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Diet of the Eurasian Skylark (*Alauda arvensis* Linnaeus, 1758) Wintering in the Agro-ecosystem of the Pothwar Plateau, Pakistan

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Abstract: This study provides information on the diet of wintering skylarks which is scanty in the currently available literature on its ecology and range in Southern Asia. Eurasian skylark (*Alauda arvensis*) shows a decreasing population trend worldwide. It is a winter visitor to agro-ecosystems of Pakistan including the rain fed area of the Pothwar Plateau. We aimed to determine the diet constituents of this species in agro-ecosystems of Pothwar Plateau, by micro-histological analysis of faecal droppings. We collected 120 faecal samples in total: 40 in fall, winter and spring each. Analysis of the bird droppings revealed that grains and leaves of wheat, and leaves of mustard were preferred by this bird during the crop growth period. The bird supplemented its diet also with leaves and seeds of wild plants and weeds present in the agro-ecosystem of this plateau. The invertebrate component of the diet was owing to insects belonging to the orders Coleoptera and Hemiptera. We suggest reduced anthropogenic use and habitat degradation may increase winter food availability in agro-ecosystems.

Key words: Food habits, diet composition, Eurasian skylark, protected species, agro-ecosystem

Introduction

The Eurasian skylark, *Alauda arvensis* Linnaeus, 1758, is one of the cereal farmland birds that is rapidly declining in numbers (Donald *et al*. 2001, EBCC 2013). Population of this species is declining globally (IUCN 2015), whereas such trend is more evident in Europe (PECBMS 2009). Croplands and coastal habitats are the main winter habitat of skylark in much of its range (Gillings & Fuller 2001). In the agro-ecosystems it prefers open agricultural fields with low crop field boundary vegetation in winter, and specimens aggregate in the mid-field area for feeding (Donald 2004). *Alauda arvensis* prefers leaves of cereal crops during the crop season (Robinson 2001) and feeds on recently sown seeds of cereal crops and spilled grains after their harvest. In the absence of cereal crops, these birds prefer seeds of broad-leaved weeds (Donald *et al*. 2001).

Agricultural intensification, decline in heterogeneity of farmland habitats and reduced food availability during winter are among the multiple factors believed to be responsible for the decline of this species (Geiger *et al*. 2010; Guerrero *et al*. 2012, Kuiper *et al*. 2015). Advancement in crop harvesting technologies has resulted in reduction of post-harvest grain spillage in the fields while use of herbicides suppresses the availability of weed seeds.

The Eurasian skylark is a partly migratory bird (Spaepen & Van Cauteren 1968, Spaepen 1995). Its northern and eastern populations migrate to south-west, the populations of Southern Europe are resident, while that of Central Asia migrate towards southeast (Donald 2004). It is a protected species under the wildlife laws of Pakistan and is among several other birds that come to Pakistan from Europe and Central Asian states via the Indus Flyway or International Bird Migratory Route No. 4 (also called Green Route) during the winter season. There is no resident population within Pakistan: it is a winter migrant to the country

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throughout Baluchistan and Punjab (Roberts 1992). *Alauda arvensis* has experienced a severe population decline in the recent years (Hargues *et al*. 2007, Bhinder *et al*. 2015). This bird has been reported to arrive in the first week of October and stay in Pakistan until the last week of April (Roberts 1992).

Studies on the wintering ecology of Eurasian skylark are scanty in the south-eastern states but several authors have suggested that increased mortality occurs during winter in Europe (Siriwardena *et al*. 2008, Geiger *et al*. 2014, Hegemann *et al*. 2015). In order to develop effective conservation plans, detailed studies on the wintering ecology of this species are crucial. This study was carried out to determine the diet of *A. arvensis* in croplands of Pothwar Plateau, Pakistan which is considered a favourite destination of this winter visitor. The results of our study can help to develop an effective strategy for the conservation of skylarks in this ecosystem.

Materials and Methods

Study area

The Pothwar Plateau, Pakistan (N 33° 30′ 0″ and E 73° 0′ 0″) has an area of ~ 13,000 km^2, with elevation ranging between 305 — 610 m (Nadeem *et al*., 2012). It is an eroded region with undulating topography, gullies, low fertility and erratic rainfall falling mainly in July and August. Its climate is sub-tropical, semi-arid to humid. The region is in the sub-humid zone. The summer temperature ranges between 15 °C and 40 °C while the winter temperature is generally between 4 °C and 25 °C but it can occasionally drop below freezing (Hussain *et al*. 2003). Around 110,600 ha of the Pothwar Plateau is cultivated (GOP 2002-03). Four percent of the cultivated area is irrigated while 96% is dependent on rain (Majeed *et al*. 2010). Agriculture consists of two types of cropping systems: wheat-maize/millet and wheat-groundnut. Wheat is generally intercropped with mustard (*Brassica campestris*, see; Arif & Malik 2009).

On the Pothwar Plateau, crop fields are usually small in size (< 0.2 ha) and there are patches of wild vegetation interspersed within cultivated areas (Shah *et al*. 2012). The common tree and shrub species of this region are *Albizzia lebbek*, *Bauhinia variegata, Eucalyptus camaldulensis*, *Heteropogon contortus*, *Capparis decidua*, *Prosopis juliflora*, *Zizyphus mauritiana*, and *Leucaena leucocephala* (Hussain *et al*. 2009). Jabeen & Ahmad (2009) have reported the ten most abundant species of grasses, i.e. *Cenchrus ciliaris*, *Cannabis sativa*, *Euphorbia helioscopia*, *Dodonaea viscosa*, *Cynodon dactylon*, *Ranunculuc muricatus*, *Parthenium hysterophorus*, *Carissa opaca*, *Otostegia limbata*, and *Saurrurea heteromalla*. The natural vegetation of the plateau is affected by the low rainfall, extensive deforestation, coal mining, and oil and gas exploration (Nizami *et al.* 2004). The farmers prefer manual weeding, presumably to use the weeds as fodder for their livestock, while currently the weed control by herbicides is limited (Hussain *et al*. 2009, Shah *et al*. 2012).

Collection of bird droppings

The faecal droppings were collected from four sites in the agro-ecosystems of the Pothwar Plateau, Pakistan: Thatti Gujran (N 33˚32.915**,** E 072˚49.194), Koont (N 33˚07.365, E 073˚00.541), Shah Syed Billu (N 32˚48.333, E 072˚57.393) and Balkassar (N 32˚56.591, E 072˚33.727). In order to ensure correct identification, the birds were followed to collect their fresh droppings. A total of 120 samples was collected over a period of seven months, i.e. from October 2013 to April 2014. Season-wise distribution resulted in 40 samples each for fall (October-November 2013), winter (December-February 2013-2014) and spring (March-April 2014). The individual droppings were collected in plastic vials with a label containing all information and were immediately transported to the laboratory for analysis.

Collection of reference materials

Simultaneously with faecal sampling, we collected local vegetation, i.e. trees, shrubs, grasses and cultivated crops. Based on information in the literature (Roberts 1992, Khaleghizadeh *et al*. 2006), all local plants possibly contributing to the diet of skylarks were collected. Two specimens of each reference plant or its parts were collected, one for identification and maintaining the reference record, and another for the preparation of micro-histological slides. Distinguishing characters of each part of the reference plant were recorded as a key to identify the plant materials found in the faecal droppings of the birds. Similarly, collection of all invertebrate and insect fauna possibly contributing to the diet of skylarks was also carried out as reference material.

Processing of bird droppings

In the laboratory, the faecal contents were segregated (first by naked eye and then by 10X hand lens) into plant based and animal based materials. For microscopic analysis, the isolated sub-samples of droppings and different parts of reference plants were identified following Vavra & Holechek (1990). The microscopic slides were studied in detail by recording the specific cell characteristics of different parts of the plants or wings, heads and mandibles of arthropods that survived digestion. Since it is unlikely

to recover any intact insect specimen from bird faeces, insects were identified up to the level of the order following Asokan *et al.* (2009).

The proportion of different food components in the diet of skylark were estimated on the basis of their frequency of occurrence. The frequency of occurrence of the identified fragments per microscopic field was converted into theoretical density of fragments following Fracher & Brischle (1944). This theoretical density of different food items was then used to calculate the relative density.

Results

The analysis of the bird droppings showed that skylarks relied predominantly on plant based food. Analysis of the bird droppings showed that skylarks relied on plant based food during the winter season (Fig. 1). The fragments belonging to ten plant species were recorded in the faecal droppings. Among the plant species consumed, there were cultivated crops, i.e. wheat (*Triticum aestivum*) and mustard (*Brassica campestris*), while the other eight species were wild. The bird mainly relied on leaves of the plants, but grains of wheat and seeds of four weed species were also identified in the droppings during their respective maturity periods (Table 1). The animal based diet was composed of insects which were found in 25 out of 120 samples (21%).

Seasonal segregation of the analysed faecal samples showed a seasonal shift in food selection. In fall, the bird mainly relied on leaves of *B. campestris*, and seeds and leaves of *Chenopodium album*. Fifty percent (n = 20) of the faecal pellets had leaves of B. campestris while 45% (n = 18) had seeds and leaves of *C. album*. Other plants consumed by this species were *Xanthium strumarium*, *Setaria pumila* and *Sonchus asper*. Insects of the orders Coleoptera (beetles and weevils) and Hemiptera (true bugs) were also found in the droppings (Table 2) collected in this season.

During winter, skylarks showed a high preference for leaves of *B. campestris* and *Heteropogon contortus* (Table 3). The diet was supplemented by leaves and grains of *T. aestivum* and *Capparis decidua*, and seeds and leaves of *Ipomea eriocarpa*. The insects recovered from the droppings belonged to the orders Coleoptera and Hemiptera.

The skylark continued to ingets high proportion of *B. campestris* along with *Gymnosporia royleana*, *T. aestivum*, *H. contortus* and *Sonchus asper* during spring (Table 4). The insect based food in this period was comprised of beetles and weevils (Coleoptera).

Our results showed that the Eurasian skylarks consumed leaves and grains of cultivated cereal crops during their respective seasons of cultivation. Both wheat and mustard are the winter crops of Pothwar Plateau sown between October and December, and leaves of both were consumed by skylarks.

Discussion

The results of this study revealed that the winter diet of *Alauda arvensis* was dominated by plant matter, mainly seeds and leaves (83%), with the remaining

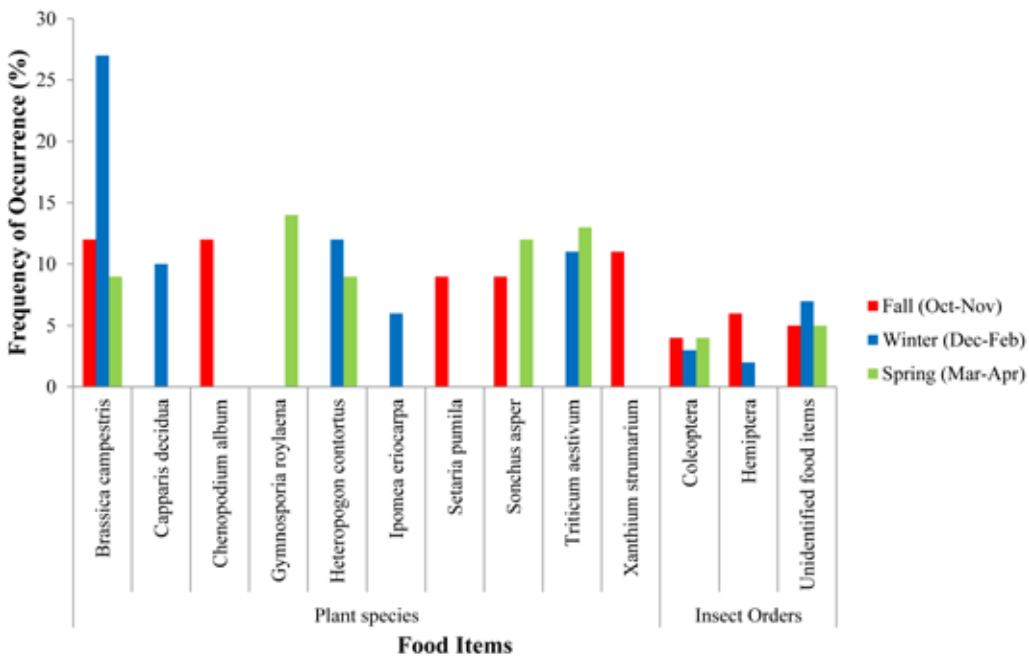

Fig. 1. Frequency of occurrence (%) of different food items identified in the fecal droppings of Eurasian skylark collected from the agro-ecosystem of Pothwar Plateau, Pakistan in different seasons

Table 1. Food items identified in the fecal droppings of Eurasian skylark (*Alauda arvensis*) collected from the agro-ecosystems of Pothwar Plateau, Pakistan

Food components	**Parts consumed**	**No. of droppings with the food items (n)**		
Plant species		Fall 2013	Winter 2013-14	Spring 2014
Ipomea eriocarpa	Leaves, Seeds	-	10 (7L, 3S)	-
Triticum aestivum	Grains, Leaves	-	9 (L)	13 (8L, 5G)
Brassica campestris	Leaves	20	18	10
Heteropogon contortus	Leaves	-	13	11
Capparis deciduas	Leaves	-	10	-
Gymnosporia roylaena	Leaves	-	-	18
Sonchus asper	Leaves, Seeds	11 (9L, 2S)	-	13 (4L, 9S)
Chenopodium album	Leaves, Seeds	18 (10L, 8S)	-	-
Setaria pumila	Leaves, Seeds	11 (7L, 4S)	-	-
Xanthium strumarium	Leaves	6	-	-
Insect Orders				
Coleoptera	-	4	5	4
Hemiptera	-	4	3	

*G=Grains, L=Leaves, S=Seeds

Table 2. Frequency of occurrence, absolute and relative densities of different food items identified in the fecal droppings of Eurasian skylark collected from the agro-ecosystem of Pothwar Plateau, Pakistan in fall (October-November, 2013)

Food items	**Frequency (%)**	**Theoretical density**	**Relative density**
Plant species (Parts eaten)*			
Brassica campestris (L)	12	1.4415	18.3
Sonchus asper (L,S)	9	1.0831	13.74
Chenopodium album (L,S)	12	2.249	17.44
Setaria pumila (L,S)	9	1.9465	13.59
Xanthium strumarium (L)	11	0.6959	16.2
Insect Orders			
Coleoptera	4	0.1426	4.99
Hemiptera	6	0.238	8.31
Unidentified	5	2.1297	7.43

*L=Leaves, S=Seeds

Table 3. Frequency of occurrence, absolute and relative densities of different food items identified in the faecal droppings of Eurasian skylark collected from the agro-ecosystem of Pothwar Plateau, Pakistan in winter (December 2013-February 2014)

Food items	**Frequency (%)**	**Theoretical density**	**Relative density**
Plant species (Parts eaten)*			
Ipomea eriocarpa (L,S)	6	0.8833	8.3
Triticum aestivum (L)	11	1.3615	16.09
Brassica campestris (L)	27	2.9708	35.09
Heteropogon contortus (L)	12	2.4483	16.06
Capparis deciduas (L)	10	1.0448	12.34
Insect Orders			
Coleoptera	3	0.1422	3.35
Hemiptera	2	0.0606	2.39
Unidentified	5	2.2655	6.38

*L=Leaves, S=Seeds

Table 4. Frequency of occurrence, absolute and relative densities of different food items identified in the fecal droppings of Eurasian skylark collected from the agro-ecosystem of Pothwar Plateau, Pakistan in spring (March-April, 2014)

Food items	Frequency (%)	Theoretical density	Relative density
Plant species (Parts eaten)*			
Triticum aestivum (L,G)	13	1.2815	6.07
Brassica campestris (L)	9	1.4367	8.85
Heteropogon contortus (L)	9	1.0983	61.48
Gymnosporia roylaena (L)	14	2.8381	9.71
Sonchus asper (L,S)	12	1.7157	8.13
Insect Orders			
Coleoptera	4	0.1642	2.53
Unidentified	5	2.0956	3.23

*G=Grains, L=Leaves, S=Seeds

proportion being arthropods. Our results showed that the Eurasian skylarks consumed leaves and grains of cultivated cereal crops during their respective growth periods/seasons. Both wheat and mustard are the main winter crops of Pothwar Plateau, sown from October to December and are at foliage stages over this period. Consequently, leaves of both were consumed by skylarks over this period. The presence of wheat grains in the droppings in winter suggests that this ground feeding bird had consumed spilled or surfaced grains during sowing. Mustard crop stays in the fields until late April and its leaves were consumed throughout its availability time while absence of its seeds in the faecal contents prompts us to believe that they were avoided by A. *arvensis*.

We found that the seeds and green plant parts of *B*. *campestris* were preferred by skylark followed by *Heteropogon contortus*. This is in concordance with the findings of Khaleghizadeh *et al*. (2006) from Iran where the Eurasian skylarks are a winter migrant and feed mainly on leaves and grains of *Triticum aestivum*. Geiger *et al*. (2014) have also reported preference of skylarks for cereal grains in winter owing to their high energy content but as soon as they are depleted the birds switch over to weed leaves and seeds.

We recorded leaves of *Capparis deciduas, Gymnosporia royleana*, *Heteropogon contortus* and *Xanthium strumarium*, and seeds and leaves of *Ipomea eriocarpa, Setaria pumila, Sonchus asper* and *Chenopodium album* contributing to the diet of *A*. *arvensis*. These findings are supported by several studies which reported seeds and green parts of weeds constituting the winter diet of this bird (Akhlaq 1987, Roberts 1992, Donald *et al.* 2001, Grzimek 2003). Our findings showed dominance of weed leaves compared to weed seeds in the diet of A. *arvensis*. Such dichotomy could be related with quantitative availability, nutritive values of the relevant parts, as well as with physiological needs and taste preference of skylarks. Similar evidence of smaller proportional occurrence of weed seeds as compared to their leaves has been reported in the stomach contents of ashy crowned finch larks (*Ammomanes phoenicurus*) captured from cotton based agro-ecosystem of Punjab, Pakistan (Hussain & Afzal 2005).

Holland *et al*. (2006) and Smith *et al*. (2009) observed adults and larvae of invertebrates belonging to Arachnida, Coleoptera, Diptera, Lepidoptera, Orthoptera, Hemiptera and Hymenoptera in the droppings of skylark but we were able to record remains of Coleoptera and Hemiptera only. It has been documented that skylarks do not rely much on invertebrate based food during winter (Green 1978, Bruun *et al*. 1992) but members of the order Coleoptera have been reported to have significant contribution in the skylarks' diet during summer, likely for physiological development of their nestlings (Hegemann *et al*. 2013, Ottens *et al*. 2014).

Although we did not measure abundance of food sources which could be crucial in determining the food preference of a species, our results demonstrated that the agro-ecosystem of the Pothwar Plateau could provide suitable winter habitats to this winter visitor. Conservation efforts should be made, such that within the wintering habitats of skylark anthropogenic use of natural vegetation occurring within crop fields should be decreased, along with reducing habitat degradation to a minimum possible extent. Availability of weed seeds and spilled grains of cereals should be increased especially in the stubble fields to enhance the winter populations of this species.

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References

Akhlaq K. A. 1987. Bird life of Daphar and Pakowal irrigated forest plantation of the Punjab. Punjab Government Printing Press, Karachi.

Arif M. & Malik M. A. 2009. Economic feasibility of proposed cropping patterns under different soil moisture regimes of Pothwar Plateau. – *Int. J. Agric. Biol.,* **11**: 27-32.

Asokan S., Ali A. M. S., Samsoor A. & Manikannan R. 2009. Diet of three insectivorous birds in Nagapattinam District, Tamil Nadu India-a preliminary study. – *J. Threat. Taxa*, **1**: 327-330.

Bhinder M. A., Iqbal M., Shahbaz M., Zaheer M. Y. & Shehzad W. 2015. Avian biodiversity of Bajwat wetland, district Sialkot, Pakistan. – *J. Anim. Plant Sci*., **25**: 416-422.

Bruun B., Delin H. & Svensson L. 1992. Birds of Britain and Europe. London, Hamlyn Publishing Group Limited.

Donald P. F. 2004. The Skylark. T & AD Poyser, London.

Donald P. F., Buckingham D. L., Moorcroft D., Muirhead L. B., Evans A. D. & Kirby W. B. 2001. Habitat use and diet of skylarks *Alauda arvensis* wintering on lowland farmland in Southern Britain. – *J. Appl. Ecol*., **38**: 536-547.

EBCC 2013. Pan-European Common Bird Monitoring Scheme. European Bird Census Council. http://www.ebcc.info/pecbm. html.

Fracker S.B. & Brischle J. A. 1944. Measuring the local distribution of Ribes. – *Ecol*., **25**: 283-303.

Geiger F., Bengtsson J., Berendse F., Weisser W. W., Emmerson M., Morales M. B., Ceryngier P., Liira J., Tscharntke T., Winqvist C., Eggers S., Bommarco R., Pa¨rt T., Bretagnolle V., Plantegenest M., Clement L. W., Dennis C., Palmer C., On ate J. J., Guerrero I., Hawro V., Aavik T., Thies C., Flohre A., Ha¨nke S., Fischer C., Goedhart P. W. & Inchausti P. 2010. Persistent negative effects of pesticides on biodiversity and biological control potential on European farmland. – *Basic Appl. Ecol*., **11**: 97-105.

Geiger F., Hegemann A., Gleichman M., Flinks H., de Snoo G. R., Prinz S., Tieleman B. I. & Berendse F. 2014. Habitat use and diet of Skylarks (*Alauda arvensis*) wintering in an intensive agricultural landscape of the Netherlands. – *J. Ornithol*., **155**: 507-518.

Gillings S. & Fuller R. J. 2001. Habitat selection by Skylarks *Alauda arvensis* wintering in Britain in 1997/98. – *Bird Study*, **48**: 293-307.

GOP 2002-2003. Crops under production. Food, Agriculture and Livestock Division, Economic Wing, Islamabad, 2-12.

Green R. 1978. Factors affecting diet of Farmland Skylarks, *Alauda arvensis*. – J. Anim. Ecol., **47**: 913-928.

Grzimek B. 2003. Family: Larks. in: Hutchins, M. (Ed.) Grzimek's Encyclopedia of Animals, Vol. 2, 2nd Edition, Detroit, Gale, 353-354.

Guerrero I., Morales M. B., On ate J. J., Geiger F., Berendse F., Snoo, G. D., Eggers S., Pa¨rt T., Bengtsson J., Clement L. W., Weisser W. W., Olszewski A., Ceryngier P., Hawro V., Liira J., Aavik T., Fischer C., Flohre A., Thies C. & Tscharntke T. 2012. Response of ground nesting farmland birds to agricultural intensification across Europe: landscape and field level management factors. – *Biol. Conserv*., **152**: 74-80.

Hargues R., Girardot P., Ibanez F., Mourguiart P. & Recarte J. 2007. Migration of the skylark *Alauda arvensis* along the southern French Atlantic Coast. – *Wildl. Biol. Pract*., **3**: 93-104.

Hegemann A., Kevin D. M., Heiner F. & Irene T. 2013. Offspring pay sooner, parents pay later: Experimental manipulation of body mass reveals trade-offs between immune function, reproduction and survival. – *Frontiers in Zoology*, **10**: 77.

Hegemann A., Peter P. M. & Irene T. 2015. Causes and consequences of partial migration in a passerine bird. – *Am. Nat*., **186**: 531-546.

Holland J. M., Hutchison M. A. S., Smith B. & Aebischer N. J. 2006. A review of invertebrates and seed-bearing plants as food for farmland birds in Europe. – *Ann. Appl. Biol*., **148**: 49-71.

Hussain A., Mirza S. N., Khan T. A. & Naem M. A. 2009. Determination of relative species composition and seasonal plant communities of Nurpur reserved forest in scrub rangeland of district Chakwal. – *Pak. J. Agric. Sci*., **46**: 34-39.

Hussain I. & Afzal M. 2005. Insectivorous birds and their significance in a cotton-wheat based agro-ecosystem of Punjab, Pakistan. – *Pak. J. Zool*., **37**: 133-143.

Hussain I., Cheema A. M. & Khan A. A. 2003. Small rodents in the crop ecosystem of Pothwar Plateau, Pakistan. – *Wildl. Res*., **30**: 269-274.

IUCN 2015. The IUCN Red List of Threatened Species. http://www.iucnredlist.org/. Accessed on September 29, 2015.

Jabeen T. & Ahmad S. S. 2009. Multivariate analysis of environmental and vegetation data of Ayub National Park, Rawalpindi. – *Soil and Environ*., **28**: 106-112.

Khaleghizadeh A., Alavi J., Espahbodi A. & Taghizadeh M. 2006. Preliminary Survey of Eurasian Skylarks *Alauda arvensis* and Crested Lark *Galerida cristata* feeding on Oilseed Rape in Northern Iran. – *Podoces*, **1**: 80-82.

Kuiper M. W., Ottens H. J., van Ruijven J., Koks B. J., de Snoo G. R. & Berendse F. 2015. Effects of breeding habitat and field margins on the reproductive performance of Skylarks (*Alauda arvensis*) on intensive farmland. – *J. Ornithol.*, **156**: 557-568.

Majeed S., Ali I., Zaman S. M. & Ahmad S. 2010. Productivity of Mini Dams in Pothwar Plateau: A diagnostic analysis. Research Briefings, Natural Resource Division, Pakistan Agricultural Research Council, Islamabad, **2** (13): 1-19.

Nadeem S. M., Naz R., Shah S. I., Beg M. A., Kayani A. R. & Mahmood T. 2012. Season and locality related changes in the diet of Asiatic jackal (*Canis aureus*) in Potohar, Pakistan. – *Turk. J. Zool*., **36**: 1-8.

Nizami M., Shafiq I. M., Rashid A. & Aslam A. 2004. The soils and their agricultural development potential in Potwar. WRRI and NARC, Isl. Pak., 5-7.

Ottens H.J., Kuiper M.W., Flinks H., van Ruijven J., Siepel H., Koks B.J., Berendse F. & de Snoo G.R. 2014. Do field margins enrich the diet of the Eurasian Skylark *Alauda arvensis* on intensive farmland? – *Ardea*, **102**: 161-171.

PECBMS 2009. The State of Europe's Common Birds 2008. CSO/RSBP, Prague; available online at http://www.ebcc.info/wpimages/video/SECB2008.pdf.

Roberts T.J. 1992. The Birds of Pakistan-II; Passeriformes. Oxford University Press, Karachi, 617 pp.

Robinson R.A. 2001. Feeding ecology of skylarks in winter – a possible mechanism for population decline? – In: Donald P.F., Vickery J.A. (Eds.): The Ecology and Conservation of Skylarks *Alauda arvensis*: RSPB, Sandy, 129-138.

Shah N. A., Saeed I., Farooq A. & Afzal M. 2012. Adoption and economic impact of improved wheat varieties in rain-fed Pothwar, Punjab, Pakistan. – *J. Biotech. Ph. Res*., **3**: 94-103.

Siriwardena G. M., Calbrade N. A. & Vickery J. A. 2008. Farmland birds and late winter food: does seed supply fail to meet demand? – *Ibis*, **150**: 585-595.

Smith B., Holland J., Jones N., Moreby S., Morris A.J. & Southway S. 2009. Enhancing invertebrate food resources for skylarks in cereal ecosystems: how useful are in-crop agri-environment scheme management options? – *J. Appl. Ecol*., **46**: 692-702.

Spaepen J. F. 1995. A study of the migration of the Skylark *Alauda arvensis*, based on European ringing data. – *Le Gerfaut*, **85**: 63-89.

Spaepen J. F. & Van Cauteren F. 1968. Migration of the Skylark (New results). – *Le Gerfaut*, **58**: 24-77.

Vavra M. & Holechek J.L. 1990. Factors influencing microhistological analysis of herbivore diets. – *J. Rang. Mgmt*., **35**: 371-375.

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