academicJournals

Vol. 5(10), pp. 616-624, October 2013
DOI: 10.5897/IJBC2013.0581
ISSN 2141-243X © 2013 Academic Journals
http://www.academicjournals.org/IJBC

International Journal of Biodiversity and Conservation

Full Length Research Paper

Cropland bird community of rain fed region in India: Abundance, activity pattern and susceptibility to pesticide use

Manoj Kale[1]*, Nandkishor Dudhe[2], Raju Kasambe[3], Kiran Morey[4] and Prosun Bhattacharya[1]

[1]Department of Sustainable Development and Environmental Science and Engineering, KTH Royal Institute of Technology, Teknikringen, 76, SE-100 44, Stockholm, Sweden.
[2]Environment Service Scheme (ESS), Centre for Environment Education (CEE), Pune, 411 007, India.
[3]Project Manager, IBA-IBCN, Bombay Natural History Society, Mumbai, 400023, India.
[4]Zilla Parishad, Amravati, 444601, India.

Accepted 19 July, 2013

The activities of cropland birds in an agricultural land are most likely unpredictable in the rain fed region of Maharashtra, India, and therefore the exposure to risk of pesticides application by cropland bird species cannot be sufficiently categorized. The pattern of abundance, territorial, foraging and other activities of cropland avian species was examined at two croplands in Amravati District of Maharashtra State to distinguish the susceptibility of bird species to the application of pesticide use. Overall, 53 bird species were identified in the two croplands over two years period during 2011 and 2012, from June to December. However, out of 53 species, only 14 species were common (recorded at ≥50 of visits) in both croplands. Twenty-one (21) bird species were recorded at Zadgaon Cropland in crops of tur (*Cajanus cajan*), cotton (*Gossypium arboreum*) and soybean (*Glycine max*). Nineteen (19) bird species were recorded at Bhankhed Cropland for more than 50% of visits in crops of jawar (*Sorghum bicolor*), cotton and mung (*Phaseolus aureus*). For Zadgaon cropland, territorial activity is most significant for four species: house sparrow (*Passer domesticus*), jungle babbler (*Turdoides striata*), yellow-eyed babbler (*Chrysomma sinense*) and red-wattled Lapwing (*Vanellus indicus*). House sparrow and jungle babbler were maximum, yellow-eyed babbler was less frequent but more than other species in the month of June, while red-wattled lapwing was maximum in the month of July. Foraging was the imperative activity for most of the species in all months: 24 to 49% of the birds in June; 41 to 61% of the birds in July; 63 to 90% of the birds in August; 77 to 97% of the birds in September; 57 to 97% of the birds in October; 66 to 98% of the birds in November and 74 to 97% of the birds in December. For Bhankhed cropland, foraging was significantly less for Ashy Prinia (*Prinia socialis*), Brahminy Myna (*Sturnia pagodarum*) and Black Drongo (*Dicrurus macrocercus*) in the month of June. The application of pesticides in croplands took place from June to August, which means four species were under high risk, 13 species were at medium risk and eight species at low risk. The level and intensity of this exposure depends on occurrence of types of species in both croplands. This study is significant to recognize crucial species that can be used for detailed study on exposure to pesticides used in cropland.

Key words: Cropland birds, agricultural activities, risk exposure, pesticide use, India.

INTRODUCTION

The activity pattern of birds in the croplands is impacted by a number of factors such as crop type, non-crop physical structural arrangement and the agricultural practices (Rodenhouse et al., 1995). However, the shift in

*Corresponding author. E-mail: kmanoj@kth.se. Tel: +46(8)7908695 or +46 723101301. Fax: +46 (8) 208946.

cultivation timing significantly affects the agricultural activities pattern of cropland birds, which further results in reduction of the population of farmland birds (Best, 1986; Jobin et al., 1996). Shift in cultivation timing occurs as the time of rainfall varies year by year, and rainfall period creates the possibility for bird breeding activities, habitat formation and food availability. In spite of the natural and atmospheric conditions, the increase in land use by humans for other than agriculture purposes influences the avian habitat degradation rate, as these birds are sensitive to the changing pattern of agricultural practices (Lohr et al., 2002).

Our study mainly concentrates on the activities of birds in the rain fed region, as nearly 70% of the population depends on agricultural outcomes rain fed region in India (Comprehensive Assessment, 2007). Farmland birds have significantly adapted to the immovable nature due to climate certainty, primary efficiency and diverse nature of species (Järvinen, 1979). It has been noted that there is an enormous deterioration in bird's population in the last 30 years and consequently many farmland birds are listed as endangered species (Donald et al., 2006). Therefore, considerable measures are needed in this sector starting from crop field's preparation till harvesting in order to protect avian biodiversity (Ranganathan et al., 2012). The trend of reduction in cropland area, agricultural intensity and biodiversity is not only common to Asia (Semwal et al., 2004), but research in North America (Brennan and Kuvlesky, 2005), Europe (Clay, 2004) and Africa (Söderström et al., 2003) have also an identical scenario. that extensive use of pesticides in croplands influences the endocrine disruption and weakens the immune function of bird species; and hence it has destructive biological effect on the birds (Lundholm, 1987; Fairbrother et al., 2004). Pesticide residues are found in eggs of many bird species in different parts of the world (Tannock et al., 1983; Medvedev, 1995). Recent study in Iran indicates that organochlorine pesticide and polychlorinated biphenyl residues are found in bird's feathers (Dahmardeh et al., 2009) and there are many pesticides which are noted to be more harmful to birds than that of mammals (Walker, 1983). In addition, pesticides coated seeds create enough risk to the birds in terms of toxicity and pesticide poisoning even though the area with these seeds typically repels the birds from foraging activity (Hart, 1990; Fletcher et al., 1995; Pascual et al., 1999).

India holds 12th rank in the world and 1st rank in Asia in pesticide production and farmers use pesticides on a large scale in order to protect and improve agricultural production. The large quantity of pesticide usage leaves high pesticide deposit (Abhilash and Singh, 2009).

Due to competition in crop yield, farmers have started modern cropping management from the traditional ones. It is important to know the activities of birds in cropland from pre-harvesting stage to post-harvesting in order to protect the avian biodiversity including the endangered bird species (Donald, 2004).

Our aim of the study to find the influence of pesticide towards the cropland birds in the rain fed agricultural areas in India. this gap of knowledge regarding the farmland birds and agricultural activities, a survey is conducted in two agricultural fields in Amravati District during the year 2011 and 2012, for 14 months (7 months per year, from June to December). Lack of bird population data at different crop lands in most of the areas in Maharashtra State, India is a major obstacle to understand the role and impact of pesticide applications. Our specific objectives in the present study are to determine farmland bird species and pattern of their general activities along with the evaluation of risk assessment tests of these species due to pesticide application.

METHODS

Description of study area and crop type

Amravati District (between 20°56'N, 77°45'E and 20°93'N and 77°75'E, 343 m above mean sea level) in the Maharashtra State of India, located near the passage of River Purna and River Wardha Basin was selected as the study area (Figure 1). We selected on two agricultural farms with area 4 that are situated in Bhankhed and Zadgao villages. Both of the agricultural fields are approximately 65 km far from each other in the same district. Selected crop fields are in the rain fed region of the country and crop production completely depends on the rainwater. This area is close to the forest and rich in avifaunal diversity and compactness. Based on a previous study in the nearby forest reserve (*Pohara-Malkhed*), 171 bird species from 56 bird families were identified (Kasambe and Wadatkar, 2002). Bird count at five pre-decided transect line in Amravati City during the year 2010 confirmed that 61 bird species (57 were resident species and 4 were winter migrant), 30 plant species, 2860 birds were found in highly urbanized areas and 612 birds in industrial areas (Kale et al., 2012). The cropping pattern is conventional type in this area; and the available crops in the jawar, cotton and mung and crops in Zadgao village were tur, cotton, soybean respectively.

Plot selection and bird recording

Bird survey, count and identification were carried out by point count method and observation of birds was taken from a fixed point; other new species of birds are counted on a pre-defined transect line. This method was particularly chosen as it avoids miscounting or missing a particular bird. In this case, one day was spent on each transect route as described by Gaston et al. (2003). The birds were observed by using binoculars with specifications of 10 x 50 and spot identification of birds was done by using field guides provided by Ali and Ripley (1969), Abdulali (1981), Ali and Ripley (1983) and Grimmett et al. (2006). Ten observation points were selected, two at each perimeter (border) of the crop field and two at the center by keeping 20 m distance between them (Boutin et al., 1996). Three minute time was spent at each observation point for recording the species at the crop field, that are resting in the nest of surrounding trees or bushes, on electric cables or other objects. Species which were flying more than 10 m distance from the crop were not recorded because their chances to stop in the crop field are not

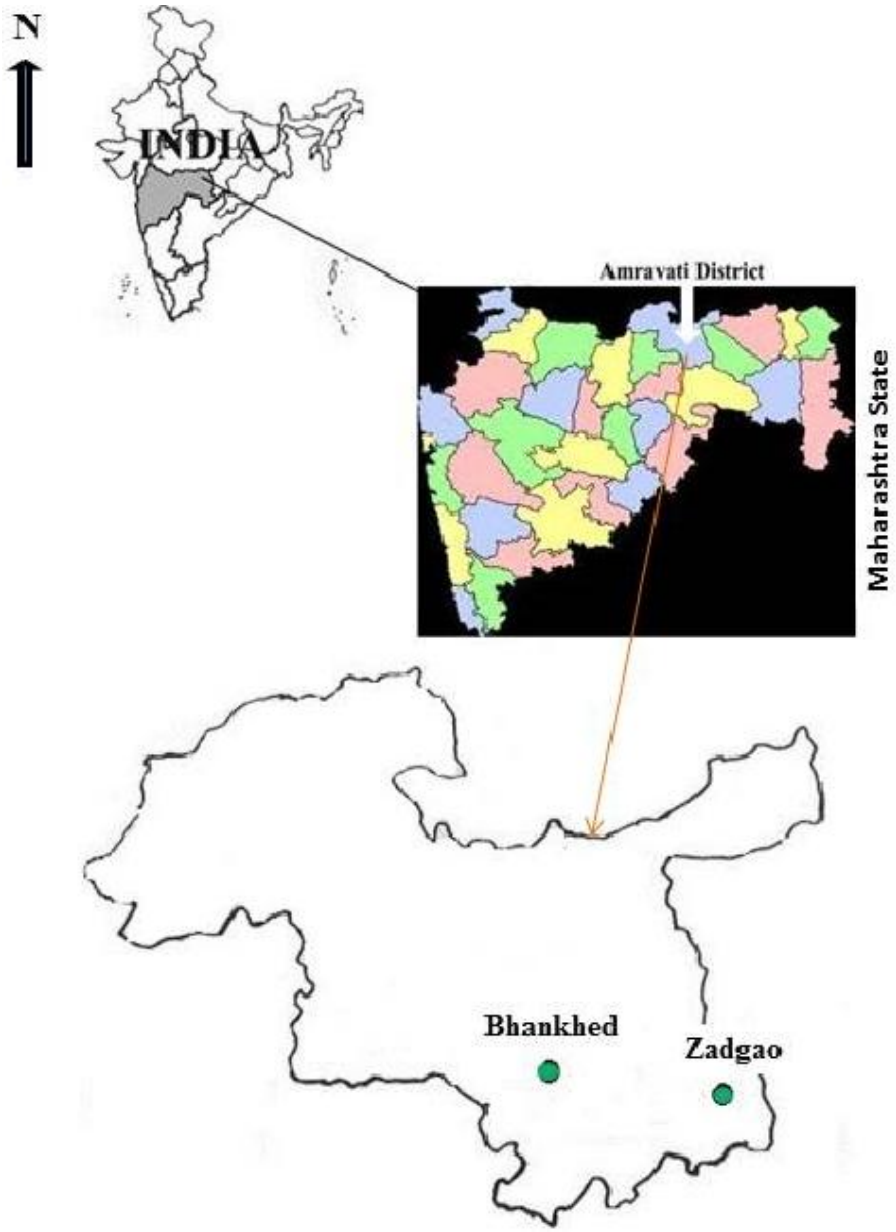

Figure 1. Study area of Bhankhed and Zadgao, Amravati District, India.

significant, but the birds those are 10 meter distance from the field area in an adjacent field were recorded. Counting was carried out on weekly basis from 1st June to 31 December in 2011 and 2012 respectively, both the morning and evening of the same day. The activities of birds are classified into four main categories: abundance, territorial behavior, foraging and others. Critical observation of activities in the study fields from preparation of soil for sowing to harvesting of the crop was taken. Use of pesticides and its frequency in the cropland were recorded.

Pesticide applications

Both the crop fields were conventionally ploughed using tractor ploughs. Information of pesticide use in crop fields is directly obtained from farmers and the suggested usage procedure for pesticides in Jawar, Cotton, Mung, Tur and Soybean crops is obtained by consulting the Ministry of Agriculture, GOI, India. In Amravati District India, cotton is generally planted in mid-June, mung is planted in early June, tur is planted in last week of June, jawar is planted in first and second week of July and soybean is planted in third-fourth week of July. Most of the available seeds are either coated or treated with fungicides and herbicides.

Insecticide used by farmers for soybean was in the mixture of chlorpyrifos (16%) and alphamethrin (1.05 %) and herbicide was wedlock imazethapyr (10%). For cotton, insecticide was found in the mixture of monocrotophos (36%), thiamethoxam (25%), and imidacloprid (17.8%) and herbicide was glyphosate (41%). Insecticide used for tur was the mixture of chlorpyrifos (16%) and emamectin benzoate (50%) and herbicide was glyphosate (41%).

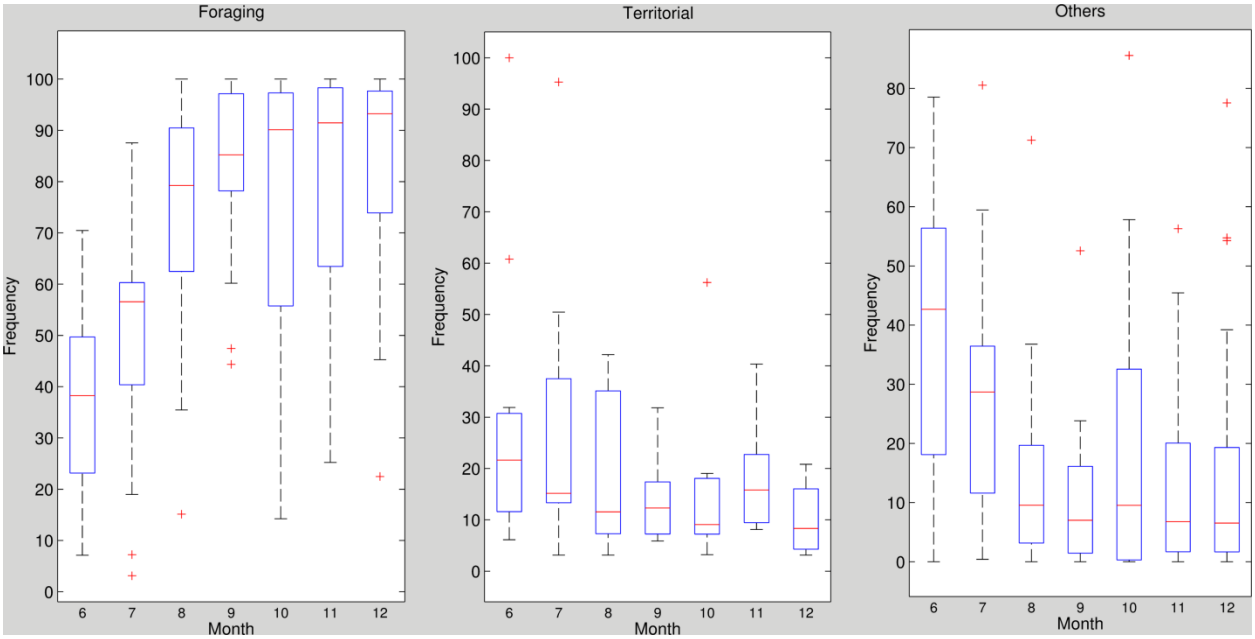

Figure 2. Foraging, territorial behavior and other activities of cropland bird recorded for the birds which were visited ≥50% of occasions during June to December of 2011 and 2012 in crop field of Zadgaon, Amravati District, India.

Analysis of data

Recorded data of birds and pesticide application are treated separately. The statistical comparison for territorial behavior and foraging is carried out for common bird species in both study area. Crop field sizes were not exactly 4 ha, but the average of both selected crop fields is approximately equal to 4ha. The role of length of edges of crop field is more on shape of the field than its size as the size is not that much important for edge-dwelling species of birds. Shape of the crop fields was approximately rectangular and the 4 ha size is appropriate than very large area of crop field that may further result in underestimation of statistical significance. Statistical software MATLAB is used for analyzing the acquired data.

RESULTS

Overall, 53 bird species were recorded over the period of two years of observation in the crop field where 14 species were common. The species that were recorded on ≤ 25% of visits were not considered for the statistical analysis.

Activity pattern

Twenty-one (21) bird species were recorded at Zadgao cropland for more than 50% of visits in crops of tur (*Cajanus cajan*), cotton (*Gossypium arboreum*) and soybean (*Glycine max*). For Zadgao Cropland, territorial activity is most significant for four species: House Sparrow, Jungle Babbler, Yellow-eyed Babbler and Red-wattled Lapwing (Figure 2). Foraging was the noticeable activity for most of the species in all months: 24 to 49% of birds forage in June, 41 to 61% of birds forage in July, 63 to 90% of birds forage in August, 77 to 97% of birds forage in September, 57 to 97% of birds forage in October, 66 to 98% of birds forage in November and 74 to 97% of birds forage in December. Foraging was less important activity for the species like Jungle Babbler and Green Bee-eater in July, Black Drongo in August and September, Oriented Magpie-Robin in September and Common Babbler in December.

At Bhankhed Cropland, nineteen species were recorded on ≥50 of visits in crops like jawar (*Sorghum bicolor*), cotton and mung (*Phaseolus aureus*). Percentages wise, 10 to 40% of birds show territorial activity from June to November and 5 to 15% in December (Figure 3). For most of the birds, foraging was an important activity from June to December; however the frequency of birds activity increased gradually from June to December and it was maximum in December. Foraging was significantly less in June for Ashy Prinia, Brahminy Myna and Black Drongo, as it was initial period of soil preparation for cropping.

Abundance was high from June to December in Bhankhed for few cropland bird species like Asian Pied Starling, Brahminy Myna, Baya Weaver, Common Myna, Eurasian Collared Dove, House Crow, House Sparrow, Plum-headed Parakeet, Rock Pigeon and Rose ringed Parakeet. At Zadgaon Cropland, species like red vented bulbul, small green bee eater, jungle babbler were high in foraging activity.

Comparison of activities of common bird species in field of Zadgao and Bhankhed showed that abundance of bird

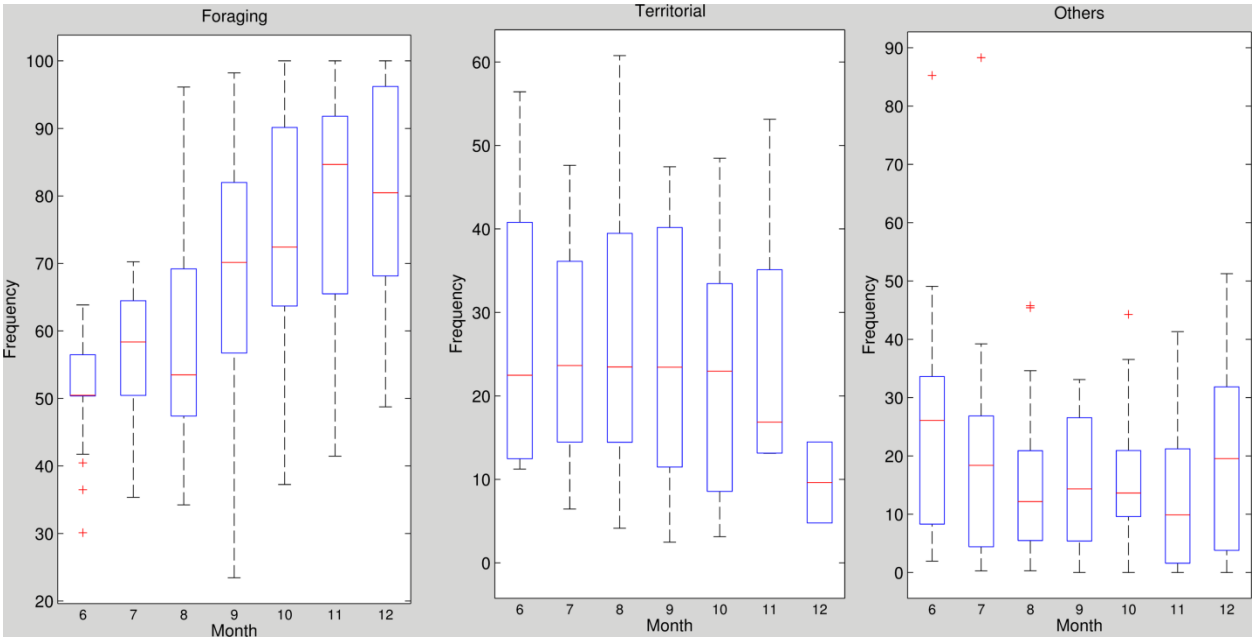

Figure 3. Foraging, territorial behavior and other activities of cropland bird recorded for the birds which were visited ≥50% of occasions during June to December of 2011 and 2012 in crop field of Bhanked, Amravati District, India.

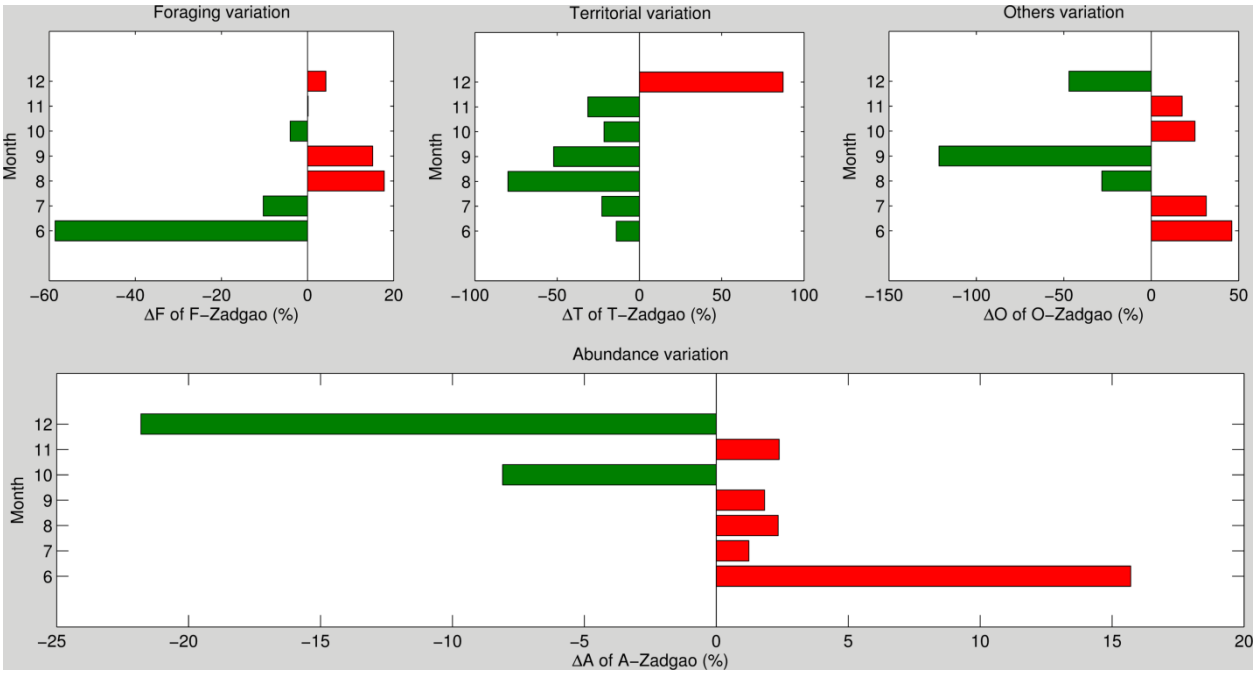

Figure 4. Comparison of variations in foraging, territorial, abundance and other activities of most frequently visiting cropland bird species in Zadgaon and Bhankhed field, Amravati District, India during June to December of 2011 and 2012.

species were more in Zadgao from June to September and November, while abundance was more in Bhankhed for October and December (Figure 4). Bird abundance in Zadgao field was significantly more in June and it was more in the month of December in Bhankhed. The occurrence of territorial behavior is more in Bhankhed from June to November while it was more in Zadgao in the month of December. Territorial activities were maximum

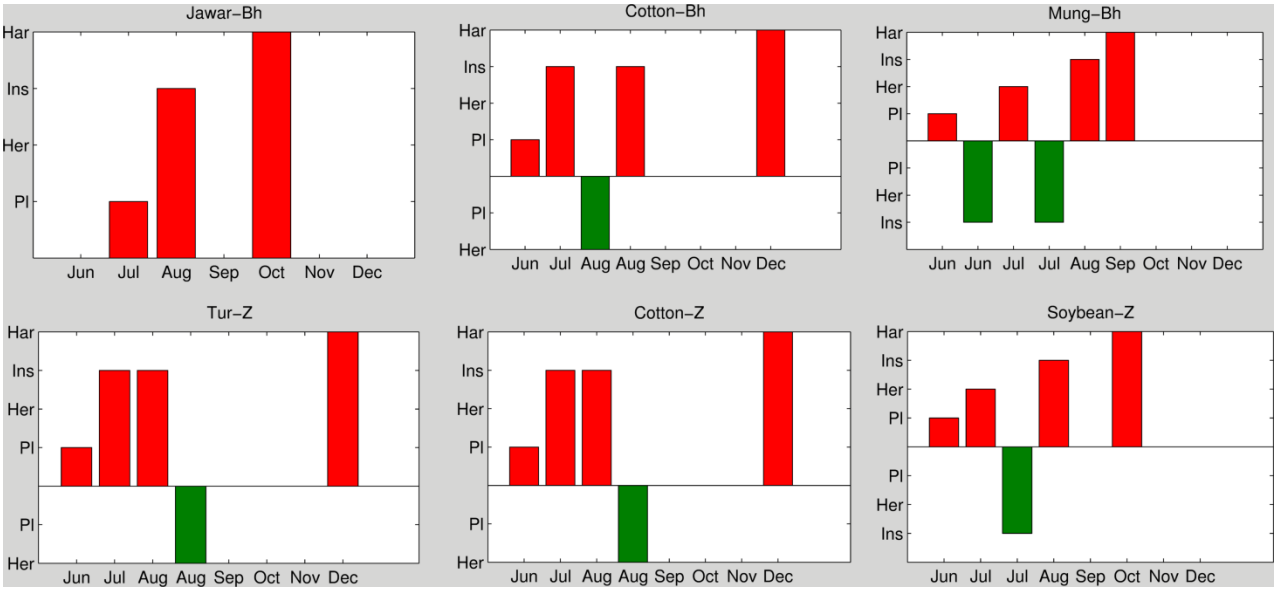

Figure 5. Schedule of planting, applications of pesticides and harvesting in the field of Jawar, Cotton, Mung, Tur and Soybean crops in Bhankhed and Zadgaon cropland during June to December of 2011 and 2012. PI- planting, Her- Herbicide, Ins- Insecticide, Har- Harvest, Bh-Bhankhed, Z- Zadgao.

in August and minimum in June in Bhankhed. Foraging is maximum in Bhanked in the month of June and it is more in Zadgao in the months of August and September. In the month of December, foraging is more in Zadgao as compared with Bhankhed.

Susceptibility of the avifaunal population to pesticide applications

The risk of pesticides is high for the species, which are looking for food or gravel in the forms of insecticides coated seeds or gritty insecticides. Most of herbicides do not produce direct effect to the bird species because they are applied in cropland during the growing of crops to reduce weed cover (Freemark and Boutin, 1995). The timing of pesticides application and agricultural activities like planting and harvesting for each crop type in respective cropland is shown in Figure 5. Risk impact of disproportionate exposure to pesticides depends on the time of spraying, frequency of the bird's presence and seed toxicity. Risk impact to crop land bird species is described in Table 1, which was calculated on the basis of percentage of individual bird species recorded on ≥50% of the visits, within crops, with reference to their occurrence in fields during time of application of pesticides (Table 2). The application of pesticides in croplands had taken place during the month of June to August, in which 4 species were under high risk, 13 species were at medium risk and 8 species at low risk. The level and intensity of this exposure depends on the occurrence of types of species in the cropland.

DISCUSSION

It is observed that birds have shown much interest in resting and foraging at soybean and tur crops, as these plants have secure bushy characteristics and abundant food availability in terms of grasshoppers, hornworms, many other small insects and their eggs. During the harvesting time of soybean and jawar in October, most of the birds prefer Jawar due to the easy access to the grains and they generally select high crops for foraging. Abundance of birds was significantly high at Bhankhed because of the neighboring crops in the agricultural land. Foraging activity was comparatively more at Zadgao cropland, as it contained two crops viz. cotton and tur. It was recorded that most of the birds are busy with territorial activity at Zadgao because cotton and tur are harvested in December. Foraging activity at Zadgao field during August and September was considerably high because the birds preferred soybean compared to other crops. Foraging activity was significantly high at Bhanked field due to early planting of mung crop which was in the beginning of June and there was no plantation of other crops at that time.

Observation period was completed in December, in which only two months of winter were taken into consideration that could have resulted in less winter migrant species. Raptor birds like Black-shouldered Kite, Shikra have also been seen in less than 50% of the visits, as these birds prefer to be in open country side and forestry regions for their foraging.

The risk impact of pesticides on the cropland bird species has varied as per crop type; the impact was more

Table 1. Avian susceptibility risk assessment of most frequently observed (on ≥ 50% visits) 26 species due to pesticides use in both croplands in Amravati District, India.

Species	Months of pesticide use when birds were recorded under risk during foraging activity[a]		Ri[b]	Status[c]
Asian pied starling Z[d] & B[e]	JL^{11}, JL^{12}		M(2)	R,O
Ashy Prinia B			L(0)	R,O
Baya Weaver B		A^{11}, A^{12}	M(2)	R,G
Brahminy Myna Z & B			L(0)	R,O
Brown rock chat B		A^{11}, A^{12}	M(2)	R,I
Black Drongo Z & B			L(0)	R,I
Bulbul red Vented Z & B		A^{11}, A^{12}	M(2)	R,I
Common babbler Z & B	JL^{11},JL^{12}	A^{11}, A^{12}	H(4)	R,O
Common myna Z & B			L(0)	R,O
Eurasian Collared dove Z & B	JL^{11},JL^{12}	A11, A12	M(4)	R,G
Green Bee eater Z & B		A11, A12	M(2)	R,I
House Crow Z & B			L(0)	R,O
House Sparrow Z & B		A^{11}, A^{12}	M(2)	R,O
Indian Roller B			L(0)	R,I
India Robin Z & B		A^{11}, A^{12}	M(2)	R,I
Oriental Magpie-Robin Z	JL^{11},JL^{12}		M(2)	R,O
Jungle babbler Z	JL^{11},JL^{12}	A^{11}, A^{12}	H(4)	R,O
Jungle Prinia Z	JL^{11},JL^{12}		M(2)	R,I
Large Grey Babbler B	JL^{11},JL^{12}	A^{11}, A^{12}	H(4)	R,O
Laughing Dove Z		A^{11}, A^{12}	M(2)	R,G
Plain Prinia Z	JL^{11},JL^{12}	A^{11}, A^{12}	H(4)	R,I
Plum-headed Parakeet Z & B			L(0)	R,G
Rock Pigeon Z & B		A^{11},A^{22}	M(2)	R,G
Yellow-eyed Babbler Z	JL^{11},JL^{12}	A^{11},A^{12}	H(4)	R,O
Rose-ringed Parakeet Z & B			L(O)	R,G
Red-wattled Lapwing Z	JL^{11},JL^{12}		M(2)	R,C

[a]Months when applications of pesticides in crop-field during June and August; when birds were engaged in foraging. J^{11} = June 2011, JL^{11} = July 2011, JL^{12} = July 2012, A^{11} = August 2011, A^{12} = August 2012. [b]Avian susceptibility risk index (Ri) based on the number of month in which birds observed less than expected during the pesticides application in all type of crops; 0-1 month=Low risk, 2-3 months = Medium risk, 4-6 months = High risk. [c]Residential status of the species (Ali, 1996). R, Resident, food habit, O- omnivore, I- insectivore, C- carnivore, G- granivore. [d,e]Field area, B-Bhankhed, Z- Zadgao, Z and B- common species in Zadgao and Bhankhed.

for the species which depend on the interior of the field for food or habitats and the impact was less for the birds which depend on the habitats present at the periphery of agriculture farm. More than fifty percentage of cropland birds used interior of the field for foraging. Birds had been at cotton, tur and soybean fields for foraging during the months of July and August where they were exposed due to toxicity of insecticide spraying. Interesting behavior was detected for most of the species during July and August where they were most susceptible to the insecticide impact. Long range toxicity of such pesticide to invertebrates may cause reduction in food resources for cropland birds.

Abundance of bird species like Asian Pied Starling, Brahminy Myna, Black Drongo, Red-vented Bulbul, Common Babbler, Common Myna, Eurasian Collared Dove, Green Bee-eater, House Crow, House Sparrow, Indian Robin, Plum-headed Parakeet, Yellow-eyed Babbler and Rose-ringed Parakeet were more at field which has tur, cotton and soybean crops. Observations during the months of June, July, August and September indicate that most of the crop land species prefer fields with short and thin vegetation for foraging.

Species like Indian Robin, House Sparrow, House Crow, and Brahminy Myna are not confined only to the agro-ecosystem but such species are suitable for agricultural as well as non-agricultural habitats. A research is needed to study the habitat changing trend of the avian population due to urbanization, easy access to food, habitat opportunity. The reduction of certain bird species in agro-ecosystem is not only due to the use of pesticides but there may be a number of additional factors

Table 2. Percentage of individual bird species recorded on ≥50% of the visits, within crops during different months of 2011 and 2012 in both croplands, Amravati District, India.

Species-common name (Latin name)	June (11/12)	July (11/12)	Aug (11/12)	Sept (11/12)	Oct (11/12)	Nov (11/12)	Dec (11/12)
Asian pied starling (*Sturnus contra*) [Z & B]	64	**50-**	74	63	**56-**	85	**49-**
Ashy Prinia (*Prinia socialis*) [B]	40	50	63	**54-**	66	90	**96+**
Baya Weaver (*Ploceus philippinus*) [B]	60	70	**50-**	80	85	70	80
Brahminy Myna (*Sturnia pagodarum*) [Z & B]	30	63	80	83	90	86	**70-**
Brown rock chat (*Cercomela fusca*) [B]	42	53	**36-**	**31-**	63	84	79
Black Drongo (*Dicrurus macrocercus*) [Z & B]	36	46	53	70	72	82	93
Bulbul red Vented (*Pycnonotus cafer*) [Z & B]	60	70	**50-**	80	85	70	80
Common babbler (*Turdoides caudata*) [Z & B]	50	**36-**	**47-**	**23-**	**44-**	63	71
Common myna (*Acridotheres tristis*) [Z & B]	50	56	64	74	81	86	91
Eurasian Collared dove (*Streptopelia decaocto*) [Z & B]	60	**54-**	**46-**	71	90	**100+**	**100+**
Green Bee eater (*Merops orientalis*) [Z & B]	54	65	**47-**	70	64	**41-**	**53-**
House Crow (*Corvus splendens*) [Z & B]	50	60	65	70	86	90	**96+**
House Sparrow (*Passer domesticus*) [Z & B]	56	64	**34-**	**53-**	**37-**	**44-**	66
Indian Roller (*Coracias benghalensis*) [B]	50	52	60	66	**50-**	73	**63-**
India Robin (*Saxicoloides fulicatus*) [Z & B]	56	63	**51-**	63	71	**50-**	**67-**
Oriental Magpie-Robin (*Copsychus saularis*) [Z]	35	**22-**	46	**32-**	59	68	78
Jungle babbler (*Turdoides striata*) [Z]	48	**33-**	**38-**	63	75	82	83
Jungle Prinia (*Prinia sylvatica*) [Z]	52	**38-**	64	**52-**	72	76	78
Large Grey Babbler (*Turdoides malcolmi*) [B]	50	**35-**	**40-**	53	71	**64-**	81
Laughing Dove (*Spilopelia senegalensis*) [Z]	25	32	**28-**	42	56	63	75
Plain Prinia (*Prinia inornata*) [Z]	36	**21-**	**28-**	47	63	79	82
Plum-headed Parakeet (*Psittacula cyanocephala*) [Z & B]	60	70	82	**97+**	**98+**	**100+**	**100+**
Rock Pigeon (*disambiguation*) [Z & B]	50	67	**51-**	82	**100+**	**100+**	**100+**
Yellow-eyed Babbler (*Chrysomma sinense*) [Z]	58	**22-**	**33-**	63	71	78	78
Rose-ringed Parakeet (*Psittacula krameri*) [Z & B]			96	98	**89-**	**100+**	**100+**
Red-wattled Lapwing (*Vanellus indicus*) [Z]	37	**21-**	42	55	63	67	72
Total -	0	10	14	6	5	4	5
Total +	0	0	0	1	2	4	6

Z, Zadgao, B, Bhanked, Z&B, Common species in Bhanked & Zadgao, signs indicate whether the proportion of birds recorded within crop field is more (+) or less (-) than expected; significance results are shown in bold.

such as agricultural intensification, rainfall variability and changing cropping pattern.

ACKNOWLEDGEMENTS

We are thankful to the farmers who allowed access to their cropland and provide the information about pesticides use on the study area. We are also thankful to Lavan Kumar Eppanapelli and Arifin Sandhi, KTH who helped with the figure preparation and editing. Immense thanks to European Union as this study was carried out with financial support from European Union under the umbrella of ERASMUS MUNDUS Program. We are thankful to reviewers for their suggestions.

REFERENCES

Abdulali H (1981). A Checklist of the birds of Maharashtra. Bombay Natural History Society, Bombay.

Abhilash PC, Singh N (2009). Pesticide use and application: An Indian scenario, J. Hazard. Mater. 165:1-12.

Ali S, Ripley SD (1969). Handbook of birds of India and Pakistan, Vol. 2, Oxford University press, Bombay.

Ali S, Ripley SD (1983). Handbook of the birds of India and Pakistan, Compact edition. Oxford University Press, Bombay.

Best LB (1986). Conservation tillage: ecological traps for nesting birds? Wildl. Soc. Bull.14:308-317.

Boutin C, Freemark KE, Weseloh DV, Donaldson GM, Csizy M, Martin PA, Wormington A, McCracken J, Shepherd D (1996). Bird use of crops in southern Ontario: implications for assessment of pesticide use, Can. Wild. Serv. Tech. Rep. Ser., Environment Canada, Hull, QueÂbec. p. 264.

Brennan LA, Kuvlesky WP (2005). North American grassland birds: an unfolding conservation crisis? J. Wildl. Manage. (69):1-13.

Comprehensive Assessment (CA) (2007). Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture. Earthscan, London and International Water Management Institute, Colombo, Sri Lanka.

Dahmardeh BR, Esmaili SA, Mahmoud S, Bahramifar G, Nader CA (2009). Environ. Inter. 35:285-290.

Donald PF (2004). Biodiversity impacts of some agricultural commodity

production systems. Conserv. Biol. 18:17-37.
Donald PF, Sanderson FJ, Burfield IJ, Van Bommel FPJ (2006). Further evidence of continent-wide impacts of agricultural intensification on European farmland birds, 1990-2000. Agriculture, Ecosystems and Environment, 116:189-196.
Fairbrother A, Smits J, Grasman KA (2004). Avian immunotoxicology. J. Toxicol. Environ. Health, 7:105-137.
Fletcher MR, Hunter K, Barnett EA (1995). Report of the Environmental Panel of the Advisory Committee on Pesticides, DEFRA Publications, London.
Freemark K, Boutin C (1995). Impacts of agricultural herbicide use on terrestrial wildlife in temperate landscapes: A review with special reference to North America. Agric. Ecosyst. Environ. 52:67-91.
Gaston KJ, Blackburn TM, Goldewijk KK (2003). Habitat conversion and global avian biodiversity loss. P. Roy. Soc. Lond. B Bio, 270:1293-1300.
Grimmett R, Inskipp C, Inskipp T (2006). Pocket guide to the birds of the Indian subcontinent, Oxford University Press.
Hart ADM (1990). The assessment of pesticide hazards to birds: the problem of variable effects. Ibis 132:192-204.
Järvinen O (1979). Geographic gradients of stability in European land bird communities. Oecologia, 31:51-69.
Jobin B, DesGranges JL, Boutin C (1996). Population trends in selected species of farmland birds in relation to recent developments in agriculture in the St. Lawrence Valley. Agric. Ecosyst. Environ. 57:103-116.
Kale M, Dudhe N, Kasambe R, Chakane S, Bhattacharya P (2012). Impact of Urbanization on Avian Population and its Status in Maharashtra State, India, Inter. J. Appl. Environ. Sci. 7(1):59-76.
Kasambe R, Wadatkar JS (2002). Checklist of Birds from Pohara-Malkhed Reserve Forest, District Amravati, Maharashtra, Zoos'Print J. 17(6):807-811.
Lohr SM, Gauthreaux SA, Kilgo JC (2002). Importance of coarse woody debris to avian communities in Loblolly pine forests, Conserv. Biol. 16 (3):767-777.
Lundholm E (1987). Thinning of eggshells in birds by DDE: mode of action on the eggshell. Comp. Biochem. Physiol. 88:1-22.
Medvedev NM (1995). Lubov. Residues of chlorinated pesticides in the eggs of Karelian birds, 1989-90, Environmental Pollution, 87:65-70.
Pascual JA, Hart ADM, Fryday SL (1999). Incidence of lethal bird poisoning reduced by the regurgitation of pesticide-treated food. Environ. Toxicol. Chem. 18(2):247-253.
Ranganathan J, Krishnaswamy J, Anand MO (2012). Landscape-level effects on avifauna within tropical agriculture in the Western Ghats: Insights for management and conservation, Biol. Conserv. 143:2909-2917.
Semwal RL, Nautiyal S, Sen KK, Rana U, Maikhuri RK, Rao KS, Saxina KG (2004). Patterns and ecological implications of agricultural land-use changes: a case study from Central Himalaya, India. Agric. Ecosyst. Environ. 102:81-92.
Söderström B, Kiema S, Reid RS (2003). Intensified agricultural land use and bird conservation in Burkina Faso. Agric. Ecosyst. Environ. 99:113-124.
Tannock J, Howells WW, Phelps RJ (1983). Chlorinated Hydrocarbon Pesticide Residues in Eggs of Some Birds in Zimbabwe, Environmental Pollution (Series B), 5:147-155.
Walker CH (1983). Pesticides and birds- Mechanism of selective toxicity, Agriculture, Ecosystems and Environment, 9: 211-226.