Turkish Journal of Zoology

http://journals.tubitak.gov.tr/zoology/

Research Article

Turk J Zool
(2018) 42: 700-708
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doi:10.3906/zoo-1802-31

Ecomorphological associations and abundance of birds across the agricultural landscape of Pothwar Plateau, Pakistan

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Received: 20.02.2018 • **Accepted/Published Online:** 27.09.2018 • **Final Version:** 12.11.2018

Abstract: Some species are exceptionally common in landscapes heavily impacted by humans, such as agricultural lands. This study was carried out over a period of 2 years (July 2012 to June 2014) in the arid agricultural landscape of Pothwar Plateau, Pakistan, to identify adaptations that govern bird distribution and abundance across 2 different cropping systems associated with differences in water availability. We used regular surveys and foraging observations to quantify species abundance, distribution, and habits. We then examined morphological correlations with ecological attributes. We found the following: (1) larger birds tended to spend more time in trees; (2) birds with small beaks and relatively long wings more commonly forage on the ground; (3) birds with narrow and long beaks and long tarsi were more likely to be insectivorous in habits. Of these associations, only the third axis, bill stubbiness and short tarsus, correlated with feeding on crops, implying that feeding on plant material is one preadaptation to crop exploitation. Bird abundance was not correlated with feeding on crops. This is because some common species are crop exploiters, but other common species feed on secondary growth (e.g., bulbuls, *Pycnonotus* spp.) or may be common in this region even in the absence of humans (e.g., the green bee-eater, *Merops orientalis*). The best predictor of distribution was not crop-feeding but abundance. This appears to be because common species feed on a set of resources that are common everywhere, whereas range-restricted species are found in areas with water—but even in these areas, water is scarce.

Key words: Agriculture, bird abundance, crop-feeding, ecomorphology, Pakistan

1. Introduction

A growing human population is putting increasing pressure on natural resources to meet food and shelter demands. Conversion of natural habitat to agriculture is considered to be the single largest cause of habitat change on a global scale (Ormerod and Watkinson, 2000). Conversion of larger areas of land to agriculture has reduced habitat heterogeneity and led to reduction in species richness, particularly a decline in avifauna (Benton et al., 2003). Birdlife International's World Bird Database suggests that agriculture is the main threat to bird species listed as threatened; it is substantially more significant a threat for species in developing countries than in developed countries (Green et al., 2005). There are forecasts that about 27%–44% bird species could be lost to agricultural expansion from the Neolithic era to 2050 as a result of measures taken involving pesticide use, intensive agriculture, year-round tillage, fertilization, and insects in agroecosystems (Teyssedre and Couvet, 2007).

The bird species of the plateau include mostly residents, but some are summer breeding visitors, while others are winter visitors. Roberts (1992) reported that 24 bird species are associated with the agricultural landscape of Pothwar Plateau. Similarly, Maan and Chaudhry (2001) observed 24 species of birds in Rawalpindi and 25 in Attock and found that residential avifauna of the plateau are Oriental in region. However, Qaisrani (2006) listed 77 species of birds in this plateau on a field trip, many of these being occasional visitors. During the study period, we surveyed bird densities to compare the 2 major agricultural systems of Pothwar Plateau, and recorded 29 species of birds. As part of another study, we linked habitat characteristics to these estimates of population sizes of bird species associated with the different cropping systems (Sarwar et al., 2015, in preparation; entitled 'Avian abundance and diversity in two different cropping systems of Pothwar Plateau, Pakistan').

Some species of birds benefit from agricultural and other land use changes and may as a consequence become very abundant (Fuller et al., 1997; Moorcroft et al., 2002; Stephens et al., 2003; Morris et al., 2004). These species may be preadapted to exploit agricultural lands, as a result

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of evolution in environments similar to those produced by agriculture. In this context, species in agricultural landscapes are forced to comply with the challenges of everchanging novel foods and shelter. Data regarding ecomorphological correlations of species are particularly lacking from agricultural landscapes, and we are not aware of any assessment of the relationship between morphology and foraging behavior among locally co-occurring bird species on agricultural lands.

It is well understood that morphology is a good predictor of ecology (Price, 1991; Hrabar and Perrin, 2002). The foraging ecology of birds has been widely studied in many parts of the world (Stoate et al., 2001; Barnett et al., 2004), but we did not find any such studies in Pakistan. Therefore, we designed this study to identify features that make species preadapted to crop-feeding, and to determine if these features affect both the abundance and distribution of birds inhabiting the agricultural landscape of Pothwar Plateau, Pakistan. The first part of this study (i.e. avian species identification and their population in different agroecosystems of Pothwar Plateau) is being prepared as a separate manuscript (Sarwar et al., 2015, in preparation). In this paper, we use correlations of morphology with ecology to identify the traits associated with crop-feeding. We then ask whether foraging on crops affects the distribution and abundance of bird species in Pothwar Plateau.

2. Materials and methods

2.1. Study site

The Pothwar Plateau of Pakistan is a dissected region with undulating topography, gullies, low fertility, and erratic rainfall which falls mainly in July and August. Climatically, it is a semiarid subhumid zone (Arif and Malik, 2009), with elevation varying between 305–610 m a.s.l. (Nadeem et al., 2012). An area of around 110,600 ha of Pothwar Plateau is being cultivated (GOP, 2008). Four percent of the cultivated area of Pothwar Plateau is irrigated, while 96% is dependent on rain (Majeed et al., 2010). The crops cultivated include wheat, groundnut, barley, sorghum, maize, millet, legumes, and lentils. However, 2 major types of traditional cropping systems present in this region are wheat–groundnut and wheat–maize/millet (Kazmi and Rasul, 2009). Fruit, particularly apple, citrus, apricot, guava and banana, is also grown in suitable habitat under favorable conditions (GOP, 2008).

The study was conducted in Pothwar Plateau, Punjab, Pakistan, comprising 4 districts: Rawalpindi, Attock, Jhelum, and Chakwal (Figure 1). The total area of Pothwar Plateau is ~13,000 km^2, which accounts for 2.9% of the total area of Pakistan (Ali, 2004). The climate is semiarid to humid. Summer temperatures range between 15 °C and 40 °C, while winter temperatures are generally between 4 °C and 25 °C, but can drop below freezing for some time during winter nights (Hussain et al., 2009). Pothwar Plateau represents 23% of the rain-fed tract of Pakistan (Shah et al., 2012). Sixty percent of the area of Pothwar has been affected by soil and water erosion (Majeed et al., 2010).

Major cultivated crops include wheat, groundnut, barley, sorghum, maize, millet, legumes, and lentil (Rashid and Rasul, 2011). Traditionally 2 types of cropping systems are present in this region: (1) wheat–groundnut at drier locations with hard soil, and (2) wheat–maize/millet

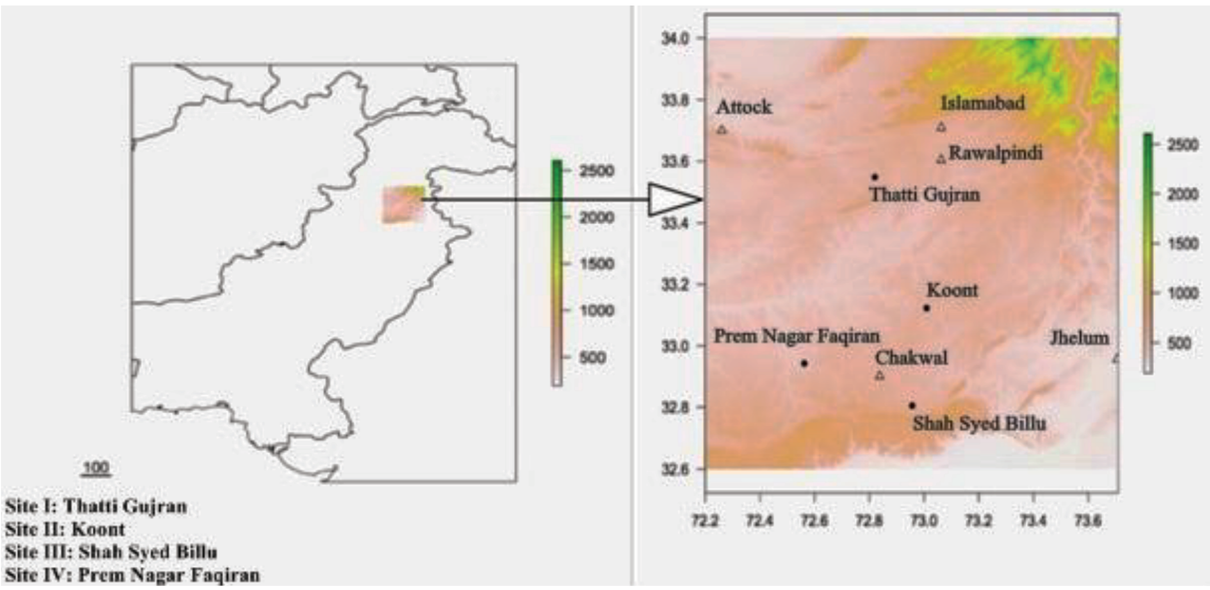

Figure 1. Map of the study area showing the locations of selected study sites.

in areas of loamy soil with relatively more rainfall. The second has relatively better water availability in the form of rainwater ponds (Kazmi and Rasul, 2009).

2.2. Study plan

After an initial reconnaissance survey, we selected 4 study sites, 2 in each cropping system. One site was located in District Attock (site I), another in District Rawalpindi (site II), and the remaining 2 (sites III and IV) in District Chakwal (Figure 1). At each selected site, an intact area of 100 ha was selected for field observations and sampling. The selected areas were visited regularly for data collection once every month over a period of 2 years (July 2012 to June 2014). Two sites (I and IV) were close to rainwater ponds and had the wheat–maize/millet type of cropping system, and 2 (II and III) were located in drier areas with the wheat–groundnut type of cropping system.

2.3. Foraging observations

We observed birds using the point count method (Bibby et al., 1992). At each point, after an initial settling time period of 1 minute, observations were recorded for 10 minutes. M. Sarwar collected all the data. Water ponds (only present at sites I and IV) were especially observed. Any periods of adverse weather (e.g., heavy rain) were avoided (Benton et al., 2003; Douglas et al., 2009). Observations were recorded in the early morning and late evening, coinciding with the periods of greatest daily activity of the birds. Two aspects of foraging were recorded: (1) foraging in trees, shrubs, on the ground, or in crop fields; and (2) identifiable food, categorized as plant material or insect.

The census work on which this paper is based recorded only 29 species of birds associated with 2 different cropping systems in the arid agricultural landscape of Pothwar Plateau (Sarwar et al., 2015, in preparation). In the same dataset of species abundance recorded in the study sites, we considered 28 species (Table 1, where common and scientific names are listed) for this part of study, i.e. foraging ecology. The redheaded merlin (*Falco chicquera*) was not included in this study because it was a raptor, and because we have no information on its foraging habits.

Foraging observations were entirely based on visual observation with either the naked eye or binoculars. We observed a total of 4930 individual birds during the entire study period, of which 60% (2946) were observed feeding (Table 1). Among these, on 92% of the occasions the food item could be classified as plant or animal material. A species-based breakdown of foraging habits is given in Table 1. For each species, we estimated the proportion of observations in each category (sample sizes and raw data are in Appendix I).

2.4. Morphometric measurements

M. Sarwar measured specimens of each species available in the ornithological collection of the Field Museum of Natural History, Chicago. She measured 4 specimens (2 males and 2 females) of each species to reduce measurement error (Perktas and Gosler, 2010). Whenever possible we selected specimens of subspecies obtained from India and/or Pakistan, but sometimes we had to select a closely related subspecies collected from elsewhere. Using dial calipers we measured 5 morphological characters, namely bill length (from front of nares to the tip), bill width (across nares), bill depth (perpendicular, at front of nares), wing length, and tarsus length as functional traits following Botero-Delgadillo and Bayly (2012). Measurements are in Appendix II. Body masses of birds were taken from Dunning (2007).

We collapsed the mean morphological measurements (excluding mass) using a principal components analysis on the correlation matrix of log-transformed species means. The first 3 principal components were employed for analysis (Table 2).

All traits positively correlate with PC1, which is hence a measure of body size, and PC1 scores are highly correlated with log-transformed body mass ($r = 0.87$, $P = 0.0001$). Results were similar whether body mass or PC1 scores were used; we present body mass throughout as the more intuitive measure. Species with high scores on PC2 had large bills and relatively short wings. Higher values for PC3 indicated birds with long, narrow bills and long tarsi. Although variance explained on the second 2 principal components is low, the loadings are readily interpretable shape measures. Because the scores on each component are uncorrelated, we consider both of these components rather than the original measurements.

All proportion data were arcsine–square root transformed before computing statistical significance of correlations. We also calculated significance after correcting for phylogeny using the independent contrast method (Felsenstein, 1985), based on an estimate of phylogenetic relationships and associated branch lengths downloaded from birdtree.org (Jetz et al., 2012) and the APE package (Paradis et al., 2004) in R (R Core Team, 2013). The phylogeny is in Appendix III.

3. Results

3.1. Morphological correlations with foraging habits/ecology

Each of the 3 morphological axes showed a single unique correlation with ecology. Correlations were generally weak, and not all are robust to multiple testing, but can be explained in terms of the birds' natural history. Figure 2 shows the correlations. We drew this figure with morphology as the dependent variable, under the assumption that morphology has evolved in the context of these feeding habits.

3.1.1. Body mass

Body mass and the proportion of time a species was observed in a tree is close to significantly correlated ($r =$

Table 1. Total number of birds, number foraging, and number of birds observed where food was identified in selected study sites of the agricultural landscape of Pothwar Plateau, Pakistan.

		Bird records		
Common name	**Scientific name**	**Total observed (n)**	**Foraging (n)**	**With identified food (n)**
Eurasian collared dove	*Streptopelia decaocto*	413	200	148
*Indian roller	*Coracias benghalensis*	34	23	21
Green bee-eater	*Merops orientalis*	662	499	481
*Golden oriole	*Oriolus oriolus*	32	25	22
Ashy drongo	*Dicrurus leucophaeus*	140	52	47
*Indian tree magpie	*Dendrocitta vagabunda*	34	11	11
*Singing bush lark	*Mirafra cantillans*	46	32	32
Eastern calandra lark	*Melanocorypha bimaculata*	177	91	86
Rufous-tailed finch lark	*Ammomanes phoenicura*	52	38	38
Common lark	*Alauda arvensis*	113	69	56
*Grey-crowned prinia	*Prinia cinereocapilla*	22	9	9
Ashy prinia	*Prinia socialis*	188	87	36
Himalayan bulbul	*Pycnonotus leucogenys*	240	162	135
Red-vented bulbul	*Pycnonotus cafer*	314	173	149
Indian tailor bird	*Orthotomus sutorius*	51	29	29
**Phylloscopus* warbler	*Phylloscopus* spp.	12	7	7
Common whitethroat	*Sylvia communis*	42	21	21
*Large grey babbler	*Turdoides malcolmi*	93	30	30
Common myna	*Acridotheres tristis*	373	212	212
Himalayan thrush	*Myophonus caeruleus*	40	33	29
Redstart	*Phoenicurus ochruros*	21	14	14
Pied bushchat	*Saxicola caprata*	101	57	57
Common sparrow	*Passer domesticus*	1575	976	976
Yellow-throated sparrow	*Petronia xanthocollis*	38	19	19
*Baya weaver	*Ploceus philippinus*	11	5	5
*White wagtail	*Motacilla alba*	29	29	29
Common chaffinch	*Fringilla coelebs*	62	40	33
*White-capped bunting	*Emberiza stewarti*	15	3	3
Total		4930	2946	2735

*Species confined to sites I and/or IV which have rainwater ponds with wheat–maize/millet cropping system.

0.37, P = 0.05, phylogenetic correction, P = 0.08; Figure 2). The main pattern here is that small species are less commonly seen in trees, concentrating their foraging in shrubs and other low vegetation.

3.1.2. Beak size

A measure of beak size relative to wing length (PC2) was generally not significant with respect to foraging habits. However, after removing the white wagtail that always feeds on the ground (Davies and Houston, 1983; Watanabe and Maruyama, 1977), the relationship between PC 2 and proportion feeding observations where a bird was seen on the ground is strong and significant (r = –0.509, P = 0.005, phylogenetic correction, P = 0.03; Figure 2, middle panel). Birds with relatively small beaks tend to feed on the ground.

3.1.3. Beak and tarsus length

Birds with high scores on PC3—i.e. those that have long, narrow bills and long tarsi—tend to eat more insects than

Table 2. Correlations of log-transformed raw variables with the first 3 principal components across the 28 species of birds present in the agricultural landscape of Pothwar Plateau, Pakistan.

Parameters	Component		
	I	II	III
Bill length	0.83	0.49	0.26
Bill width	0.89	0.39	–0.12
Bill depth	0.91	0.27	–0.27
Wing length	0.93	–0.16	0.03
Tarsus length	0.74	–0.05	0.33
% variance explained	0.87	0.07	0.02

plant matter (r = –0.43, P = 0.02, phylogenetic correction P = 0.01; Figure 2, bottom panel).

3.2. Morphological correlations with agriculture

Neither body mass nor PC2 are correlated with the proportion of birds feeding on crops (r = –0.13, P = 0.50 and r = 0.11, P = 0.58, respectively) but PC3 (the measure of bill stubbiness and short tarsi) was correlated with feeding on crops (r = –0.39, P = 0.04, phylogenetic correction, P = 0.06; Figure 3). Given the correlations demonstrated in the previous section, this implies that feeding on plant material is a predictor for foraging on crops.

3.3. Abundance

Abundance and body mass are generally correlated across bird species (Nee et al., 1991). However, in this study abundance and body mass are not correlated (correlations in log-transformed data; r = 0.023, P = 0.91; Figure 4). Nor do PC2 or PC3 scores predict abundance (r = –0.02, P = 0.92; r = –0.16, P = 0.42, respectively). Finally, crop-feeding was not a predictor of abundance. For example, the house sparrow (*Passer domesticus*) was the most common bird species in the agricultural landscape (976 birds observed foraging), and this is crop-associated (being found 791 times in crop fields). However, the second most common species is the green bee-eater (with a sample size of 499 individuals), which never feeds on crops.

3.4. Abundance and distribution across sites

Although causes of abundance are varied, abundance does correlate with distribution. All 28 species were recorded at sites I and/or IV, but only 14 of these were present at sites II and/or III (see Table 1). We asked if abundance predicts distribution. To avoid circularity, we evaluated abundance of birds in sites I and IV only and compared these abundances between widespread and range-restricted species. The widespread species were 4 times more abundant than range-restricted species (mean abundance of widespread species in sites I and IV combined = 185.28, mean abundance of range-restricted species = 82.86, t-test on log-transformed data, t_{26}= 3.02, P = 0.004, phylogenetic correction, P <0.001).

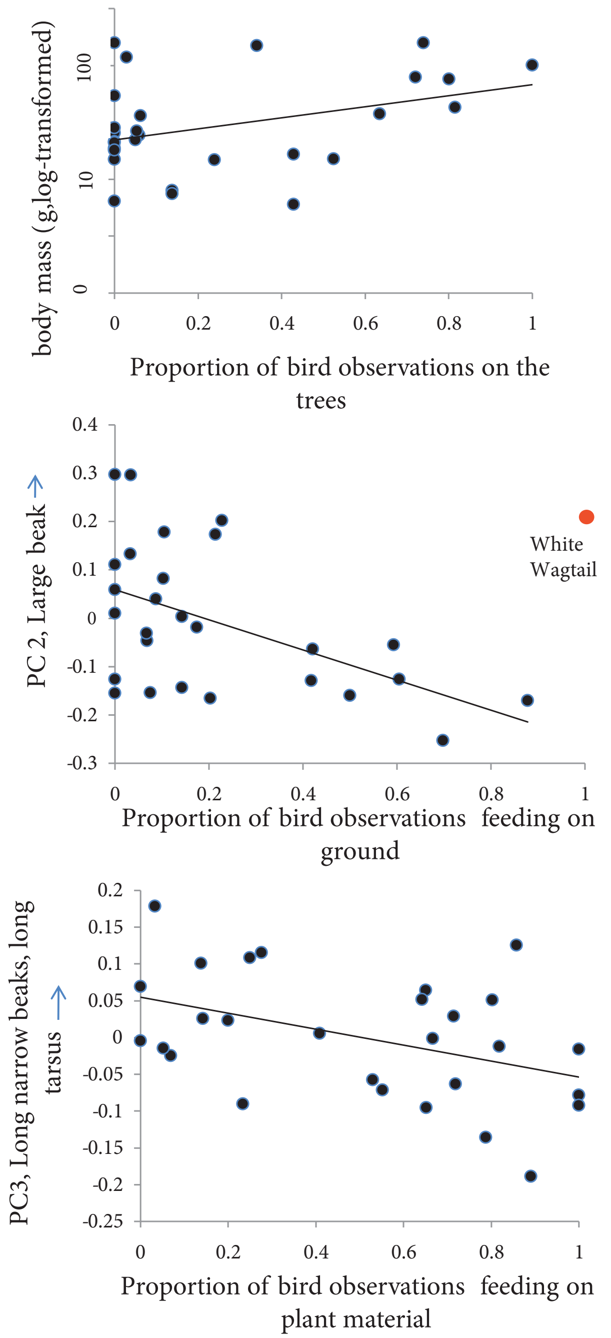

Figure 2. Scatter plots of the 3 indices of morphology in relation to the feeding habits of birds in the agroecosystem of Pothwar Plateau, Pakistan.

The correlation between the abundances of the 14 species found at both sites I and IV and sites II and III was highly significant, implying that species that are

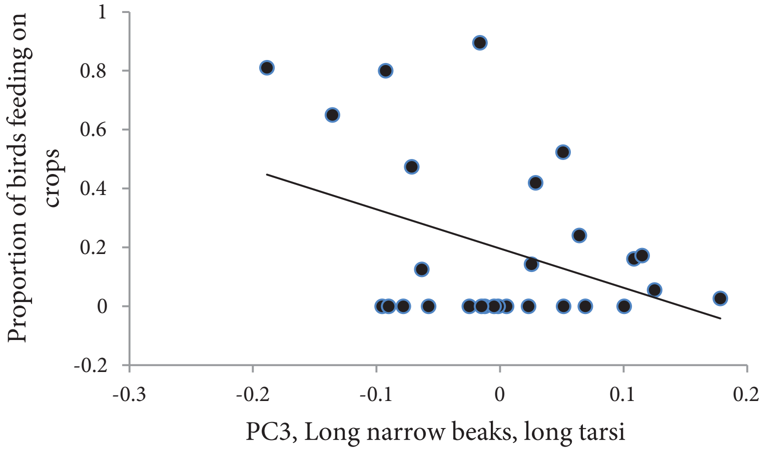

Figure 3. The proportion of birds feeding on crops with respect to PC3; birds having long narrow beaks and long tarsi.

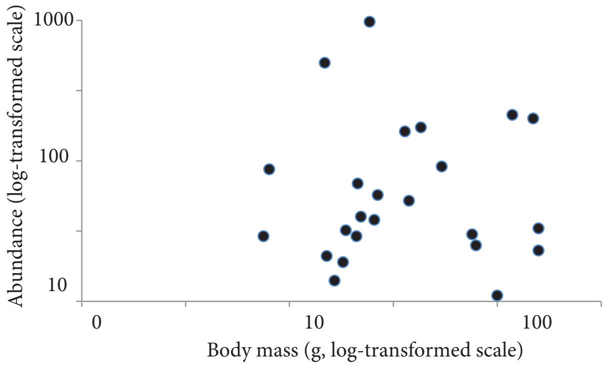

Figure 4. The relationship between number of foraging birds observed and their body mass.

common are common everywhere, and species that are rare are rare everywhere (log-transformed data, r = 0.87, P <0.001; n = 14, phylogenetic correction, P <0.001, Figure 5). The abundance of the common species does not differ significantly between the cropping systems (paired t-test using species as replicate, t_{13} = 1.83, P = 0.09).

4. Discussion

Several studies have addressed the decline in avifauna due to conversion of natural habitat to agriculture (Devictor and Jiguet, 2007; Donald et al., 2001). Although agriculture is reducing species diversity, some bird species are becoming more common (Doxa et al., 2010; Wolff et al., 2001). This study focused on the foraging habits of birds at selected study sites of the agricultural landscape of Pothwar Plateau in the northern part of Punjab, Pakistan to determine which attributes of a species make it advantageous to be on crops, and if crop-foraging also means that the species is abundant and widespread. Using morphology as an index, we found that birds with shorter beaks and tarsi, which tend to feed on plants, are also those that tend to feed on crops, but this does not necessarily make a species common. However, common species do have broad distributions.

We found that 3 individual axes of morphology each correlated with different aspects of ecology. First, body size correlates with being arboreal (body size is also likely to correlate with prey size, but we were not able to measure this). The presence of large species in trees is partly because some of these species (e.g., ashy drongo and Indian roller) use them as vantage points from which they sally to pick up prey from the air or ground, respectively. Several species, like Eurasian collared dove and common myna, seek open sites where grain is available. These species use trees for resting, but are mainly ground foragers (Feare and Craig, 1999; Bates, 2011). Second, birds with relatively large beaks tend to feed more in trees. The 2 species with exceptionally large beaks are the Baya weaver (always seen consuming plant material in our data) and green bee-eater (always eating insects), both of which never forage on the ground, suggesting that this correlation arises for diverse reasons. Third, birds with short and wide beaks and short tarsi (e.g., house sparrow, common chaffinch) tend to eat more plant material than birds with long beaks and long tarsi do (e.g., green bee-eater).

Neither body size nor beak size can predict crop-foraging; however, birds with relatively short and wide bills tend to forage on crops. Thus, as might be expected, birds that feed on plant material are those more commonly observed on crops. Pinowski and Kendeigh (2012) recognize granivores as important crop pests. However, crop-feeding does not automatically raise abundance. The 6 most common species were house sparrow, green bee-eater, common myna, Eurasian collared dove, red-vented

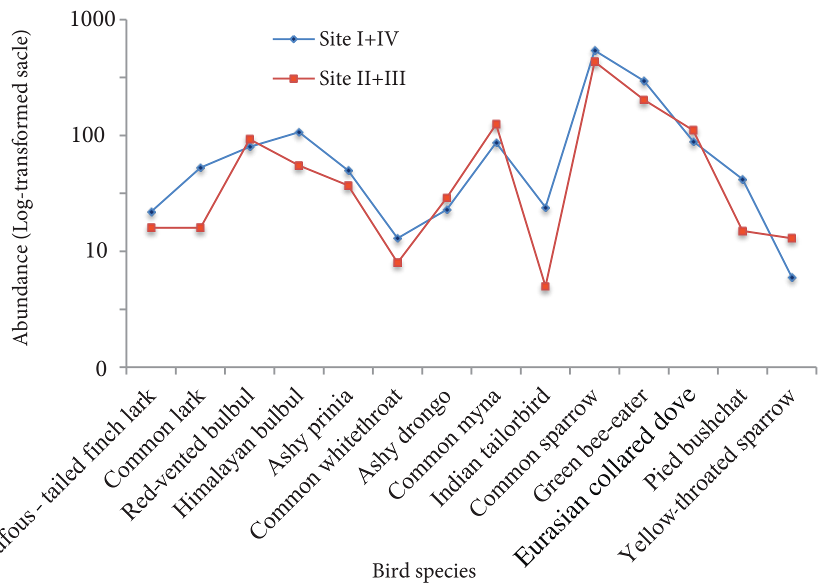

Figure 5. Log-transformed abundance of widespread species across the selected study sites of Pothwar Plateau, Pakistan.

bulbul, and Himalayan bulbul. Among these, except for the green bee-eater, all are common in human populations (Bates, 2011). However, only 3 of these are common in crop fields, notably the sparrow, dove, and myna. We suggest that the green bee-eater has historically been common in the region. The red-vented and Himalayan bulbuls were never seen in crop fields, but they do clearly utilize human-disturbed habitat. For example, *Lantana camara* is an invasive species that thrives in disturbed habitats; it is an important food source for bulbuls (Ali, 1943; Bhatt and Kumar, 2001). The 6 common species are all intermediate to large in size. Thus, although abundance is often determined by mass in natural systems (Jeremy et al., 1996), this is not true across this agricultural landscape (Figure 4).

Abundance is a good predictor of distribution. One general explanation for the correlation between abundance and distribution is that common species exploit a greater diversity of resources, which can then be found at more places (Brown, 1984). However, in this case, massive disturbance by humans across all the sites we studied appears to raise the abundance of 5 of the 6 most common species, because these particular species' resources are elevated everywhere. Interestingly, each species' requirements seem to be similarly affected in each location, as each species' abundance is quite similar at the different sites (Figure 5). The rare species that are also range-restricted seem to be confined to sites with rainwater ponds. These ponds are rare even in the wetter sites, again implying it is the presence and absence of the particular resource that jointly determines both distribution and abundance of the species. Small water areas can reduce the effects of habitat loss, and they can be alternative areas for many bird species in semiarid regions (Karakas, 2017).

It is well established that agricultural habitats decrease species diversity (Benton et al., 2003; Devictor and Jiguet, 2007). In the arid environment of Pothwar Plateau, Pakistan, with rugged topography and small agricultural holdings, the great variation in abundance of species seems to be explained by the abundance and rarity of the resources, with some resources becoming particularly common in human-disturbed habitats. Here we found that some aspects of species which feed on crops could be predicted from their natural foraging ecology, but the foraging measurements we took were necessarily crude. The ecology of Pothwar Plateau does not provide large-scale consistent/uniform cropland. Rather, the ecology is intermittent, with noncrop vegetation in gullies, rain streams, and patches of scrub forest in an undulating landscape. Further studies that measure foraging habits in more detail (such as prey size and prey type), coupled with measurements of the importance of natural areas on species, should allow us to more completely understand how humans have impacted rarity and abundance of birds in this system.

Acknowledgments

This research was funded by the Higher Education Commission, Pakistan, under Indigenous PhD Fellowship for 5000 Scholars' Program, Phase-II, Batch-I. The authors are also thankful to Prof Dr Trevor Price, Department of Ecology and Evolution, University of Chicago, for his valuable assistance in this study.

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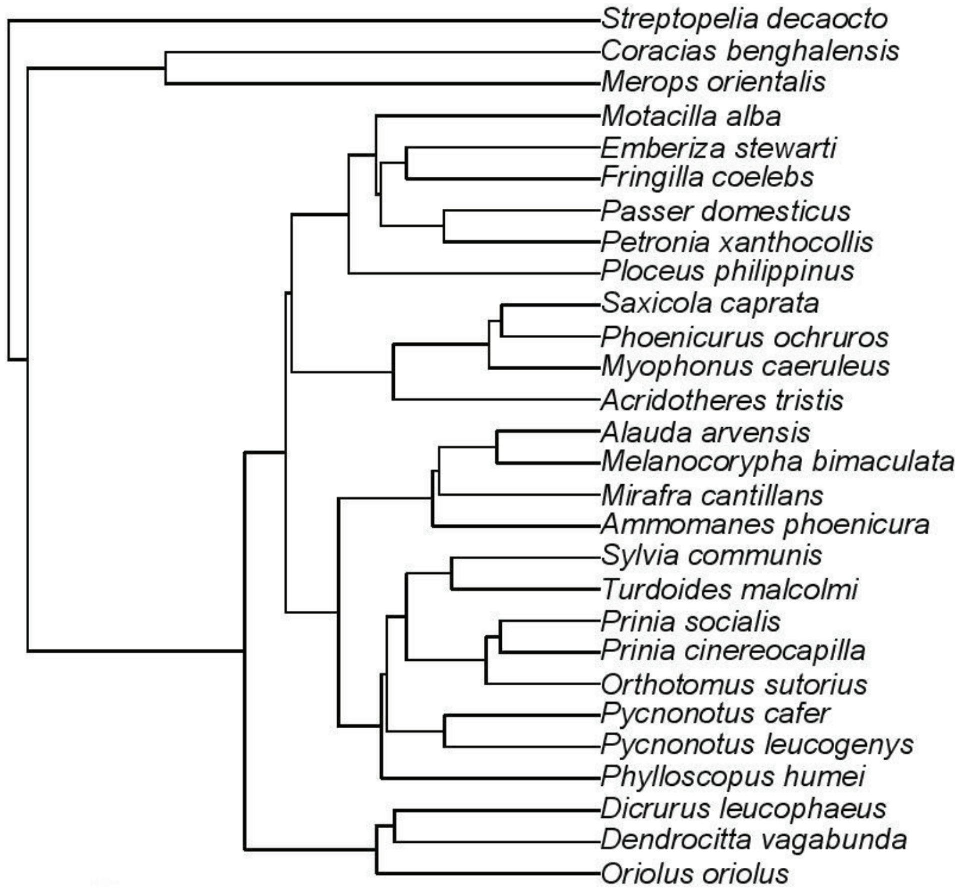
Appendix I. Record of the foraging observations for 28 bird species observed in the selected study sites of the agricultural landscape of Pothwar Plateau, Pakistan.

Species	**Scientific name**	**Substrate (proportion)**				**Water proximity (proportion)**		**Diet matter (proportion)**	
		Tree	**Shrub**	**Ground**	**Crop**	**Yes**	**No**	**Plant**	**Insect**
Eurasian collared dove	*Streptopelia decaocto*	0.34	0	0.61	0.06	0.11	0.89	0.86	0.14
Indian roller	*Coracias benghalensis*	0.74	0.17	0.09	0	1	0	0	1
Green bee-eater	*Merops orientalis*	0.24	0.70	0.03	0.02	0.55	0.45	0.03	0.97
Golden oriole	*Oriolus oriolus*	0.72	0.28	0	0	1	0	0.41	0.59
Ashy drongo	*Dicrurus leucophaeus*	0.63	0.36	0	0	0	1	0.23	0.76
Indian tree magpie	*Dendrocitta vagabunda*	1	0	0	0	1	0	0.82	0.18
Singing bushlark	*Mirafra cantillans*	0	0.28	0.59	0.13	0.59	0.41	0.72	0.28
Eastern Calandra lark	*Melanocorypha bimaculata*	0	0.58	0.42	0.52	0	1	0.80	0.19
Rufous-tailed finch lark	*Ammomanes phoenicura*	0	0.11	0.42	0.47	0	1	0.55	0.45
Common lark	*Alauda arvensis*	0	0.08	0.5	0.42	0	1	0.71	0.28
Grey-crowned prinia	*Prinia cinereocapilla*	0	0.78	0.14	0.14	1	0	0.14	0.89
Ashy prinia	*Prinia socialis*	0.14	0.63	0.07	0.16	0	1	0.25	0.75
Himalayan bulbul	*Pycnonotus leucogenys*	0.06	0.73	0.20	0	0	1	0.65	0.35
Red-vented bulbul	*Pycnonotus cafer*	0.82	0.11	0.07	0	0.39	0.60	0.53	0.47
Indian tailorbird	*Orthotomus sutorius*	0.14	0.59	0.10	0.17	0.66	0.34	0.28	0.72
Phylloscopus warbler	*Phylloscopus* spp.	0.42	0.57	0	0	1	0	0	1
Common whitethroat	*Sylvia communis*	0.52	0.33	0.14	0	0	1	0.67	0.33
Large grey babbler	*Turdoides malcolmi*	0.8	0.16	0.03	0	0.7	0.3	0.2	0.8
Common myna	*Acridotheres tristis*	0.02	0.03	0.69	0.24	0	1	0.65	0.35
Himalayan thrush	*Myophonus caeruleus*	0	0.12	0.88	0	1	0	0.14	0.86
Black redstart	*Phoenicurus ochruros*	0.43	0.36	0.21	0	0	1	0.64	0.36
Pied bushchat	*Saxicola caprata*	0.05	0.72	0.23	0	1	0	0.05	0.95
Common sparrow	*Passer domesticus*	0.05	0.06	0.07	0.81	0.13	0.87	0.89	0.11
Yellow-throated sparrow	*Petronia xanthocollis*	0	0	0.11	0.89	0.37	0.63	1	0
Baya weaver	*Ploceus philippinus*	0	0.2	0	0.8	0	1	1	0
White wagtail	*Motacilla alba*	0	0	1	0	1	0	0.07	0.93
Common chaffinch	*Fringilla coelebs*	0.05	0.13	0.18	0.7	0.15	0.85	0.79	0.21
White-capped bunting	*Emberiza stewartia*	0	1	0	0	1	0	1	0

Appendix II. Mean values of 5 morphological traits obtained from the Field Museum of Natural History, Chicago, for 28 bird species observed in the selected study sites of the agricultural landscape of Pothwar Plateau, Pakistan.

Species	Scientific name	Bill size/shape (mm ± SE)			Wing length (mm ± SE)	Tarsus length (mm ± SE)
		Length	Depth	Width		
Eurasian collared dove	*Streptopelia decaocto*	24.2 ± 0.7	8.25 ± 0.3	9.15 ± 0.1	189 ± 2.2	27.49 ± 0.4
Indian roller	*Coracias benghalensis*	29.48 ± 0.9	11.0 ± 0.1	13.98 ± 0.4	186.75 ± 3.5	22.73 ± 0.6
Green bee-eater	*Merops orientalis*	23.5 ± 0.6	6.46 ± 0.2	5.14 ± 0.2	90.75 ± 0.6	18.47 ± 0.3
Golden oriole	*Oriolus oriolus*	20.85 ± 0.4	8.70 ± 0.3	9.03 ± 0.2	136.5 ± 2.7	19.63 ± 0.6
Ashy drongo	*Dicrurus leucophaeus*	16.59 ± 0.2	8.74 ± 0.3	8.79 ± 0.1	135 ± 3.7	16.35 ± 0.3
Indian tree magpie	*Dendrocitta vagabunda*	22.69 ± 0.8	9.99 ± 0.3	13.66 ± 0.4	149.75 ± 1.1	30.96 ± 1.5
Singing bushlark	*Mirafra cantillans*	8.61 ± 0.3	4.79 ± 0.2	5.69 ± 0.1	73.25 ± 1.8	20.59 ± 0.5
Eastern Calandra lark	*Melanocorypha bimaculata*	14.49 ± 0.3	5.15 ± 0.4	7.59 ± 0.1	121.25 ± 2.3	25.36 ± 0.4
Rufous-tailed finch lark	*Ammomanes phoenicura*	9.99 ± 0.5	5.32 ± 0.3	6.80 ± 0.3	106.25 ± 3.9	20.37 ± 0.3
Common lark	*Alauda arvensis*	8.91 ± 0.2	4.07 ± 0.1	4.65 ± 0.1	99.25 ± 1.9	20.61 ± 2.1
Grey-crowned prinia	*Prinia cinereocapilla*	7.12 ± 0.6	3.32 ± 0.1	2.91 ± 0.2	39.75 ± 1.1	15.41 ± 1.4
Ashy prinia	*Prinia socialis*	8.18 ± 0.5	3.06 ± 0.1	2.81 ± 0.1	50 ± 1.8	17.15 ± 1.3
Himalayan bulbul	*Pycnonotus leucogenys*	8.79 ± 0.5	5.64 ± 0.1	6.18 ± 0.1	92.25 ± 3.7	19.17 ± 0.6
Red-vented bulbul	*Pycnonotus cafer*	9.96 ± 0.1	6.31 ± 0.2	6.12 ± 0.2	96.25 ± 1.5	20.30 ± 1.1
Indian tailorbird	*Orthotomus sutorius*	9.98 ± 0.1	3.70 ± 0.1	3.22 ± 0.1	47.25 ± 1.7	18.59 ± 0.5
Phylloscopus warbler	*Phylloscopus* spp	5.51 ± 0.2	2.72 ± 0.1	2.285 ± 0.2	55.25 ± 2.3	16.61 ± 0.4
Common whitethroat	*Sylvia communis*	7.49 ± 0.2	3.87 ± 0.1	3.90 ± 0.2	72.5 ± 1.1	17.93 ± 0.6
Large grey babbler	*Turdoides malcolmi*	22.93 ± 0.5	10.3 ± 0.3	12.46 ± 0.2	113.25 ± 1.8	34.99 ± 0.4
Common myna	*Acridotheres tristis*	14.39 ± 0.8	7.17 ± 0.2	7.51 ± 0.3	138 ± 2.9	30.19 ± 1.8
Himalayan thrush	*Myophonus caeruleus*	18.61 ± 0.5	9.18 ± 0.3	9.83 ± 0.3	153.5 ± 1.5	42.52 ± 1.6
Black redstart	*Phoenicurus ochruros*	15.46 ± 0.6	5.32 ± 0.2	7.00 ± 0.2	81.75 ± 1.9	24.18 ± 0.5
Pied bushchat	*Saxicola caprata*	16.28 ± 0.3	8.16 ± 0.4	8.59 ± 0.4	74 ± 2.1	26.6 ± 0.3
Common sparrow	*Passer domesticus*	8.86 ± 0.3	5.52 ± 0.2	7.53 ± 0.3	74.5 ± 2.5	16.15 ± 1.1
Yellow-throated sparrow	*Petronia xanthocollis*	14.77 ± 0.9	6.88 ± 0.1	6.35 ± 0.3	83.5 ± 2.1	17.58 ± 0.4
Baya weaver	*Ploceus philippinus*	19.31 ± 0.8	9.00 ± 0.2	10.65 ± 0.1	70.25 ± 1.9	20.04 ± 0.6
White wagtail	*Motacilla alba*	15.14 ± 0.6	8.16 ± 0.6	8.01 ± 0.3	89.75 ± 3.2	24.72 ± 0.5
Common chaffinch	*Fringilla coelebs*	9.17 ± 0.7	5.83 ± 0.2	6.92 ± 0.2	87.5 ± 0.9	18.28 ± 0.6
White-capped bunting	*Emberiza stewartia*	7.48 ± 0.1	3.44 ± 0.2	5.07 ± 0.2	77 ± 2.4	16.26 ± 0.4

*SE's are based on measurements of 2 males and 2 females.



Appendix III. Phylogeny of the 28 bird species studied (taken from Jetz et al., 2012).