

# Effect of forest composition on bird species abundance in tropical dry deciduous forest: A case of Bhimbandh Wildlife Sanctuary, India

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**Abstract.** Khan MS. 2017. *Effect of forest composition on bird species abundance in tropical dry deciduous forest: A case of Bhimbandh Wildlife Sanctuary, India. Biodiversitas 18: 78-85.* The tropical dry deciduous forest (TDDF) with 38.2% of total forest cover in India forms the largest forest type of India. TDDF have been managed for centuries in the Indian subcontinent. However, so far it is not clear how different forest compositions and structures influence the abundance and the distribution patterns of faunal species vice versa. To provide further insights in this respect, we analysed how different habitat variables influence the abundance and diversity of forest birds. The difference in relative species abundances and habitat separation between forest specialist and generalist birds was also investigated. Different classes of bird density were discriminated with habitat variables. In general, it was found that higher bird densities were concentrated in the lower tree and shrub densities and diversities, however, high grass density and diversity with low tree density and diversity favoured the overall high bird density. Results further indicate the positive association of relative density of specialist bird species with the high grass density and diversity and low tree density and diversity. Specialists occurred in the lower relative densities ( $0.75\pm 0.68$ ) than that of generalists ( $0.86\pm 0.69$ ) and were found restricted to dense, pristine woody forest patches with high tree diversity.

**Keywords:** Bhimbandh Wildlife Sanctuary, birds, Forest Composition, India, Tropical Dry Deciduous Forest

## INTRODUCTION

Extending over 24.9 million hectares of land in Punjab, Haryana, Uttar Pradesh, Bihar, Jharkhand, Chhattisgarh, Orissa, Madhya Pradesh, Rajasthan, Gujarat, Maharashtra, Andhra Pradesh, Karnataka, and Tamil Nadu states of India, the tropical dry deciduous forest (TDDF) forms the 38.2% of total forest cover in country (Champion and Seth 1968). This largest forest type of India is developed in the area with low and seasonal rainfall that is 70-100cm/annum and most of the rain received during monsoon season (June-September). Therefore the ability to drop the leaves in deciduous trees helps in avoiding the water loss during dry seasons.

TDDF have been managed for centuries in the Indian subcontinent (Kumar 2008). However, so far it is not clear how different forest compositions and vegetation type (i.e. tree, shrub or grass) influence the abundance and the distribution patterns of faunal species and vice versa. Most of the ornithological research in the tropical region were focused in tropical rainforests. In contrast to tropical rainforests, TDDFs have received little attention with respect to ornithological research (Herzog and Kessler 2002) and habitat conservation (Sanchez-Azofeifa et al. 2005). TDDFs provide suitable habitats for most terrestrial birds, and the type of vegetation is a vital component of their life cycle (Koli 2014). Therefore the composition of bird species is highly related to the vegetation structure of forests (Robertson and Hackwell, 1995). Understanding the level to which forest habitat factors influence faunal species' distribution is an essential step for successful

conservation of forest biodiversity and for the development of appropriate forest land management (Scarascia-Mugnozza et al. 2000).

There is broad consensus among the experts that birds being eye-catching and sensitive towards environmental changes are the most suitable biological indicators for monitoring the health of an ecosystem (Gregory et al. 2003, Khan et al. 2013). Ecologically, birds are of tremendous importance because of their key roles as pollinators and agents of seed dispersal (Bibi and Ali 2013). A simple bird survey (biological monitoring) can tell, simply and directly, the condition of living systems in a landscape of interest. Such knowledge is more direct and integrative than information which comes from a chemical or physical testing, which is merely about a site's contamination status (Khan et al. 2013). Different abundances, compositions and modus vivendi of bird communities may influence the modus operandi of a terrestrial ecosystem. The effects of bird communities on the ecosystem and vice versa do not operate in isolation but are context dependent, being conditioned by other factors, such as availability of food, shelter, and human interference.

The association of birds with their habitats has been essential to know for understanding the influence of biotic interactions on bird species distributions (Wiens 1989; Jankowski et al. 2013). Vegetation provides infrastructure for terrestrial avian habitats and provides cues that guide habitat selection (Lee and Rotenberry 2005), as well as food and substrates used for shelter, foraging (Robinson and Holmes 1984) and breeding. Likewise, many plants also depend on birds for pollination and seed dispersal (van

Schaik et al. 1993). The correspondence between avian assemblages with vegetation composition and types is well studied in temperate regions (Lee and Rotenberry 2005, Fleishmann and Mac Nally 2006). On the contrary, the association of bird and plant communities in tropical regions is poorly studied (Khan and Pant 2016), although generally the type and structural complexity of habitats are known to influence avian diversity and composition (MacArthur and MacArthur 1961; Terborgh 1985; Jayapal et al. 2009). Also, understanding the diversity and structure of bird communities is essential to delineate the importance of regional and local landscapes for avian conservation (Kattan and Franco 2004).

In order to fill some of these gaps of knowledge and to enable the local managers to make informed decisions, a study was conducted in the Bhimbandh Wildlife Sanctuary (BWS) Bihar, India. Across the investigated gradient, following questions were addressed: (i) What are the habitat variables that determine the high, medium and low densities and diversities of birds in the tropical dry deciduous forest? (ii) What is the difference in bird abundances and habitat choices by the forest specialist and generalist bird species?

## MATERIALS AND METHODS

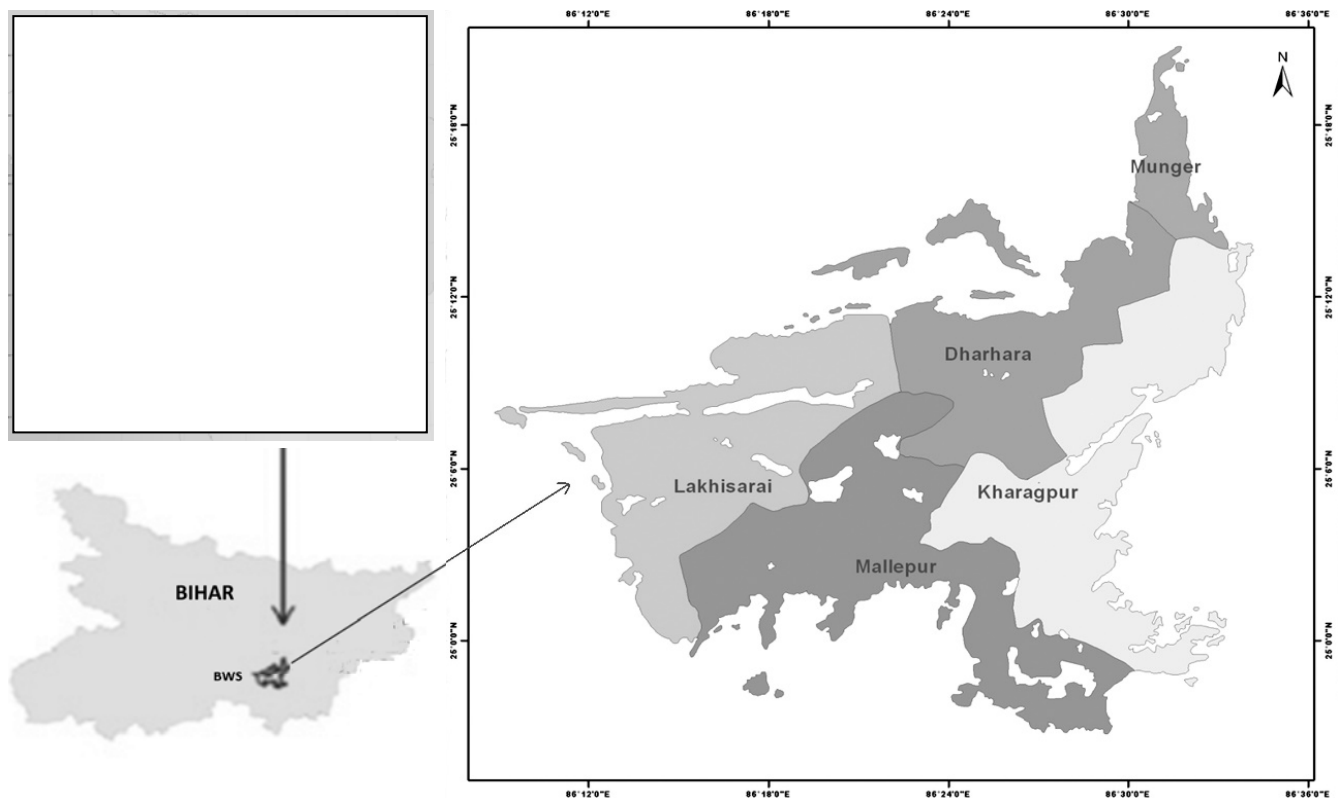
### Study area

BWS lies between 25° 55' and 25° 15' North (Latitude) and 86° 15' and 86° 33' East (Longitude) in the state of

Bihar (India) and extends over an area of 680.94 Km<sup>2</sup> (Figure 1). The BWS is situated in the lower portion of Gangetic plains near to northeast bio-geographical region, therefore it shares the wildlife species of both the regions, which makes the sanctuary a unique ecosystem with a wide diversity of wildlife species (Khan et al. 2016). Unfortunately, the ecosystem of the sanctuary is vulnerable due to the high pressure of several illegal anthropogenic activities such as mining, deforestation, poaching etc. The high density of human population around the BWS further worsen the situation. In the present scenario, the sanctuary is almost an isolated patch of forest which is highly infested by the left wing extremism and facing a potential threat of habitat destruction (Khan et al. 2016). Instead of having the exceptional biological importance the sanctuary has never been explored with regards to avifauna diversity and status. The study was designed particularly to form the baseline data for conservation and management planning of the sanctuary (Khan and Pant 2016).

### Data collection and analysis

The present study was carried out in a limited timeframe during 2013-14 in BWS. Most of the core area of the sanctuary was inaccessible due to Left Wing Extremists. This resulted in no sample plots being laid in affected areas like Paisra and Gurmaha forest beats of the sanctuary. The avian population was assessed through open radius point count method for a fixed time of 20 min/point (n=162). The points were chosen randomly in different forest microhabitat types of BWS with a minimum in



**Figure 1.** Location map of Bhimbandh Wildlife Sanctuary (Bihar), India showing different forest ranges

**Table 1.** Equal classes of bird species diversities and densities

Groups	Bird diversity	Bird density (birds/km <sup>2</sup> )
1	1.30-1.70	600-5733
2	1.71-2.10	5734-10866
3	2.11-2.50	10867-16000

between distance of 250 m to avoid double count of the same individual bird. At each point, bird species and their respective distance from the observer were recorded, using binoculars (7×35) as an optical aid. Authentic field guides on Indian birds such as Ali and Ripley (1987), Grimmett et al. (1999) and Kazmierczak (2000) were used for the purpose of proper species identification. Corresponding to every point count plot, a square plot of 20m x 20m size was laid to collect detailed information on tree composition. Nested within each of these plots, plots of 5m x 5m were laid for shrub data and one plot of 1m x 1m size for herbs and grasses. For each plot, the species diversity was calculated using PAST software (Version 3.02; Hammer et al. 2001) whereas the density was estimated by dividing the total number of individuals to the area in Microsoft Excel 2013.

Discriminant function analysis (DFA) was used to investigate the habitat differentiation by different classes of birds' density and diversity. The plots were grouped into three equal classes of bird species diversities and densities (Table 1). Discriminant analysis has built a predictive two model for group membership for different classes of birds' density and diversity respectively. Each model is composed of two discriminant functions based on linear combinations of the predictor variables that provide the best discrimination between the groups.

The bird species with at least 70% of its occurrence restricted in one undisturbed habitat and specific feeding habits were classified as forest specialist birds and the remaining as generalists. Those species that are strongly associated with one micro-habitat of forest and are very particular about their food items were classified as specialist species and forest generalists are those birds that mainly use forest but also other non-forested habitats and were quite open for their food. Independent sample t-test was performed to examine the difference in habitat choices and bird abundances between generalist and specialist species (Zar 1984; Khan and Pant 2016).

## RESULTS AND DISCUSSION

The TDDF of BWS is dominated by *Shorea robusta* with the abundant occurrence of other tree species that is *Madhuca indica*, *Odina wodier*, *Buchnanian latifolia* and *Terminalia tomentosa*. Amongst the shrubs, *Wrightia tomentosa*, and *Carissa caranda* are to be most dominant while in herbs *Euphorbia hirta* is dominant and amongst grasses, *Cyperus rotundus* is most common. The forest of the sanctuary supports 123 terrestrial bird species

belonging to 48 families. Amongst these, 120 species are of Least Concern category and three species namely Alexandrine Parakeet *Psittacula eupatria*, Blossom-Headed Parakeet *Psittacula roseate*, and Lager Falcon *Falco jugger* belong to Near Threatened category of IUCN (IUCN 2015). Some bird species are shown in Figure 4.

The multivariate statistic of Wilks' Lambda varies from 0-1, it is a product of the values of (1- canonical correlation<sup>2</sup>). The larger values of Wilks' Lambda indicated the lower discriminatory ability of the functions. The associated chi-square statistics tested the null hypothesis that the means of functions listed are equal across the groups. In other words, chi-square statistics tested the null hypothesis that the functions have no discriminatory ability. In the case of bird diversity, the chi-square statistics failed to reject the null hypothesis (Table 2).

DFA resulted in the correct classification of only 45.7% and 35.7% of cases of bird density and diversity respectively. It produced two sets of two discriminant functions (DFs) accounting 68% and 32% variance in the case of bird density and 85.5% and 14.5% variances in the case of bird diversity (Table 3). In table 3, the standardized coefficient showed the comparative account of variable measured on different scales. In general coefficients with large absolute values correspond to variables with greater discriminating ability. The Discriminant loadings of discriminant functions represented the correlations between the observed variables (the six continuous discriminating variables) and the dimensions created with the unobserved discriminant function (DF). For bird density the discriminant function (DF) 1 can be seen as an indicator of a gradient of increasing Tree and shrub diversities with decreasing grass diversity. DF 2 indicates high Tree and shrub densities with low grass density. For bird diversity, DF 1 is found associated with high tree and grass diversities whereas DF 2 represents decreasing tree density and increasing densities of shrub and grass and shrub diversity (Table 3).

A study of the Discriminant loadings of discriminant functions (Table 3) and the relative location of the group centroids against the two extracted functions indicated the occupancy of medium bird density group (5734-10866 birds/km<sup>2</sup>) higher along the gradient, indicated by the DF 2, whereas the occupancy of low bird density group (600-5733 birds/km<sup>2</sup>) along the gradient is indicated by the DF 1 (Figure 2). The high bird density group (10867-16000 birds/km<sup>2</sup>) occupies the lower portion of both DF 1 and 2. In figure 3, the bird diversity group can be seen occupying from higher to lower sector of DF 1 with lower (1.30-1.70), medium (1.71-2.10) and higher (2.11-2.50) bird species diversity groups (Figure 3). The location of the diversity group centroids along the central value of DF 2 indicates the lesser discriminating ability of the DF 2 for Bird species diversity groups (Figure 3).

The results showed that the specialist bird species tended to be located in less fragmented and less disturbed landscapes than generalists. Specialists occurred in the lower relative densities (0.75±0.68) than that of generalists (0.86±0.69) and were found restricted to dense, pristine woody forest patches with high tree diversity (Table 4).

Their habitat also included higher density ( $95.94 \pm 107.87$ ) and diversity ( $1.44 \pm 0.50$ ) of grass species (Table 4). On the other hand, generalists were found to be associated with degraded habitat patches around these woody forests. Their habitat was characterised by the higher density ( $0.88 \pm 0.80$ ) and diversity ( $0.92 \pm 0.46$ ) of shrubs (Table 4).

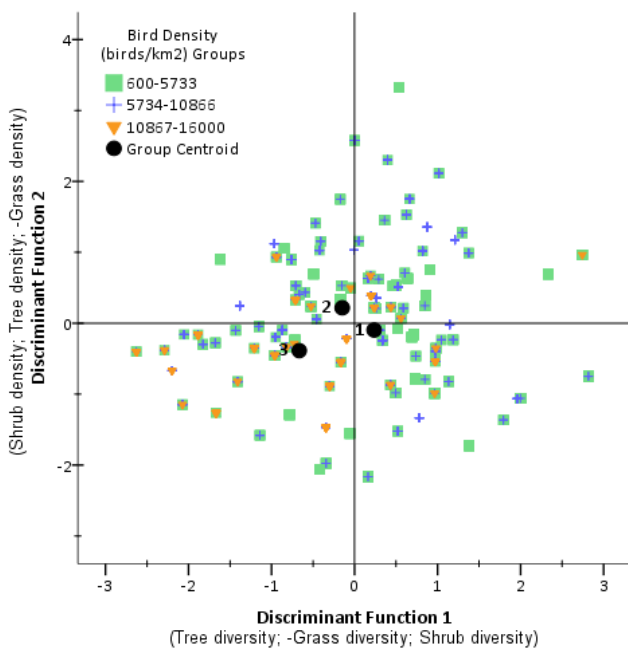
**Discussion**

Floral and faunal species composition together with abiotic factors characterises the habitat of a site (Montague-Drake et al. 2009, Brown et al. 2010). The habitat quality of a site, represented by the attributes such as the spatial extent of habitat patch, its connectivity with nearby habitat patches and composition of vegetation, has consistently been found to have an important influence on the population size, persistence, distribution and dispersal of faunal species (McGarigal and Cushman 2002, Fahrig 2003, Radford and Bennett 2004, Bennett et al. 2006, Lindenmayer et al. 2010, Boscolo and Metzger 2011).

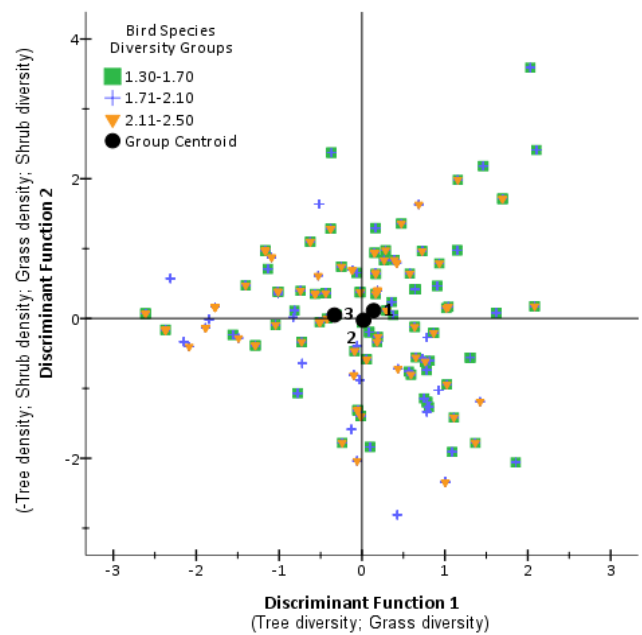
The relationships between the forest composition and bird species abundance is intimate and regular occurring; so much so that (i) the two are co-existing, (ii) together they form a self-sustainable community called as biotic association, (iii) Neither plant nor bird assemblage can survive independently of one another, (iv) the geographic distribution of many of the plants and bird species which make up the assemblages are in general correspondence and (v) The species composition of the association over its range, varies no more widely, relatively speaking, than

would an assemblages of plant alone (Vestal 1914). Therefore understanding the relationship of forest composition i.e. classes of plants diversity and density and type (e.g. tree, shrub or grass) with birds may enable more accurate predictions of bird species abundance and distributions. Despite the importance of these measures, no study has yet examined the relationship between them within the tropical forest in Indian sub-continent, which holds both highest species richness and the highest numbers of threatened taxa (Wilson 1992, Anon 2000).

The species diversity and ecosystem resilience have been found positively correlated in many studies (Khan and Pant 2016). Presently, there is consensus among ornithologist that a lesser number of species are required for ecosystem functioning under constant conditions and that a larger number of species is probably necessary for maintaining the stability of ecosystem processes in changing environments (Loreau et al, 2001). Local abundance and habitat limitation both are an important correlate of extinction risk of species (Pimm 1988). Low local abundance is believed to be played an important role in the case of local extinction of the species due to demographic and stochastic environmentally hazardous events (Diamond 1984; Pimm 1991; Caughley 1994). Whereas habitat-restricted species are more prone to extinction from habitat loss (McKinney 1997). The species using a wide variety of habitats should be better able to survive certain habitat changes than species that are confined to a few habitat types (Goerck 1997).



**Figure 2.** Habitat discrimination among the three bird density (birds/km<sup>2</sup>) groups. Centroid 1 represents 600-5733 birds/km<sup>2</sup> group, centroid 2 represents 5734-10866 birds/km<sup>2</sup> group, and centroid 3 represents 10867-16000 birds/km<sup>2</sup> group.



**Figure 3.** Habitat discrimination among the three different bird species diversity groups. Centroid 1 represents 1.30-1.70 group, centroid 2 represents 1.71-2.10 group, and centroid 3 represents 2.11-2.50 group

**Table 2.** Multivariate statistic of Wilks' Lambda associated with chi-square

Population parameters	Test of discriminant function	Wilks' Lambda	Chi-square	Degree of freedom	Sig.
Bird density	1 through 2	0.893	142.083	12	<0.001
	2	0.964	46.154	5	<0.001
Bird diversity	1 through 2	0.985	19.609	12	0.075
	2	0.998	2.86	5	0.722

**Table 3.** Discriminant function properties, standardized canonical discriminant function coefficients, and discriminant loadings of discriminant functions

Variables	Bird density		Bird diversity	
	Discriminant function 1	Discriminant function 2	Discriminant function 1	Discriminant function 2
% Variance	68	32	85.5	14.5
Canonical correlation	0.271	0.19	0.115	0.048
Standardized canonical discriminant function coefficients				
Tree density	0.15	0.379	0.135	-1.04
Tree diversity	0.77	0.216	0.581	0.653
Shrub density	-0.015	0.712	0.44	0.494
Shrub diversity	0.23	-0.201	-0.278	0.087
Grass density	0.461	-0.417	-0.374	0.039
Grass diversity	-0.883	0.506	0.559	-0.108
Discriminant loadings of discriminant functions				
Tree density	0.448	0.546*	0.516	-0.706*
Tree diversity	0.613*	0.455	0.738*	-0.011
Shrub density	0.003	0.593*	0.273	0.505*
Shrub diversity	0.205*	0.014	-0.189	0.191*
Grass density	0.166	-0.203*	-0.009	0.201*
Grass diversity	-0.383*	0.376	0.583*	0.014

Note: \*Largest absolute correlation between each variable and any discriminant function

**Table 4.** Differences in habitat choices and bird population parameters between forest specialist and generalist bird species

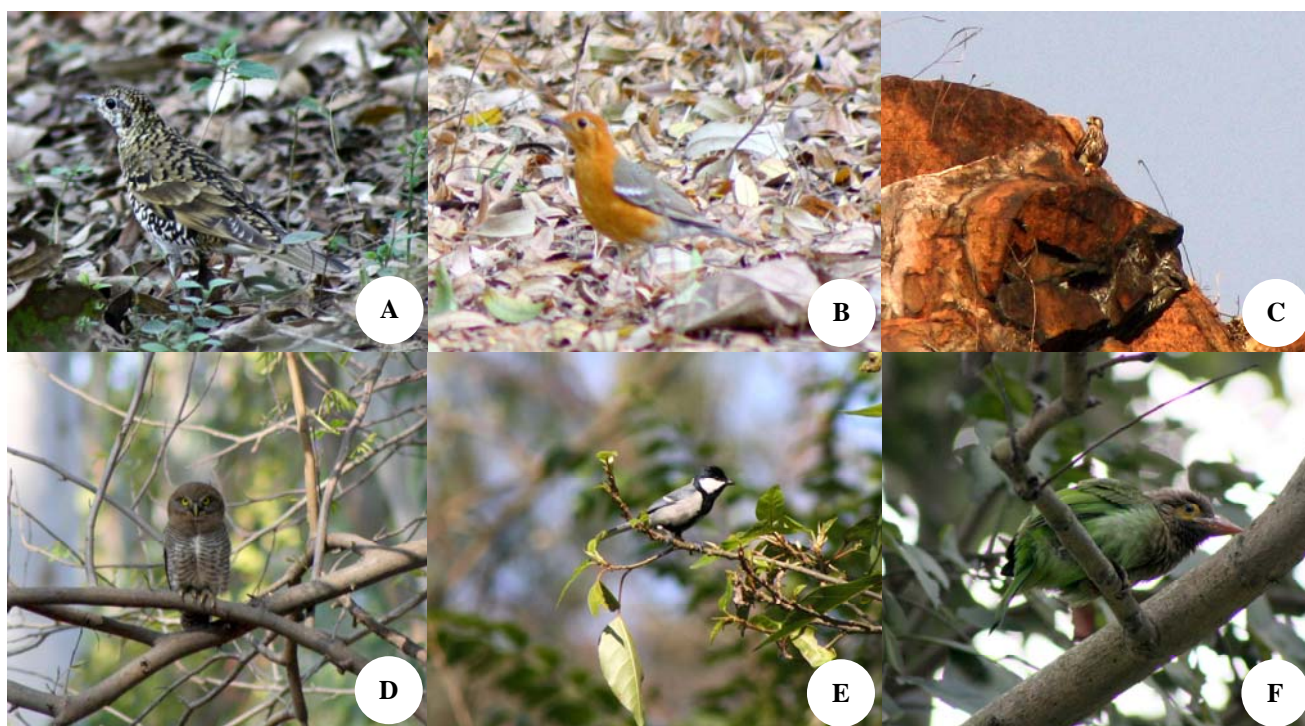
Variables	Specialist		Generalist		t	Sig.
	Mean	SD*	Mean	SD*		
Birds relative density	0.75	0.68	0.86	0.69	-1.230	0.219
Tree density	0.16	0.13	0.15	0.12	1.026	0.305
Tree diversity	1.60	0.56	1.34	0.71	3.741	<0.001
Shrub density	0.80	0.78	0.88	0.80	-0.869	0.385
Shrub diversity	0.87	0.49	0.92	0.46	-0.867	0.386
Grass density	95.94	107.87	75.36	95.56	1.761	0.078
Grass diversity	1.44	0.50	1.34	0.56	1.512	0.131

Note: \*SD=Standard deviation

Specialist species are expected to be found in the forest habitats that are relatively more towards its climax stage of ecological succession, whereas generalist are the species that favoured by the initial or intermediate stage of ecological succession in a forest advancing towards its climax community (Futuyma and Moreno 1988; Kassen 2002; Marvier et al. 2004; Ostandard and Ehrlen 2005). Any natural or man-caused activity that pushes back the climax stage of succession through habitat degradation would negatively affect specialists is predicted by niche evolution theory. Hence, emerging evidence suggests that specialist species across taxa are declining throughout the

world (Julliard et al. 2004). Forest specialist species primarily required a significant area of forest habitat, apart from other needs regarding forest structure and composition, whereas the generalist species are not much choosy about habitat selection, they occur in other non-forest habitats more frequently than specialist species (Gil-Tena et al. 2007). Since the shrub-dominated areas were majorly distributed in narrow strips alongside the forest fringe or around human settlements in BWS, therefore, support the higher abundance of a generalist (Edge species) (Table 4).





**Figure 4.** Some bird species in Bhimbandh Wildlife Sanctuary (BWS) of Bihar, India. A. Scaly thrush *Zoothera dauma*, B. Orange headed thrush *Zoothera citrina*, C. Laggar Falcon *Falco jugger*, D. Jungle owlet *Glaucidium radiatum*, E. Great Tit *Parus major*, F. Brown Headed Barbet *Psilopogon zeylanicus*

Different classes of bird density were discriminated with habitat variables. In general, it was found that higher bird densities were concentrated in the lower tree and shrub densities and diversities, however, high grass density and diversity with low tree density and diversity favoured the overall high bird density (Figure 2). Results further indicate the positive association of relative density of specialist bird species with the high grass density and diversity and low tree density and diversity. Keeping the unfortunate fact in the mind that in the present scenario, the ecosystem of BWS cannot achieve its climax community due to the prevalent anthropogenic disturbances. Hence, most of the old forest patches are experiencing the successional dynamics in response to natural disturbances such as fire and to human-caused disturbances such as uncontrolled grazing and logging. In this scenario, the specialist bird species have chosen the best available habitat that suits their ecological requirements.

The location of the group centroids of bird diversity (Figure 3) nearer the central value indicates the weaker relationship between bird and vegetation communities or low explanatory power of vegetation structure or composition of bird species diversity. In this condition, one should expect greater flexibility in bird-vegetation interactions.

Forest fire is the major human-caused disturbance, influencing species composition and shaping the character of a forest community in BWS. It has long played an important role in the development of vegetation in the region. Accumulated dry lichens and fungus on the

branches of trees, and dry dead grass and organic debris serve as a fuel for the forest fire during dry summers (in May-June). There are only two sources of ignition i.e. lightning and human. The incidents of dry lightning (without rainfall) are very rare in BWS. Most of the time the fires are caused by the ignorant forest dwellers through accidental ignition of fuel. In many cases, the forest fire were found to be set intentionally as well, because fires induce fresh blades of grass which are succulent and preferred by the cattle. Similarly, minor forest produce (especially *Mahua* and *Kendu*) collectors also at times put forests on fire intentionally. Damage to plants depends upon the intensity of the fire and the susceptibility of plants to heat. Shallow-rooted grasses and shrubs are more vulnerable to fire than deep-rooted trees. The areas of high grass and shrub abundances having good density and diversity of birds are also more susceptible to caught fire. Therefore, it is important to take strict management measures to stop incidental ignition of fire and its spreading into the forest.

The studies such as this, which are based on field data, have implicit limitations that may affect the accuracy and predictive capacity of models. The variations in forest composition, vegetation density, and diversity on temporal and spatial scale characterised the landscape. Low vegetation density areas may not necessarily representative of low vegetation density areas before they were cleared or disturbed. The increased probability of species occurrence with the increased availability of proximal vegetation provides an opportunity to benefit biodiversity by

incorporating the restoration and afforestation of contiguous degraded land into conservation strategies.

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