56± 0.25	3.39± 0.23	0.62± 0.08	4.01± 0.31	2.25± 0.13	-	2.25± 0.13	2.87± 0.21	0.61± 0.11	3.48± 0.32
Dactyloctenium sp.	2.76± 0.23	1.07± 0.12	3.83± 0.35	2.67± 0.12	-	2.67± 0.12	2.62± 0.13	-	2.62± 0.13	1.95± 0.11	-	1.95± 0.11	2.57± 0.22	0.31± 0.11	2.88± 0.33
Cucumis prophetarum	-	1.38± 0.13	1.38± 0.13	2.23± 0.21	1.04± 0.11	3.27± 0.32	3.39± 0.12	-	3.39± 0.12	3.59± 0.22	-	3.59± 0.32	2.27± 0.23	0.61± 0.11	2.88± 0.34
Triticum aestivum	2.31± 0.22	-	2.31± 0.22	1.49± 0.12	-	1.49± 0.12	3.39± 0.22	-	3.39± 0.22	3.74± 0.22	-	3.74± 0.03	2.72± 0.12	-	2.72± 0.22
Aristida sp.	3.37± 0.33	-	3.37± 0.33	2.45± 0.13	-	2.45± 0.13	1.70± 0.13	-	1.70± 0.13	2.99± 0.18	-	2.99± 0.02	2.57± 0.14	-	2.57± 0.22
Pennisetum typhoides	1.84± 0.12	0.77± 0.11	2.61± 0.33	2.14± 0.12	-	2.14± 0.12	3.39± 0.12	-	3.39± 0.12	2.55± 0.14	-	2.55± 0.02	2.44± 0.13	-	2.44± 0.23
Acacia sp.	-	-	-	2.67± 0.22	0.31± 0.11	2.97± 0.33	3.08± 0.10	-	3.08± 0.10	3.14± 0.13	-	3.14± 0.03	2.27± 0.14	-	2.29± 0.16
Lasiurus sindicus	1.23± 0.10	-	1.23± 0.10	2.14± 0.10	-	2.14± 0.10	1.85± 0.10	-	1.85± 0.10	1.8± 0.12	-	1.81± 0.02	1.81± 0.12	-	1.81± 0.12
Limeum indicum	0.92± 0.09	-	0.92± 0.09	1.19± 0.12	0.31± 0.03	1.22± 0.15	2.77± 0.22	-	2.77± 0.22	2.41± 0.13	-	2.40± 0.03	1.81± 0.12	-	1.83± 0.13
Lathyrus sp.	0.31± 0.11	0.46± 0.13	0.77± 0.24	1.19± 0.14	0.30± 0.02	1.49± 0.16	2.16± 0.11	-	2.16± 0.11	2.84± 0.11	-	2.84± 0.02	1.66± 0.13	-	1.68± 0.12
Aerva javanica	0.62± 0.11	0.92± 0.12	1.54± 0.33	0.74± 0.12	0.61± 0.11	1.35± 0.23	2.31± 0.12	-	2.31± 0.12	1.65± 0.11	1.35± 0.15	3.01± 0.02	1.36± 0.12	-	1.38± 0.12
Peganum harmala	1.07± 0.11	0.62± 0.08	1.69± 0.19	-	-	-	2.00± 0.11	-	2.00± 0.11	2.25± 0.13	-	2.25± 0.01	1.36± 0.13	-	1.38± 0.13
Cyperus rotundus	1.53± 0.12	-	1.55± 0.12	0.89± 0.11	-	0.89± 0.11	1.54± 0.12	-	1.54± 0.12	1.20± 0.12	-	1.20± 0.01	1.36± 0.13	-	1.38± 0.13
Capparis deciduas	-	0.46± 0.06	0.46± 0.06	1.19± 0.09	1.34± 0.12	2.53± 0.21	-	-	-	1.81± 0.11	0.60± 0.14	2.41± 0.03	0.76± 0.08	0.61± 0.12	1.37± 0.12
Ziziphus sp.	-	2.14± 0.22	2.14± 0.22	-	2.23± 0.22	2.23± 0.23	-	-	-	-	0.31± 0.09	0.31± 0.01	-	1.21± 0.11	1.21± 0.11
Alhagi maurorum	-	-	-	1.19± 0.11	-	1.19± 0.11	1.85± 0.09	-	1.85± 0.09	1.82± 0.12	0.45± 0.11	2.25± 0.02	1.21± 0.11	-	1.23± 0.12
Fagonia sp.	0.77± 0.11	-	0.77± 0.11	1.19± 0.12	-	1.19± 0.12	-	-	-	1.51± 0.11	-	1.52± 0.02	0.91± 0.11	-	0.91± 0.17
Corchorus depressus	1.07± 0.09	1.07± 0.22	2.14± 0.31	0.61± 0.09	0.45± 0.09	1.05± 0.18	-	-	-	-	-	-	0.46± 0.12	0.46± 0.14	0.92± 0.15
Zea mays	0.77± 0.12	-	0.77± 0.12	0.74± 0.12	-	0.74± 0.12	1.08± 0.09	-	1.08± 0.09	0.45± 0.11	-	0.45± 0.01	0.76± 0.12	-	0.76± 0.12

Continued

Food species	Spring (n=7)			Summer (n=9)			Autumn (n=7)			Winter (n=8)			Total (n=31)		
	Seeds	Leaves	Total	Seeds	Leaves	Total	Seeds	Leaves	Total	Seeds	Leaves	Total	Seeds	Leaves	G. Total
Panicum sp.	0.62± 0.12	-	0.62± 0.12	0.45± 0.08	-	0.45± 0.08	1.23± 0.12	-	1.23± 0.12	0.60± 0.14	-	0.61± 0.02	0.76± 0.12	-	0.76± 0.12
Polygonum sp.	-	1.07± 0.01	1.07± 0.12	0.45± 0.11	-	0.45± 0.11	0.62± 0.06	1.08± 0.12	1.70± 0.18	0.45± 0.15	-	0.45± 0.02	0.46± 0.11	0.31± 0.11	0.77± 0.14
Calligonum sp.	1.38± 0.11	-	1.38± 0.11	1.49± 0.13	0.74± 0.07	2.23± 0.20	0.31± 0.03	-	0.31± 0.03	-	-	-	0.61± 0.13	-	0.63± 0.13
Fagonia cretica	-	0.31± 0.09	0.31± 0.09	0.89± 0.12	-	0.89± 0.12	0.31± 0.05	-	0.31± 0.05	0.75± 0.17	-	0.75± 0.01	0.46± 0.16	-	0.48± 0.16
Atylosia sp.	0.92± 0.11	-	0.92± 0.11	0.45± 0.11	-	0.45± 0.11	0.62± 0.06	-	0.62± 0.06	-	0.61± 0.16	0.62± 0.01	0.46± 0.13	-	0.48± 0.11
Cymbopogon sp.	1.07± 0.11	-	1.07± 0.11	-	0.89± 0.14	0.89± 0.14	-	-	-	0.45± 0.13	-	0.45± 0.02	0.46± 0.11	0.31± 0.11	0.77± 0.13
Oligochaeata ramosa	0.62± 0.11	-	0.62± 0.11	0.45± 0.07	-	0.45± 0.07	-	0.62± 0.04	0.62± 0.04	0.60± 0.14	-	0.6± 0.01	0.46± 0.11	-	0.46± 0.09
Prosopis sp.	0.31± 0.09	-	0.31± 0.09	0.31± 0.06	-	0.32± 0.06	-	1.08± 010	1.08± 0.10	1.05± 0.11	-	1.07± 0.01	0.46± 0.12	-	0.48± 0.12
Securinega sp.	0.46± 0.11	-	0.46± 0.11	0.32± 0.08	-	0.32± 0.08	0.77± 0.11	-	0.77± 0.11	0.45± 0.07	-	0.45± 0.02	0.46± 0.12	-	0.46± 0.14
Heliotropium sp.	0.92± 0.21	-	0.94± 0.21	0.45± 0.11	-	0.45± 0.11	0.47± 0.06	-	0.47± 0.06	-	-	-	0.46± 0.13	-	0.48± 0.12
Eragrostis sp.	0..92± 0.10	-	0.92± 0.10	0.32± 0.05	-	0.31± 0.05	-	0.62± 0.06	0.62± 0.06	0.60± 0.12	-	0.61± 0.02	0.46± 0.13	-	0.46± 0.11
Mansonia sp.	0.62± 0.11	0.77± 0.11	1.39± 0.22	0.45± 0.04	-	0.45± 0.04	-	-	-	-	-	-	0.31± 0.09	-	0.33± 0.12
Suaeda fruticosa	0.62± 0.07	-	0.62± 0.07	-	-	-	-	0.62± 0.05	0.62± 0.05	0.61± 0.11	-	0.61± 0.01	0.31± 0.09	-	0.33± 0.11
Tribulus sp.	0.62± 0.11	7.04± 0.31	7.66± 0.42	-	-	-	-	0.62± 0.09	0.62± 0.09	0.60± 0.14	-	0.61± 0.01	0.31± 0.10	-	0.31± 0.11
Boerhaavia diffusa	-	4.74± 0.31	4.74± 0.31	-	0.45± 0.05	0.45± 0.05	0.31± 0.05	-	0.31± 0.05	0.45± 0.11	-	0.45± 0.01	0.19± 0.10	0.23± 0.10	0.42± 0.20
Unidentified plants	3.67± 0.22	0.46± 0.11	4.13± 0.43	3.56± 0.22	0.74± 0.12	4.30± 0.34	3.23± 0.12	1.08± 0.12	4.31± 0.24	2.10± 0.22	0.75± 0.12	2.85± 0.22	3.17± 0.22	0.76± 0.21	3.93± 0.22
Animals															
Neotermes sp.			4.59± 0.13			4.45± 0.12			6.16± 0.15			6.73± 0.15			5.43± 0.12
Homoptera			5.05± 0.13			6.67± 0.21			5.71± 0.14			4.34± 0.13			5.43± 0.14
Hymenoptera			4.59± 0.17			3.56± 0.12			2.93± 0.13			3.89± 0.16			3.77± 0.13
Mastotermitidae			4.13± 0.19			3.12± 0.12			2.47± 0.10			2.25± 0.13			3.02± 0.12

Continued

Food species	Spring (n=7)			Summer (n=9)			Autumn (n=7)			Winter (n=8)			Total (n=31)		
	Seeds	Leaves	Total	Seeds	Leaves	Total	Seeds	Leaves	Total	Seeds	Leaves	Total	Seeds	Leaves	G. Total
Diptera			2.45± 0.13			2.82± 0.10			1.54± 0.11			1.51± 0.12			2.12± 0.13
Hodotermitidae			2.45± 0.12			1.49± 0.11			1.85± 0.12			1.35± 0.12			1.81± 0.12
Gryllotalpidae			0.00± 0.00			1.78± 0.09			1.23± 0.12			0.00± 0.00			0.76± 0.08
Aeshnidae			1.53± 0.13			0.00± 0.00			0.00± 0.00			1.20± 0.14			0.76± 0.06
Trichoptera			0.62± 0.09			0.45± 0.09			0.00± 0.00			1.35± 0.13			0.61± 0.09
Heteroptera			1.53± 0.12			1.63± 0.13			0.47± 0.08			0.00± 0.00			0.91± 0.09
Lepidoptera			0.46± 0.06			1.04± 0.13			0.31± 0.03			0.61± 0.11			0.61± 0.14
Thysanoptera			1.99± 0.12			1.78± 0.13			0.00± 0.00			1.05± 0.12			1.21± 0.13
Mecoptera			1.99± 0.12			0.74± 0.07			0.31± 0.05			0.91± 0.16			1.06± 0.13
Leptoperlidae			1.38± 0.14			1.34± 0.13			0.00± 0.00			0.32± 0.13			0.76± 0.12
Cordulidae			1.69± 0.12			2.14± 0.13			0.00± 0.00			0.00± 0.00			0.91± 0.13
Staphylinidae			0.62± 0.09			0.60± 0.12			0.00± 0.00			0.00± 0.00			0.31± 0.12
Unidentified animals			5.20± 0.12			4.89± 0.13			2.77± 0.12			2.69± 0.12			3.93± 0.14
Grit			9.18± 0.22			8.60± 1.04			12.23± 0.15			13.31± 0.15			11.01± 0.15
Unidentified food			4.44± 0.12			3.12± 0.13			4.62± 0.13			4.04± 0.14			4.08± 0.13
Overall	37.16± 2.13	9.01± 2.24	40.21± 6.27	39.85± 1.11	10.07± 3.85	38.37± 4.74	48.62± 12.15	6.31± 2.15	27.23± 1.69	50.52± 9.87	4.03± 1.45	28.10± 3.29	44.04± 16.33	7.23± 2.56	33.84± 11.46

Table II.- Relative consumption of different items of food species by black (Khan and Mian, 2011) and grey (Present study) francolins in Lal Suhanra National Park, Pakistan.

Food species	Grey francolin (n=31)		Black francolin (n=28)	
	Consumption (%)	Constancy (%)	Consumption (%)	Constancy (%)
Plants				
Triticum aestivum	2.71	70.97	4.49	71.43
Eleusine sp.	3.47	67.67	5.62	71.43
Cenchrus biflorus	3.92	64.52	3.00	64.29
Aristida sp.	2.56	64.52	3.56	67.86
Lathyrus sp.	1.66	54.84	3.18	46.43
Acacia sp.	2.26	51.61	2.05	42.86
Limeum indicum	1.81	51.61	0.19	7.14
Lasiurus sindicus	1.81	51.61	0.56	14.29
Pennisetum typhoides	2.41	48.39	2.05	42.86
Panicum antidotale	0.75	48.39	0.19	14.29
Dactyloctenium spp.	2.87	38.71	3.00	50.00
Cyperus rotundus	1.36	45.16	1.69	35.71
Capparis decidua	1.36	38.71	0.56	46.42
Polygonum sp.	0.75	35.48	0.19	7.14
Suaeda fruticosa	0.30	32.26	1.50	32.14
Fagonia cretica	0.45	32.26	0.94	21.43
Corchorus depressus	0.90	32.26	0.75	35.71
Atylosia sp.	0.45	32.26	0.19	10.71
Fagonia sp.	0.90	32.26	0.19	10.71
Zea mays	0.75	29.03	1.50	46.42
Prosopis juliflora	0.45	29.03	1.12	25.00
Mansonia sp.	0.30	29.03	0.19	3.57
Eragrostis sp.	0.45	25.81	0.37	21.43
Medicago satva	-	-	3.37	67.86
Arnebia sp.	-	-	1.50	39.29
Trifolium alexandrianum	-	-	1.31	28.57
Solanum surattense	-	-	0.94	25.00
Chenopodium murale	-	-	0.56	21.43
Indigofera sp.	-	-	0.37	21.43
Polygala sp.	-	-	0.56	17.86
Chenopodium album	-	-	0.56	17.86
Solanum nigrum	-	-	0.94	14.29
Anticharis linearis	-	-	0.56	14.29
Launaea resedifolia	-	-	1.12	10.71
Leptadenia sp.	-	-	0.37	10.71
Cucumis prophetarum	2.87	67.67	-	-
Aerva javanica	1.36	61.29	-	-
Ziziphus sp.	1.21	45.16	-	-
Calligonum sp.	0.60	32.26	-	-
Securinega sp.	0.45	32.26	-	-
Peganum harmala	1.36	29.03	-	-
Oligochaeata ramosa	0.45	29.03	-	-
Alhagi maurorum	1.21	25.81	-	-
Heliotropium sp.	0.45	25.81	-	-
Cymbopogon sp.	0.45	22.58	-	-
Tribulus sp.	0.30	19.35	-	-
Boerhaavia diffusa	0.15	19.35	-	-

Continued

Food species	Grey francolin (n=31)		Black francolin (n=28)	
	Consumption (%)	Constancy (%)	Consumption (%)	Constancy (%)
Animals				
Isoptera	5.43	93.55	5.24	89.29
Homoptera	5.43	93.55	4.49	85.71
Diptera	2.11	77.42	2.25	78.57
Hymenoptera	3.77	70.97	2.25	53.57
Gryllotalpidae	0.75	29.03	0.19	7.14
Curculionidae	0.75	19.35	1.50	39.29
Staphylinidae	0.30	16.13	3.37	71.43
Cordulidae	0.90	16.13	0.94	21.43
Coleoptera	-	-	2.25	50.00
Orthoptera	-	-	2.25	42.86
Aeshnidae	-	-	0.94	21.43
Gryllidae	-	-	0.75	21.43
Lumbricus spp.	-	-	0.56	17.86
Mastotermitidae	3.02	70.97	-	-
Hodotermitidae	1.81	58.06	-	-
Heteroptera	0.90	38.71	-	-
Thysanoptera	1.21	32.26	-	-
Leptoperlidae	0.75	29.03	-	-
Mecoptera	1.06	25.81	+	-
Trichoptera	0.60	25.81	-	-
Lepidoptera	0.60	25.81	-	-

samples had relatively higher representation of grit as compared with spring (9.18±0.2) and summer (8.6±1.0%). The percent of grit exhibited a strong positive regression with seed ($Y = 0.39 X + 6.71$, $R^2 = 0.68$, $F = 55.73$, $p < 0.001$), and strong negative regression with leave ($Y = 0.77X + 16.52$, $R2 = 0.37$, $F = 10.51$, $p<0.01$) and insect ($Y = 0.38X + 23.28$, $R2 = 0.83$, $F = 128.75$, $p < 0.001$) part of food (Fig. 2).

DISCUSSION

Grey francolin food

Identification of a minimum of 51 (35 plant, 16 animal) taxa from a sample of 31 crop contents, despite the fact that 11% of the contents remained unidentified, suggests an omnivore and euryphagus nature of the grey francolin, utilizing a wide variety of food items. This has been reported previously through lists of different food items appearing in literature (Faruqi *at al*., 1960; Ullah, 1991; Chaudhry and Bhatti, 1992). The present list of food items (Table I) is longer than previous ones, despite a smaller size of the area (LSNP) and low physico-biotic variation, that can be attributed to higher diversity in food taxa under protection of a national park (Mian and Ghani, 2007). A wider base of food of grey francolin and not relying heavy on any single food item is likely advantage to this species, enhancing the possibility of survival during severe droughts which hit the area frequently in a cycle of 3-5 years (Roberts, 1971; Mian, 1985) without seriously lowering the population levels (Khan and Mian, 2011). Although our results document a wide variation in the food species consumed by this francolin only 35 plant species were consumed out of a minimum of 105 identified from LSNP (Khan, 2010) suggests that this species has definite preference for food species/item.

Results of present study suggest that grey francolin mainly subsists on ground picking of seeds (54%) and insects (37%), with leaves contributing 7% of overall diet. No previous study has reported relative consumption of seed and foliage. Raw data (Ullah, 1991) available on the composition of crop contents collected from irrigated cultivation of Faisalabad (Punjab, Pakistan) suggest that insect constitute some 28% of food of this species. Mian and Wajid (1994) suggested that insects constitute 9.8% in the diet of grey francolin population

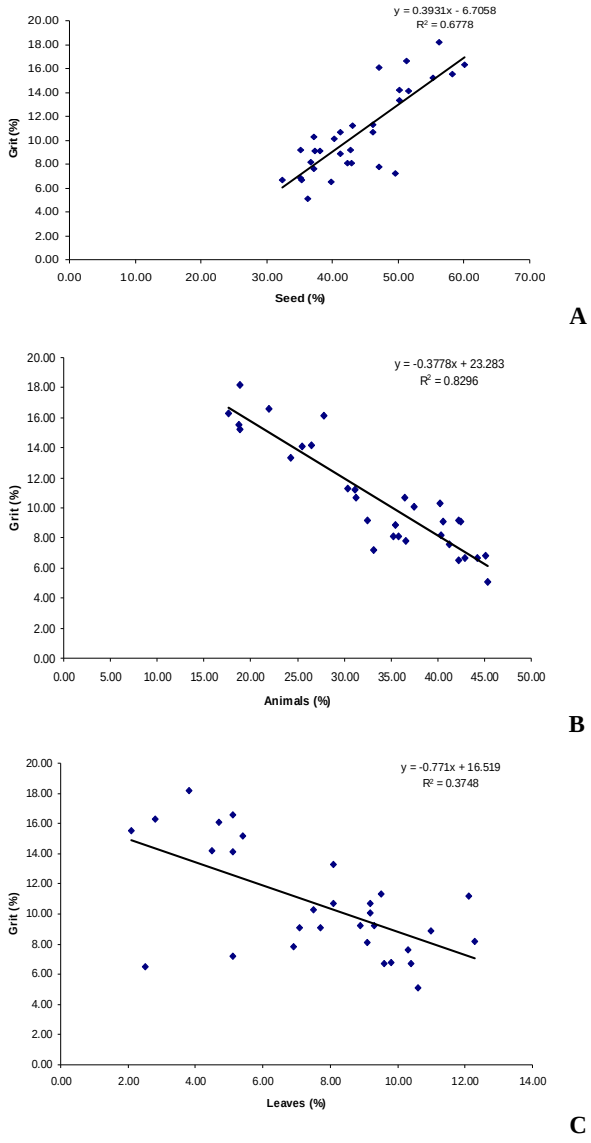

Fig. 2. Regression of the seeds (A), leaves (B), and animal (C), part of the food with the grit in the crop contents of the grey francolin.

surviving in Layyah (Pakistan). Contribution of the insect part of winter diet of grey francolins in LSNP (28%) is higher that that suggested for Bhakhar (Mian and Wajid, *lic cit.*) and can be justified on availability logic, Layyah is located at higher latitudes than LSNP and hence the lower winter temperatures results in a lower availability of insects. Snails, lizards and snakes have been previous indicated as the food items of this francolin species (Soman, 1962; Cramp and Simmons, 1980), were not recorded in the present sample of crop contents, despite the fact that both of these groups were present in the habitat, suggesting that these groups are consumed only when the other preferred food is not available.

Relative consumption of various broad types of the food items during different seasons suggests that the species maintains a higher consumption of seeds and insects in all seasons and foliage probably has a low preference. Variation in relative consumption can be ascribed to the availability logic, seeds mainly produced in autumn, insects available in higher numbers in spring and summer and foliage more abundantly available in spring.

Presence of seeds of cultivated plants (wheat and maize) in the crop contents though does not suggest their ingestion from the cultivated fields and were probably picked up from spill over of these grains along walk dirt tracts running through LSNP and used for movement of men and material. This may not directly confirm the statement of Kelso (1932), suggesting that the grey francolin as friend of the farmers. The potentials of this species to effectively act as a biological control agent for agricultural insect pests is in need of further study.

Presence of grit has been reported in the gizzard/crop contents of many bird species (black francolin, *Francolinus francolinus*: Faruqi *et al*., 1960; Khan, 1989; Khan and Mian, 2011; grey francolin, *F. pondicerius*: Faruqi *et al.*, *loc cit*, Ullah, 1991, Mian and Wajid, 1994; houbara bustard, *Chlamydotis undulate macqueeni*, Mian, 1985). A positive regression of proportion of grit in the contents of the crop with the quantity of seeds and negative association with softer food items, *i.e.*, leaves and insects (Mian, 1985; Khan and Mian, 2011; present study) convincingly suggest that grit is required to churn the harder food in the crops/gizzards of birds, where food items are directly engulfed without being masticated due to absence of teeth in buccal cavity.

Interspecific competition

Preliminary analysis (seeds: black 44.0±7.3%, grey 44.0±16.3%; leaves: black = 8.2±1.3%, grey 7.2±2.6%, insects: black = 32.6±5.4%, grey = 33.8±11.5; Table II, Black: Mian and Khan, 2011,

grey: present study) suggests a non significant difference (t = 0.7855, df 77, P>0.05) in consumption of major types of food items by grey and black francolins (Table II). Species compositions of food consumed by black and grey francolins suggest a blend of similarities and differences. A group of 22 plant and 7 animal species are consumed by both species. However, a group of 17 (12 plants, 5 animals) species are exclusively consumed by black francolin and another group of 23 (14 plants, 9 animals) species being exclusively consumed by grey francolin. Variation in species composition of crop contents of two francolin species can be expected under differential availability of food species in their habitats and by special adaptation of these species having identical feeding habits. Habitat of these species is overlapping in LSNP and grey francolin though showed a wider distribution, yet it is present in all stands having black francolin (Khan, 2010). Under such conditions difference in feeding preferences can hardly be ascribed to the availability, especially under conditions of LSNP, where the area is limited and a line demarcation of food species (especially insects) is not possible. This leads us to propose that these two ecologically allied species may have adapted to some degree of differential food preference to avoid interspecific competition, under Gause's Principle of competitive exclusion. Direct food competition between the two species is not advantageous and hence is avoided to facilitate a positive interspecific interaction. The two francolin species appear to have struck a balance, where a part of their food preference overlaps and a part remains specific to prevent excessive interspecific competition.

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Table I.- Relative frequencies (%) of different items of food recovered from the crops of the grey francolin, killed during different seasons from Lal Suhanra National Park during 1998.

Food species	Spring (n=7)			Summer (n=9)			Autumn (n=7)			Winter (n=8)			Total (n=31)		
	Seeds	Leaves	Total	Seeds	Leaves	Total	Seeds	Leaves	Total	Seeds	Leaves	Total	Seeds	Leaves	G. Total
Plants															
Cenchrus sp.	2.91± 0.12	1.07± 0.10	3.98± 0.22	3.12± 0.22	-	3.12± 0.22	4.31± 0.32	-	4.31± 0.32	4.04± 0.42	-	4.04± 0.42	3.62± 0.22	0.31± 0.08	3.93± 0.30
Eleusine sp.	3.06± 0.32	0.77± 0.18	3.83± 0.50	2.82± 0.14	0.74± 0.11	3.56± 0.25	3.39± 0.23	0.62± 0.08	4.01± 0.31	2.25± 0.13	-	2.25± 0.13	2.87± 0.21	0.61± 0.11	3.48± 0.32
Dactyloctenium sp.	2.76± 0.23	1.07± 0.12	3.83± 0.35	2.67± 0.12	-	2.67± 0.12	2.62± 0.13	-	2.62± 0.13	1.95± 0.11	-	1.95± 0.11	2.57± 0.22	0.31± 0.11	2.88± 0.33
Cucumis prophetarum	-	1.38± 0.13	1.38± 0.13	2.23± 0.21	1.04± 0.11	3.27± 0.32	3.39± 0.12	-	3.39± 0.12	3.59± 0.22	-	3.59± 0.32	2.27± 0.23	0.61± 0.11	2.88± 0.34
Triticum aestivum	2.31± 0.22	-	2.31± 0.22	1.49± 0.12	-	1.49± 0.12	3.39± 0.22	-	3.39± 0.22	3.74± 0.22	-	3.74± 0.03	2.72± 0.12	-	2.72± 0.22
Aristida sp.	3.37± 0.33	-	3.37± 0.33	2.45± 0.13	-	2.45± 0.13	1.70± 0.13	-	1.70± 0.13	2.99± 0.18	-	2.99± 0.02	2.57± 0.14	-	2.57± 0.22
Pennisetum typhoides	1.84± 0.12	0.77± 0.11	2.61± 0.33	2.14± 0.12	-	2.14± 0.12	3.39± 0.12	-	3.39± 0.12	2.55± 0.14	-	2.55± 0.02	2.44± 0.13	-	2.44± 0.23
Acacia sp.	-	-	-	2.67± 0.22	0.31± 0.11	2.97± 0.33	3.08± 0.10	-	3.08± 0.10	3.14± 0.13	-	3.14± 0.03	2.27± 0.14	-	2.29± 0.16
Lasiurus sindicus	1.23± 0.10	-	1.23± 0.10	2.14± 0.10	-	2.14± 0.10	1.85± 0.10	-	1.85± 0.10	1.8± 0.12	-	1.81± 0.02	1.81± 0.12	-	1.81± 0.12
Limeum indicum	0.92± 0.09	-	0.92± 0.09	1.19± 0.12	0.31± 0.03	1.22± 0.15	2.77± 0.22	-	2.77± 0.22	2.41± 0.13	-	2.40± 0.03	1.81± 0.12	-	1.83± 0.13
Lathyrus sp.	0.31± 0.11	0.46± 0.13	0.77± 0.24	1.19± 0.14	0.30± 0.02	1.49± 0.16	2.16± 0.11	-	2.16± 0.11	2.84± 0.11	-	2.84± 0.02	1.66± 0.13	-	1.68± 0.12
Aerva javanica	0.62± 0.11	0.92± 0.12	1.54± 0.33	0.74± 0.12	0.61± 0.11	1.35± 0.23	2.31± 0.12	-	2.31± 0.12	1.65± 0.11	1.35± 0.15	3.01± 0.02	1.36± 0.12	-	1.38± 0.12
Peganum harmala	1.07± 0.11	0.62± 0.08	1.69± 0.19	-	-	-	2.00± 0.11	-	2.00± 0.11	2.25± 0.13	-	2.25± 0.01	1.36± 0.13	-	1.38± 0.13
Cyperus rotundus	1.53± 0.12	-	1.55± 0.12	0.89± 0.11	-	0.89± 0.11	1.54± 0.12	-	1.54± 0.12	1.20± 0.12	-	1.20± 0.01	1.36± 0.13	-	1.38± 0.13
Capparis deciduas	-	0.46± 0.06	0.46± 0.06	1.19± 0.09	1.34± 0.12	2.53± 0.21	-	-	-	1.81± 0.11	0.60± 0.14	2.41± 0.03	0.76± 0.08	0.61± 0.12	1.37± 0.12
Ziziphus sp.	-	2.14± 0.22	2.14± 0.22	-	2.23± 0.22	2.23± 0.23	-	-	-	-	0.31± 0.09	0.31± 0.01	-	1.21± 0.11	1.21± 0.11
Alhagi maurorum	-	-	-	1.19± 0.11	-	1.19± 0.11	1.85± 0.09	-	1.85± 0.09	1.82± 0.12	0.45± 0.11	2.25± 0.02	1.21± 0.11	-	1.23± 0.12
Fagonia sp.	0.77± 0.11	-	0.77± 0.11	1.19± 0.12	-	1.19± 0.12	-	-	-	1.51± 0.11	-	1.52± 0.02	0.91± 0.11	-	0.91± 0.17
Corchorus depressus	1.07± 0.09	1.07± 0.22	2.14± 0.31	0.61± 0.09	0.45± 0.09	1.05± 0.18	-	-	-	-	-	-	0.46± 0.12	0.46± 0.14	0.92± 0.15
Zea mays	0.77± 0.12	-	0.77± 0.12	0.74± 0.12	-	0.74± 0.12	1.08± 0.09	-	1.08± 0.09	0.45± 0.11	-	0.45± 0.01	0.76± 0.12	-	0.76± 0.12

Continued

Food species	Spring (n=7)			Summer (n=9)			Autumn (n=7)			Winter (n=8)			Total (n=31)		
	Seeds	Leaves	Total	Seeds	Leaves	Total	Seeds	Leaves	Total	Seeds	Leaves	Total	Seeds	Leaves	G. Total
Panicum sp.	0.62± 0.12	-	0.62± 0.12	0.45± 0.08	-	0.45± 0.08	1.23± 0.12	-	1.23± 0.12	0.60± 0.14	-	0.61± 0.02	0.76± 0.12	-	0.76± 0.12
Polygonum sp.	-	1.07± 0.01	1.07± 0.12	0.45± 0.11	-	0.45± 0.11	0.62± 0.06	1.08± 0.12	1.70± 0.18	0.45± 0.15	-	0.45± 0.02	0.46± 0.11	0.31± 0.11	0.77± 0.14
Calligonum sp.	1.38± 0.11	-	1.38± 0.11	1.49± 0.13	0.74± 0.07	2.23± 0.20	0.31± 0.03	-	0.31± 0.03	-	-	-	0.61± 0.13	-	0.63± 0.13
Fagonia cretica	-	0.31± 0.09	0.31± 0.09	0.89± 0.12	-	0.89± 0.12	0.31± 0.05	-	0.31± 0.05	0.75± 0.17	-	0.75± 0.01	0.46± 0.16	-	0.48± 0.16
Atylosia sp.	0.92± 0.11	-	0.92± 0.11	0.45± 0.11	-	0.45± 0.11	0.62± 0.06	-	0.62± 0.06	-	0.61± 0.16	0.62± 0.01	0.46± 0.13	-	0.48± 0.11
Cymbopogon sp.	1.07± 0.11	-	1.07± 0.11	-	0.89± 0.14	0.89± 0.14	-	-	-	0.45± 0.13	-	0.45± 0.02	0.46± 0.11	0.31± 0.11	0.77± 0.13
Oligochaeata ramosa	0.62± 0.11	-	0.62± 0.11	0.45± 0.07	-	0.45± 0.07	-	0.62± 0.04	0.62± 0.04	0.60± 0.14	-	0.6± 0.01	0.46± 0.11	-	0.46± 0.09
Prosopis sp.	0.31± 0.09	-	0.31± 0.09	0.31± 0.06	-	0.32± 0.06	-	1.08± 010	1.08± 0.10	1.05± 0.11	-	1.07± 0.01	0.46± 0.12	-	0.48± 0.12
Securinega sp.	0.46± 0.11	-	0.46± 0.11	0.32± 0.08	-	0.32± 0.08	0.77± 0.11	-	0.77± 0.11	0.45± 0.07	-	0.45± 0.02	0.46± 0.12	-	0.46± 0.14
Heliotropium sp.	0.92± 0.21	-	0.94± 0.21	0.45± 0.11	-	0.45± 0.11	0.47± 0.06	-	0.47± 0.06	-	-	-	0.46± 0.13	-	0.48± 0.12
Eragrostis sp.	0..92± 0.10	-	0.92± 0.10	0.32± 0.05	-	0.31± 0.05	-	0.62± 0.06	0.62± 0.06	0.60± 0.12	-	0.61± 0.02	0.46± 0.13	-	0.46± 0.11
Mansonia sp.	0.62± 0.11	0.77± 0.11	1.39± 0.22	0.45± 0.04	-	0.45± 0.04	-	-	-	-	-	-	0.31± 0.09	-	0.33± 0.12
Suaeda fruticosa	0.62± 0.07	-	0.62± 0.07	-	-	-	-	0.62± 0.05	0.62± 0.05	0.61± 0.11	-	0.61± 0.01	0.31± 0.09	-	0.33± 0.11
Tribulus sp.	0.62± 0.11	7.04± 0.31	7.66± 0.42	-	-	-	-	0.62± 0.09	0.62± 0.09	0.60± 0.14	-	0.61± 0.01	0.31± 0.10	-	0.31± 0.11
Boerhaavia diffusa	-	4.74± 0.31	4.74± 0.31	-	0.45± 0.05	0.45± 0.05	0.31± 0.05	-	0.31± 0.05	0.45± 0.11	-	0.45± 0.01	0.19± 0.10	0.23± 0.10	0.42± 0.20
Unidentified plants	3.67± 0.22	0.46± 0.11	4.13± 0.43	3.56± 0.22	0.74± 0.12	4.30± 0.34	3.23± 0.12	1.08± 0.12	4.31± 0.24	2.10± 0.22	0.75± 0.12	2.85± 0.22	3.17± 0.22	0.76± 0.21	3.93± 0.22
Animals															
Neotermes sp.			4.59± 0.13			4.45± 0.12			6.16± 0.15			6.73± 0.15			5.43± 0.12
Homoptera			5.05± 0.13			6.67± 0.21			5.71± 0.14			4.34± 0.13			5.43± 0.14
Hymenoptera			4.59± 0.17			3.56± 0.12			2.93± 0.13			3.89± 0.16			3.77± 0.13
Mastotermitidae			4.13± 0.19			3.12± 0.12			2.47± 0.10			2.25± 0.13			3.02± 0.12

Continued

Food species	Spring (n=7)			Summer (n=9)			Autumn (n=7)			Winter (n=8)			Total (n=31)		
	Seeds	Leaves	Total	Seeds	Leaves	Total	Seeds	Leaves	Total	Seeds	Leaves	Total	Seeds	Leaves	G. Total
Diptera			2.45± 0.13			2.82± 0.10			1.54± 0.11			1.51± 0.12			2.12± 0.13
Hodotermitidae			2.45± 0.12			1.49± 0.11			1.85± 0.12			1.35± 0.12			1.81± 0.12
Gryllotalpidae			0.00± 0.00			1.78± 0.09			1.23± 0.12			0.00± 0.00			0.76± 0.08
Aeshnidae			1.53± 0.13			0.00± 0.00			0.00± 0.00			1.20± 0.14			0.76± 0.06
Trichoptera			0.62± 0.09			0.45± 0.09			0.00± 0.00			1.35± 0.13			0.61± 0.09
Heteroptera			1.53± 0.12			1.63± 0.13			0.47± 0.08			0.00± 0.00			0.91± 0.09
Lepidoptera			0.46± 0.06			1.04± 0.13			0.31± 0.03			0.61± 0.11			0.61± 0.14
Thysanoptera			1.99± 0.12			1.78± 0.13			0.00± 0.00			1.05± 0.12			1.21± 0.13
Mecoptera			1.99± 0.12			0.74± 0.07			0.31± 0.05			0.91± 0.16			1.06± 0.13
Leptoperlidae			1.38± 0.14			1.34± 0.13			0.00± 0.00			0.32± 0.13			0.76± 0.12
Cordulidae			1.69± 0.12			2.14± 0.13			0.00± 0.00			0.00± 0.00			0.91± 0.13
Staphylinidae			0.62± 0.09			0.60± 0.12			0.00± 0.00			0.00± 0.00			0.31± 0.12
Unidentified animals			5.20± 0.12			4.89± 0.13			2.77± 0.12			2.69± 0.12			3.93± 0.14
Grit			9.18± 0.22			8.60± 1.04			12.23± 0.15			13.31± 0.15			11.01± 0.15
Unidentified food			4.44± 0.12			3.12± 0.13			4.62± 0.13			4.04± 0.14			4.08± 0.13
Overall	37.16± 2.13	9.01± 2.24	40.21± 6.27	39.85± 1.11	10.07± 3.85	38.37± 4.74	48.62± 12.15	6.31± 2.15	27.23± 1.69	50.52± 9.87	4.03± 1.45	28.10± 3.29	44.04± 16.33	7.23± 2.56	33.84± 11.46