https://doi.org/10.46344/JBINO.2021.v10i05.17

RICHNESS, DISTRIBUTION & DIVERSITY OF AVIFAUNA IN THE KONKAN COAST OF WESTERN GHATS BIODIVERSITY HOTSPOT.

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ABSTRACT

Birds occur throughout almost every habitat across the world. They are important because they play vital role to maintaining the balance of many ecosystems by providing various ecological services. The avifauna richness and diversity at different land-use types were investigated in Konkan coast of Western Ghats biodiversity hotspot. The objectives of investigation were to study bird richness, abundance, diversity, distribution pattern and conservation status. The Point transect method was employed to identify birds in seven land use types: forest, agriculture land, grassland, mango plantations, homegardens, mangrove forest and casuarina plantations. In a total of 4796 encounters, 9348 individual birds belonging to 114 species and 51 families were detected from seven habitats in two seasons during the study period. The highest species richness was observed in the monsoon season. Overall 72% bird species were common in the both seasons. The most dominating families are Accipitridae, Columbidae, Hirundinidae, Muscicapidae, Ardeidae, Corvidae, Cuculidae and Sturnidae. In the dry season the highest species richness and Shannon-Weaver diversity index was observed in the forest land. In the monsoon, season the highest species richness and Shannon-Weaver diversity index was observed in the grassland. The average bird density (34 individual's ha^{-1}) was recorded during investigation period in both seasons. The findings clearly indicate that most of the abundant bird species were distributed throughout study area. However, most of the bird occurrence was restricted to coastal side where all land-use types seem to be interlinked. As per IUCN red list status among 114 bird species recorded in the study area 109 bird species has least concerned status. Four species (Eurasian Curlew, Gray-Headed Fish-Eagle, Lagger Falcon and Malabar-Pied Hornbill) are near threatened and globally their population is decreasing. One critically endangered bird species (White-Rumped Vulture) was sighted in at grassland site in the dry season. The result indicated that the study site exhibits diverse habitats types and rich in bird species. Our findings suggest that the current knowledge of bird community structure should be integrated into conservation decision making under different land-scape levels for different bird communities.

Keywords: Avifauna, Biodiversity, Hotspot, Richness, Seasonal Diversity, Western Ghats

INTRODUCTION

India comprises of over 1300 bird species that contribute 13% of the world's total bird species and of these 7% of bird species are threatened. ENVIS center on avian ecology published that in India there are 79 endemic birds or restricted range species of which, 18 (23%) species are globally threatened, 19 % are near threatened, 34% are least concern and status of 20 % species is not confirmed (Jathar and Rahmani, 2006).Threatened Bird Forum (2007) has stated that most threatened bird species are specialized in their habitat requirements, and are totally dependent on a particular type for their survival such as forest, grassland or wetland. Many bird species visit India during winter season. Similarly, some bird species shows local migration depending on season and availability of food and water.

Several researchers stated that the birds have been considered good predictors of habitat quality, because they relate to changes in their associated habitats in numerous ways (Raman *et al*., 1998; Raman, 2001; Chettri*et al*., 2001; Chettri*et al*., 2005). The monitoring of the bird-habitat relationship as well as species distribution pattern is important because they are sensitive to anthropogenic changes. Gregory and Strien (2010) argued that among bio-indicators, birds are probably better known and better studied than any other taxa. Estimates of bird abundance are one of the cornerstones of the IUCN Red List classification scheme (IUCN, 2001).

Almost nothing is known about the avifaunal diversity and species richness of the Konkan coast of the Western Ghats in relation to different land-use types. The study of comparing seasonal bird distribution and variation at different land-use types or habitats of the study area aims at understanding potential future impacts of the land-use changes on birds. Species richness and diversity studies of bird communities in the study area are urgently needed. The World Conservation Monitoring Centre (1992) reported that avifaunal endemism level in Western Ghats is low compared to floral endemism. However, recently many ornithologists considered Western Ghats as hotspot of bird endemism in tropical region (Bhagwat *et al*., 2005, Gunawardene *et al*., 2007). Although the avifauna in tropical forest of Western Ghats, Malabar and Goa region has been relatively well studied but little is known about bird diversity, species richness and distribution in tropical moist deciduous forest of Konkan coast. The major objectives of the present study was to prepare the inventory of the bird species at different land-use types or habitats such as forest land, agricultural land, homegardens, grassland, mangrove forest, casuarina plantation and mango plantation in Konkan coast; to characterize seasonal composition, abundance, diversity and species richness of different bird species at different land-use types or habitats in Konkan coast and to determine the species conservation status of species in the study area.

MATERIALS AND METHODS

Birds are considered as relatively most easy to find, identify, survey and census. Their taxonomy is relatively well agreed and their phylogenetic status is well defined. It been suggested that various methods of bird counting or survey design

and analysis are well developed but that the data are realistic and expensive unless the survey or census made by skilled, competitive and motivated observer (Gregory and Strien, 2010).

Field methods for the bird survey, the study area and sampling framework:

A point transect method based on distance sampling (following Bibby *et al*., 2000, Gibbons and Gregory, 2006) was used to survey the bird community. The counts were conducted under two favorable weather conditions in the dry season and monsoon season during December 2008 to May 2009 and June 2009 to November 2009 respectively. The study area (Geographical coordinates: 16˚ 30' to 16˚ 43' N latitudes and 73˚ 19' to 73˚30' E longitudes) is situated on "the Konkan coast" of the Western Ghats. Ground elevations within the site range from 0 to 225 meter above mean sea level. It covers an area approximately 460 km^2 (19.5 km east west and 25.5 km north south) land excluding water bodies in Rajapur Taluka of Ratnagiri district in the Maharashtra state.

Bird counting applications based on point counts, distances measured from a point of observation (instead of transect) which is referred as "point transect" (Taylor, 2007;Buckland *et al*., (2006). Although point transect methods have been widely used in bird surveys, there have been no attempts made to orient field methods and maximize the accuracy of abundance estimates by minimizing the violation of the critical assumptions (Taylor, 2006; Lee and Marsdan, 2008a) such as (1) Birds at 0 m distance are detected with certainty. (2) Birds are detected at their initial location and (3) Distances to object are measured accurately.

Sampling strategy:

The work was carried out using a stratified random sampling scheme in which the sample universe is divided into group of sample units (strata). The strata are assumed to have more homogeneous bird abundance than that of sample universe as whole (Pendleton 1995). Here we used land-use types as strata. All over 103 point transects randomly located within seven strata by using random numbers Table (Panse and Sukhatme, 1985). Transects were formed from a line transect, with circular shape survey plots (Marques, 2009). The 500 m long point transects were located at the 103 randomly selected sampling units of different land-use types or habitats. These transacts were then surveyed. The number of transects walked The number of transects walked in each land-use type or habitat are given in Table 1. Strata need not have an equal number of samples, but weighted estimates may be needed for some unequal sample allocations (Cochran, 1977). The flagging tapes were used to mark out the start and finish points and five points were marked out along each transect. The first point was established at fifty-meter distance from the starting point and all others at 100 m interval apart. Thus in total 5 point counts were taken along each transect. In total, 515 census points covering seven land-use type were studied.

Season, duration of count and field data collection:

In both seasons, visual bird censuses were conducted between 0700 and 0900 hours when birds are the most active, during

good weather conditions at different habitats. It was assumed that birds are most vocal at or before sunrise (Robins, 1981; Bart and Herrick, 1984). To avoid bird disturbance caused by observer's arrival the count was started four minute after reaching the point. The all birds detected visually and acoustically during fifteen minutes at each point along transects were identified, counted and recorded within 50 m radial distance. The radial distance of each individual bird or cluster of birds detected was estimated using measuring tape and rangefinder from the point where the observer was standing. The bird seen beyond 50 m range and flying overhead were excluded from the count. The key issue was to estimate the probability of detecting birds given that the birds are hidden by vegetation. The special care was taken to avoid double counting of the birds. The counts were not conducted when wind velocities were > 16 km/hour or when it was raining. The detail survey information on land-use, list number, transact number, nearest village, transect GPS location, date of survey, start and finish time, local name of bird species, number of individual birds, radial distance of the bird or cluster of birds from observer and number of species was recorded in data sheet. The activities of the birds, such sitting on the ground, rocks, roads, electricity wire and poles, ponds, trees or flying but landing with-in 50-meter radius from observer, were recorded in data sheet.

Distance estimates and Identification of birds:

Distance sampling is a way of estimating bird densities from point count transect data and assessing the degree to which our ability to detect birds differ in different habitats and at different times (Buckland *et al*., 2008). We briefly considered the key assumptions of the basic point transect method stated in various publications (Thomas *et al*., 2010). The key assumptions were: 1) objects on point are detected with certainty; 2) objects do not move; 3) all measurements are exact; and species are not misidentified.

An exclusive fieldwork was carried out with adequate level of bird identification skills. The binocular (8x40 and 10x42) was used to view the birds. During the field work photographs of the birds were taken where possible. Birds were identified using physical features with the help of field guides and reference books (Grimett*et al*., 1999; Ali and Ripley, 1983; Pande *et al*., 2003; Besten, 2008; Grimett*et al*., 2005).

Data analysis:

The analysis of variance was carried out to test the null hypotheses that variation in seasonal bird survey at different land-use or habitats will not bring about significant changes to the number of individual birds, number of species detected. Abundance, frequency and density were calculated by using following formulae. The data was analyzed by using Microsoft Excel.

Quantitative analysis:

Frequency and abundance was calculated by following formulae. Frequency is the number of plots, stations, counts (visits), transects, or intervals in which a species is detected and it is calculated by following formula

$$\text{Frequency (F)} = \frac{\text{Number of sampling in which spp. occ}}{\text{Total number of point transects stu}}$$

Bird density is the number of birds per unit area (Ralph, 1981_b). It is a fundamental

property of all populations that can vary spatially and temporally in response to habitat change (Bock and Jones, 2004).Abundance is the average number of individuals of a species per point transect for the point transect in which it occurs and it is calculated by following equation.

$$\text{Abundance (A)} = \frac{\text{Total number of individual of the species in all sampling points}}{\text{Number of sampling units in which the species occurred}}$$

Bird species diversity:

There are number of species diversity indices used in the large amount of literature on biodiversity and ecological monitoring (Harisha and Hosetti, 2009). The different indices such as the Shannon-Weaver index of diversity, Simpson's index of dominance, Simpson's index of diversity and species evenness calculated by using following formulae.

$$\text{Shannon– Weaver' Index of diversity } H' = -\sum_{i=1}^{n} pi\, ln\, pi$$

$$\text{Simpson's index of dominance } (D) = \sum_{i=1}^{n} (pi)^2$$

$$\text{Simpsons index of diversity } (1-D) = 1 - \sum_{i=1}^{n} (pi)^2$$

$$\text{Species evenness} E = \frac{H'}{LN\ (n)}$$

RESULTS AND DISCUSSION

A total number of 4796 encounters, comprising 9348 individual birds and 114 species belonging to 51 families were detected from seven habitats in two seasons during the study period. Of theses a total number of 2473 encounters, comprising 4587 individual birds and 83 bird species belonging to 40 families in the dry season and 2323 encounters, comprising 4761 individual birds and 113 species belonging to 51 families in the monsoon season were detected at seven habitats(Table 1). The data indicates that number of encounters decreased in monsoon season but total number of bird detected increased due to larger cluster size. Among 114 species 82 (72 %) bird species were common to both seasons, however only one species (red rumped Vulture belonging to the Accipitridae family) and 31 (27%) bird species belonging to 21 families were exclusive to the dry and monsoon seasons, respectively (Table 2). In the dry season, the highest number of bird species belongs to family Accipitridae (10) followed by Columbidae (5) and in monsoon season Accipitridae (10) followed by Muscicapidae (6). The maximum number of families (45) was occurred at the grassland site followed by agricultural land (40) in the monsoon season. The number of families per land-use type increased in monsoon season except the casuarina plantation site and mangrove forest site. However, there was no significant change in number of families within agricultural land, forest land and homegardens sites in two seasons.

In the monsoon, the number of bird species increased due to additional 31 species belonging to 21 families. Among them, the highest number of bird species belongs to family Scolopacidae and Sturnidae (four spp.) followed by Cuculidae (three spp.). Majority of the occurrence of these additional bird species was observed on agricultural land, forest land and the grassland sites. However, none of these species was sighted at the casuarina plantation site. The Asian paradise-flycatcher, bank Myna, golden fronted Leaf-bird, common

Sandpiper, Eurasian Curlew, Hoopoe, jungle Starling, pied-crested Cuckoo, river Tern, small Minivet, Whimbrel and yellow-wattled Lapwing were the most common additional species which occurred in the monsoon season (Table 2).

It is observed that out of the total 114 bird species only 10 (9%) bird species such as *Dicrurusmacrocerus*(black Drongo), *Bubulcus ibis* (cattle Egret), *Saxicoloidesfulicata*(Indian Robin), *Corvusmacrorhynchos*(jungle Crow), *Vanellusindicus*(red-wattled Lapwing), *Pynonotusjocosus*(red-whiskered Bulbul), *Psittaculakrameri*(rose-ringed Parakeet), *Meropsorientalis* (small Bee-eater), *Streptopeliachinensis*(spotted Dove), and *Halyconsmyrnensis*(white-throated Kingfisher)were recorded at all land-use types during the dry and monsoon season bird survey. Out of the observed 83 bird species in the dry season survey 19 (23%) species were common to all land-use types. Asian Koel, black Kite, greater Coucal, grey-hooded Warbler, house Sparrow, Indian Pond-heron, large grey Babbler, Indian pied Hornbill, jungle bush Quail along with the above ten bird species were observed at all land-use types only in the dry season. Among 113 bird species observed in monsoon season only 13 % (14 species such as Baya Weaver, Brahminy Kite, Coppersmith Barbet and Indian House Crow including above 10 bird spp.) were commonly detected at all land-use types.

Seasonal comparison of species richness and abundance:

There was significant variation in total number of bird recorded between different land-use types during the entire survey. The highest number of birds were recorded at forest land (33%) followed by grassland (26%) and agricultural land (16%). The lowest numbers of birds were recorded in the casuarina plantations; however, there was no significant difference between homegardens (11%) mango plantations (7%), Mangrove forest (5%) and casuarina plantations (3%). The land-use wise comparison of seasonal patterns of number encounters, number of species, number of total individual birds, families, average number of species per point transect and average number of bird per transect is summarized in Table 1 & Fig 1. The number of bird species and number of birds per point transect in the study area ranges from 6 to 33 and 9 to 120 respectively. On an average 16 bird species and 45 birds were recorded per point transect in the study area.

The avifaunal analysis revealed that the study area is the home for 114 bird species, however, this results are very interesting than working plan of Ratnagiri forest sub-division, Chiplun which demonstrates only 36 bird species in the whole division (Takalkar, 2002). Thus, the bird species richness in our study indicates 68% more species, which is a small part (450 km^2) of the Ratnagiri forest sub-division Chiplun. Our study revealed that area contains 22%, 16 %, 23% and about 27% of bird species identified by Daniels (1992), Besten (2008), Gunawardene *et al*., (2007) and Pande *et al*., (2003), respectively. The result showed that highest number of bird species was counted in monsoon season (113) and the lowest in the dry season (83). The number of encounters decreased in monsoon season; however, the total number of birds detected increased. The reason behind this was addition of new species and the big cluster size of the

most abundant species. In the dry season, the birds found dispersed and cluster size was small. It is revealed that in the dry season species richness was low than compared to the monsoon season but overall species abundance was higher. The fact that 72% (82 spp.) of the total number of species counted were common to both the dry and monsoon season, suggest that these birds are native to the environment and the habitats. On other hand in the monsoon, 27% (31) bird species seems to be migratory in nature and might responsible for the high species richness in the monsoon season. It was also noticed that out of the total 114 bird species, only 9% (10 spp.) bird species counted were common to all land-types in both season indicating that there is a constant variation in bird assemblage at the different land-use types. A large number of bird assemblage's diverse bird species is an indication of less competition due to differing niche requirements (Pianka, 1974).

Seasonal variation in bird composition and structure at different land-use:

Seasonal variation in average number of birds per point transect (Fig. 1) was significant (at significance level = 0.05 and 95% confidence interval). The mean numbers of bird species per point transect were highest in the dry season (17) and lowest in monsoon season (15). The number of bird species per point transects ranges from 6 to 33 in the dry season and 10 to 26 in monsoon season. However, the there was no significant difference (at significance level = 0.05 and 95% confidence interval) in average number of birds per point transect in both seasons. The case was reverse for average number of birds per point transects in the dry season (44) and monsoon season (46). The number of birds per point transects ranges from 9 to 91 and 9 to 120 in the dry season and monsoon season respectively. These results showed strong significant correlation (Pearson correlation is significant at 0.01 level, 2-tailed) between mean number of bird species and mean number of bird recorded per point transect.

In the dry season maximum mean number of bird species (21) and mean number of birds (53) per point transect were observed at the casuarina plantation and minimum 14 species and 34 birds at mango plantation site. However, in monsoon season mean number of bird species and mean number of birds per transect ranges from 14 (Forest land-use type) to 16 (Homegardens) and 40 (Casuarina plantation) to 52 (Grassland).

Bird species distribution pattern:

The bird species (e.g. jungle crow (*Corvusmacrorhynchos*), baya weaver (*Ploceusphilippinus*), brahminy kite (*Haliastur Indus*), red wattled lapwing (*Vanellusindicus*), spotted dove (*Streptopeliachinensis*), Indian myna (*Acridotherestristis*), rose ringed-parakeet (*Psittaculakrameri*), red whiskered bulbul (*Pycnonotusjocosus*), red vented bulbul (*Pycnonotuscafer*), Indian pied hornbill (*Anthracocerouscoronatus*), large gray babbler (*Turdoidesmalcolmi*), black drongo (*Dicrurusmacrocerus*), small bee-eater (*Meropsorientalis*), jungle bush quail (*Perdiculaasiatica*), black shouldered kite (*Elanuscaeruleus*), India house crow (*Corvussplendens*), cattle egret (*Bubulcus ibis*) that numerically dominated the bird

assemblage detected in agricultural land, the casuarina plantation, forest land, grassland, homegarden, mango plantation sites and mangrove forest land-use. This indicates that all land-use types are suited for colonization of these bird species. The species such as *Acridotheresginginianus, Galeridamalabarica, Hemipuspicatus, Cyornistickelliae, Gyps bengalensis, Aegithinatiphia, Athenebrama, Carpodacuserythrinus, Centropussinensis, Chalcophaps indica, Columba livia, Cyornistickelliae, Dendrocittavagabunda, Dendrocoposmahrattensis, Eudynamysscolopaceus, Falco tinnunculus, Galloperdixlunulata, Harpactesfasciatus, Hemicircuscanente, Hirundoconcolor, Hirundorustica, Laniusschach, Megalaimaflavifrons, Megalaimazeylanica, Nectariniaasiatica, Nisaetuscirrhatus, Ocycerosbirostris, Phoenicuruscoeruleocephalas, Phylloscopustrochiloides, Psittaculakrameri, Rhipiduraalbicollis, Saxicolatorquatus, Seicercusxanthoschistos, Turdusmerula, Upupaepops*are the rare species recorded in the study area.

If the distribution of the individual species is considered the species such as jungle crow, baya weaver, brahminy kite, red wattled lapwing, spotted dove, Indian myna, rose ringed-parakeet, red whiskered bulbul, red vented bulbul, Indian pied hornbill,large gray babbler, black drongo, small bee-eater, jungle bush quail, black shouldered kite, Indian house crow and cattle egret were found all over the study area. some species like black kite, crested honey buzzard, crested hawk eagle, crested serpent eagle, grey-headed fish-eagle, little cormorant, night heron, white-bellied sea-eagle, white-breasted waterhen, brown fish owl, common sandpiper, eurasian curlew, large cuckoo shrike, river tern, sirkeermalkoha, whimbrel and Indian shag were only distributed over the costal site and near estuaries. The remainder of the species reported were found in wide range of habitats in the study area. However, the bird species such as Indian peafowl, lesser golden woodpecker, heart spotted woodpecker, emerald dove and Indian grey hornbill were found only in the area of low level of human disturbances.

Bird density ha^{-1}

The results on bird density estimates per hectare are shown in Fig. 2. The average bird density (34 individual's ha^{-1}) was recorded during investigation period in both seasons. It is observed that mean bird density per hectare was higher in monsoon season (36 individual's ha^{-1}) than the dry season survey (31 individual's ha^{-1}). It is evident that the high bird density per hectare was recorded at forest land-use type (61.5 individual's ha^{-1}) in monsoon season. In the dry season bird survey, the highest bird density per hectare was estimated at forest land-use type (55.8 individual's ha^{-1}) followed by homegardens (35.7) and lowest was recorded at the casuarina plantation site (18.3 individual's ha^{-1}) followed by agricultural land-use type (23.1 individual's ha^{-1}).

On other had in the monsoon season the highest bird density per hectare was estimated for forest land (61.5 individual's ha^{-1}) followed by the homegardens (42.5 individual's ha^{-1}) and agricultural land-use type (41.4 individual's ha^{-1}). While, the least density was recorded at the

casuarina plantation site (19.2 individual's ha^{-1}) followed by mangrove forest site (20.4 individual's ha^{-1}). It is observed that there was drastic increase in bird density per hectare at agricultural land in monsoon season (23.1 to 41.4 individual's ha^{-1}). The results also indicate that the bird density at mangrove forest site decreased in monsoon season (27.9 to 20.4 individual's ha^{-1}).Our results showed that the bird density per hectare changed in the different land-use types between the dry and monsoon season. Roylee*t al*., (2004) suggested habitat or land-use co-variate affects abundance and detectability. They also concluded that the potential bias in the density estimate was due to potential heterogeneity of land-use types or habitats. The seasonal variations in bird density were due to great number of regional bird species present during the dry and monsoon season. In addition, the seasonal changes in bird assemblage may be due to temperature and humidity fluctuations or the alteration of rainy and dry period. Similar conclusions were made in Argentina stating that the seasonal variation in bird assemblage might be due to low winter temperatures (Herrera, 1981) or the alteration of rainy and dry periods (Poulin*et al*., 1992). The high density in monsoon season might be due to availability of food and habitat.Our investigation revealed that the high bird density was recorded at forest land-use type. The surprising result was the drastic increase in agricultural land bird density and decrease in mangrove bird density in monsoon season. In the dry season most of the agricultural land remain un-cultivated and temperature rose too greatly. The high summer temperatures, might be reason the bird species prefer the more sheltered forest or homegardens habitats or habitats near water bodies. In contrast, in the monsoon season the croplands are cultivated and food availability is high. Higher availability may be the reason why some bird species prefer to move from other land-uses to croplands in the dry season. Another reason for increase in monsoon season bird species richness and density may be due to migratory bird species. However, after forest land-use type the homegardens had the highest the bird density and but was stable in both seasons. This may be due to continuous supply of food and shelter to bird community. Many researchers suggested that individual birds of the many tropical bird species frequently move over large areas to follow temporal and spatial changes in food resources (Blake *et al*., 1990; Loiselle and Blake, 1990; Stiles, 1985). Loiselle and Blake (1992) theorized that the variation in abundance and richness at given site may have different implications for species ability to survive after disturbance or habitat loss. Similarly, in our study area the wetlands, open barren lands are changed to shrimp farming and human settlement, respectively. This might be the reason for moving bird communities to the forest land and the homegardens sites in search of food and shelter. Jayapale*t al*., (2009) studied avian communities in tropical deciduous forest of Central India and concluded that bird assemblage in forest land is associated with availability of a wide choice of food plant species.

Bird conservation status:

The findings clearly indicate that most of the abundant bird species were distributed throughout study area. However, most of the bird occurrence was restricted to coastal side where all land-use types seem to be interlinked. An attempt has been made to compare abundance status based on the species occurrence in the study area (Fig. 3). Our study indicated that among 114 bird species sighted 53% (61) species were common and 16% (18) were uncommon. Twelve per cent (14) bird species were abundant and 8% (9) were occasional. It is observed that 8% (9) rare bird species were recorded in the study period. Gray-hooded Warbler and Malabar Trogon are near threatened species. One vulnerable bird species (common Kestrel) was recorded in the study area.

As per IUCN red list status (IUCN, 2011) among 114 bird species recorded in the study area 109 bird species has least concerned status. Four species (Eurasian Curlew, Gray-Headed Fish-Eagle, Lagger Falcon and Malabar-Pied Hornbill) are near threatened and globally their population is decreasing. One critically endangered bird species (White-Rumped Vulture) was sighted in at grassland site in the dry season (Fig. 4)

Diversity and evenness indices:

We calculated Shannon Weaver index of diversity, Simpson's index of dominance, Simpson's index of diversity and species evenness to determine the seasonal distribution patterns of diversity at different land-use types. The data on bird species diversity indices, evenness and similarity indices for the seven land-use types in the dry and monsoon season survey are presented in Table1.

Shannon Weaver index of diversity (H')

The results for Shannon Weaver indices of diversity are depicted in Table 2 showed that the indices values ranges between 2.90 and 3.73. The mean seasonal variation in Shannon diversity indices was significant at seven land-use types. The mean species diversity was higher (3.68) at agricultural land followed by grassland (3.66) and Forest land-use types (3.60); however, there was no significant difference. It denotes that there is more species diversity and less competition between species. The lowest mean value of Shannon Weaver index (3.01) was observed at casuarina plantation land-use indicates that low species diversity and high completion between species. It is also observed that there was no significant difference in bird species diversity at the casuarina plantation, mango plantation, mangrove and homegardens land-use types.

Simpson's index of dominance (D) and diversity (1-D)

The seasonal variation in Simpsons indices of dominance and Simpsons indices of diversity at different land-use types are showed in Table 2. It is observed that there was significant difference in dominance index values between agricultural and casuarina plantation. The highest mean Simpsons index of dominance value (0.071) was recorded at casuarina plantations followed by mango plantation (0.048), mangrove forest (0.044), forest land (0.042), homegardens (0.041), grassland (0.37) and lowest at agricultural land (0.034), see Table 2. All values of dominance index tend to zero it means that there is high species diversity. However, the species diversity in the study area was decreased from agricultural land,

grassland, homegardens, forest land, mangrove forest, mango plantation to casuarina plantation.

In the dry season bird survey, the dominance index was highest (0.063) at casuarina plantation which indicates that there is low bird species diversity, however the lowest (0.033) dominance value indicates high species diversity at forest land followed by 0.034, 0.035, 0.036, 0.038, 0.047 at mangrove forest, agricultural land, homegardens, grassland and mango plantation land-use types, respectively. It is concluded that higher the value of Simpson's index higher the diversity of the community.

The species evenness measures the variance in abundance among the species at a given site. It falls between 0 and 1, where a value of 1 indicates that the species abundance is all equal (i.e. variance in abundance is 0) and the value tends to 0 when they are highly unbalanced (i.e. variance is indefinitely large). The results indicate that evenness values ranges from 0.78 to 0.92 (Table1).

The mangrove forest showed highest value of evenness (0.92) in the dry season that means less variance and species are equally abundant. The lowest evenness value (0.78) was recorded for forest land in monsoon season, which indicates that there is relatively high variance in species abundance than any other land-use. Seasonal variation in species evenness between all land-use types was not significant in both seasons. The mean species evenness values were ranged from 0.82 between 0.90 for all land-use in both season bird surveys. There was high variance in species evenness at forest land-use followed by grassland, agricultural land casuarina plantation and homegardens land-use types. However, there was high evenness in species distribution at mangrove forest followed by mango plantation land-use type.

In terms of distribution, only ten bird species were found to be co-occurring at all land-use types in both the seasons. The diversity index scores at different land-use types indicate comparable variation in bird diversity. The high value of Shannon Weaver Index indicates the most diverse habitat. The study revealed that agricultural and, grassland and forest land-use types have high bird diversity comparative to other land-use types. However, high bird diversity was recorded at forest land-use in the dry season and grassland in the monsoon season. The bird biodiversity was decreased in all land-use types in monsoon season except agricultural land and grassland sites. Overall, the agricultural land had the highest Shannon Weaver index of bird diversity followed by grassland, forestland and homegardens land-use categories. The comparison of the similarity indices indicates more heterogeneity in species assemblage between different land-use types within and between two seasons. The species diversity indices and evenness of different land-use types during the study period indicates that the forest land, agricultural land and grassland-use types had the highest species diversity and evenness. The large size of these land-use types compare to other sites might contribute to highest bird diversity and evenness.

A significant seasonal change of avian diversity and richness at different land–use types suggests that the bird species of the Konkan coast of Western Ghats have

dynamic seasonal movements including some long distance migrants. It is apparent, as 72% of total bird species recorded was common in both seasons. The seasonal movements of species for food searching might bring about such fluctuations (Chettri*et al*., 2001). Few studies on birds in India argued that the principal differences among different land-use sites were due to human pressure resulting in vegetation structure and composition (Block and Brennan, 1993; Chettri*et al*., 2001).

Conclusion

An avifaunal diversity analysis of bird community structure resulted in identification of 114 bird species and only few bird species are restricted to specific land-use types.It is concluded that the study site exhibits diverse habitats types and rich in bird species. The majority of bird species seen were restricted to grassland, forest land and agricultural land-use types.It is important to carry out repeated inventories of the Konkan coast in order to track regional and global changes in population of bird species. Although ornithological knowledge of the Western Ghats is significant, understanding the avifaunal diversity is still important for conservation planning and restoring ecosystems in long term management. We therefore suggest further systematic and long term avian survey to document changes in overall species richness and diversity in Konkan coast of Western Ghats.The current research suggests that there is crucial need to conserve this land-scape in order to reduce threat to bird diversity. Our findings also indicate that the current knowledge of bird community structure should be integrated into conservation decision making under different land-scape levels for different bird communities.The avifauna of the Western Ghats is facing the threats of rapid economic development, deforestation and installation of various energy power plants.If the present trends of land-use changes continue in the near future, the knowledge of about the effects of land-use changes on avifauna will be important to conservationist and ecologist.Our list of the bird species will also provide baseline to reserve some important bird areas for conservation of the bird communities. Further, the government authorities must be aware about importance of buffer zones for the conservation of bird communities in the region.If the human and anthropogenic disturbances increase in future, then there would be the danger of bird species homogenization. Therefore, in order to maintain diverse bird composition there is need for conservation measures and care should be taken to minimize the human disturbances in the area over a period of time. The current study showed occurrence of rare and less abundant species listed by IUCN.

ACKNOWLEDGEMENTS

This research was made possible through scholarship provided by the Social Justice and Special Assistance Department, Government of Maharashtra (India).

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Table 1: Comparison of richness of avifauna communities by land-use types in two season.

Season	Land-use type	Transects	Species richness	Abundance (N)
Dry season	Agricultural land	35	73	689
	Casuarina plantation	17	36	158
	Forest land	24	78	1635
	Grassland	8	71	1163
	Homegardens	11	62	452
	Mango plantations	5	43	267
	Mangrove forest	3	50	223
	Total	103	83	4587
Monsoon season	Agricultural land	35	76	795
	Casuarina plantation	17	28	120
	Forest land	24	86	1456
	Grassland	8	88	1251
	Homegardens	11	59	567
	Mango plantations	5	47	348
	Mangrove forest	3	40	224
	Total	103	113	4761

Table 2: Comparison of diversity indices of avifaunaby land-use types in two season.

Land-use type	Shannon Weaver index (H')	Simpsons index (D)	Simpsons index (1-D)	Species evenness (E)
Agricultural land	3.67	0.035	0.96	0.86
Casuarina plantation	3.12	0.063	0.93	0.87
Forest land	3.73	0.033	0.97	0.86
Grassland	3.6	0.038	0.96	0.84
Homegardens	3.66	0.036	0.96	0.89
Mango plantations	3.36	0.047	0.95	0.89
Mangrove forest	3.61	0.034	0.97	0.92
Average	3.54	0.04	0.96	0.88
Agricultural land	3.7	0.034	0.97	0.86
Casuarina plantation	2.9	0.079	0.92	0.87
Forest land	3.47	0.052	0.95	0.78
Grassland	3.73	0.035	0.96	0.83
Homegardens	3.47	0.046	0.95	0.85
Mango plantations	3.37	0.049	0.95	0.88
Mangrove forest	3.28	0.054	0.95	0.89
	3.42	0.05	0.95	0.85

Fig. 1: Average number of bird species and mean number of birds per point transect at different land-use in the study area. Error bars shows SE (±).

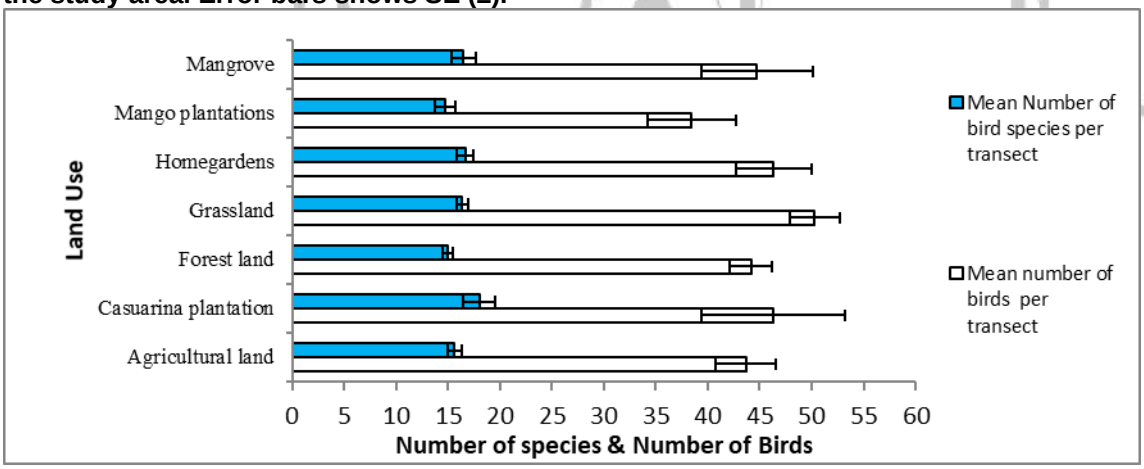


Fig. 2: Comparison of bird density ha^{-1} in the dry (a) and monsoon (b) season point transect survey at different land-use types

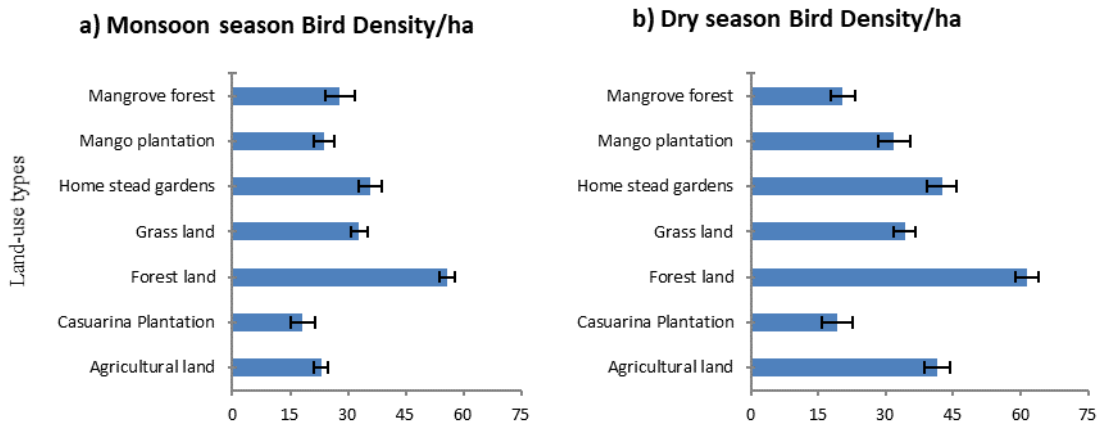


Fig. 3: Regional abundance status of the bird status recorded in this study area

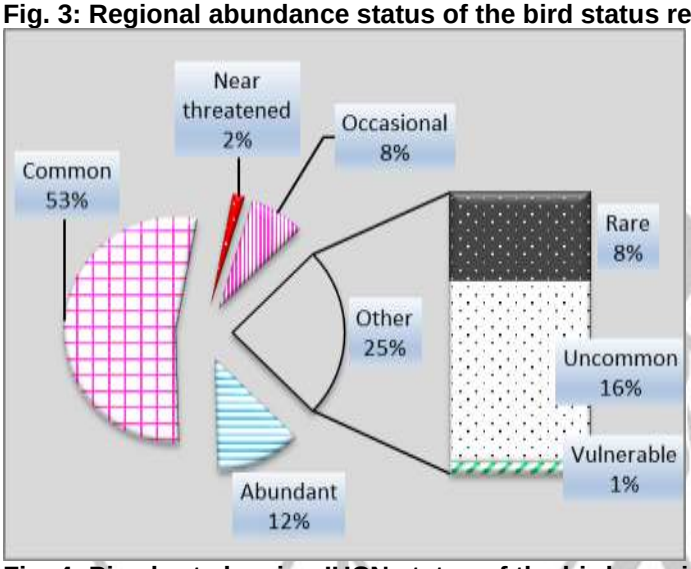
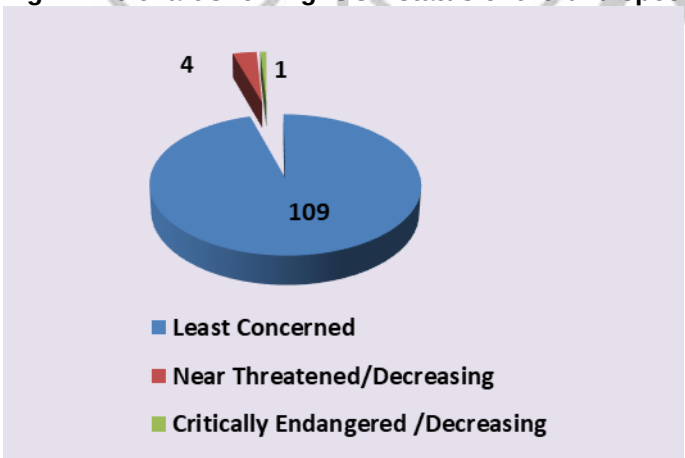


Fig. 4: Pie chart showing IUCN status of the bird species



Appendix I: The list of the bird species observed in the study area with the land-use in which they occurred. The species occurred in the dry season (D) and monsoon season (M) at all land-use types (D), and the species occurred in both season (D/M) at all land-use type.List of the common bird species sighted in the dry and monsoon season and the land-use in which they occurred

Sr.	Species	Land-use type	Sr.	Species	Land-use type
1	Asian Koel (D)	A, CP, F, G, H, MP, MF	11	Common Kestrel	A, CP, F, G, H
2	Bar-Winged Flycatcher-Shrike	A, F, G, H, MP, MF	12	Common wood Shrike	A, F, G, MF
3	Baya Weaver (M)	A, CP, F, G, H, MP, MF	13	Common/ Indian Myna	A, F, G, H, MP, MF
4	Black Drongo (D/M)	A, CP, F, G, H, MP, MF	14	Common Blue Kingfisher	A, F, H, MP, MF
5	Black Kite (D)	A, CP, F, G, H, MP, MF	15	Coppersmith Barbet (M)	A, CP, F, G, H, MP, MF
6	Black shouldered Kite	A, CP, F, G, MP, MF	16	Crested Hawk Eagle	C, G, H
7	Black-Hooded Oriole	A, F, G, H, MP, MF	17	Crested Honey Buzzard	A, CP, F, G
8	Blue-Capped Redstart	A, F, H, MP, MF	18	Crested Serpent-Eagle	C, F, G, H, MF
9	Brahminy Kite (M)	A, CP, F, G, H, MP, MF	19	Dusky Crag-martin	A, F, G, H
10	Brown-Headed Barbet	A, F, G, H	20	Emerald Dove	A, F, G, H, MP, MF
21	Cattle egret (D/M)	A, CP, F, G, H, MP, MF	35	Eurasian Black Bird	F, G, H
22	Cliff Swallows	A, CP, F, G, H, MP, MF	36	Eurasian Golden Oriole	A, F, G, H, MP, MF
23	Common Barn Swallow	A, CP, F, G, H, MF	37	Gray Francolin	A, F, G, H, MP, MF
24	Common Chiffchaff	A, F, G	38	Greater Coucal (D)	A, CP, F, G, H, MP, MF
25	Green Bee-Eater (D/M)	A, CP, F, G, H, MP, MF	39	Lagger Falcon	A, F, G, MP, MF
26	Grey Headed Fish-Eagle	F, G	40	Large Grey Babbler (D)	A, CP, F, G, H, MP, MF
27	Grey Hooded Warbler (D)	A, CP, F, G, H, MP, MF	41	Laughing Dove	A, CP, F, G, H
28	Heart Spotted Woodpecker	A, CP, F, H, MP, MF	42	Lesser Gold Backed Woodpecker	A, F, G, H, MP, MF
29	House Sparrow (D)	A, CP, F, G, H, MP, MF	43	Little Cormorant	A, CP, F, G, H, MF
30	Indian Grey Hornbill	A, F, G, H, MF	44	Little Egret	A, CP, F, G, H, MF
31	Indian House Crow (M)	A, CP, F, G, H, MP, MF	45	Long-Tailed Shrike	A, G, H
32	Indian Peafowl	A, F, G, H, MP, MF	46	Indian Pied Hornbill (D)	A, CP, F, G, H, MP, MF
33	Indian Pitta	A, F, G, H, MP, MF	47	Malabar / Indian Trogon	A, F, G, H
34	Indian Pond-Heron (D)	A, CP, F, G, H, MP, MF	48	Malabar-Crested Lark	A, F, G, H, MP, MF
49	Indian Robin (D/M)	A, CP, F, G, H, MP, MF	63	Night Heron	A, F, MF
50	Indian Roller	A, F, G	64	Orange-Headed Thrush	A, F, G, H, MP, MF
51	Indian Shag/ Cormorant	A, F, G, H, MP	65	Oriental Magpie-Robin	A, F, G, H, MP, MF
52	Indian Small Sky Lark	A, F, G, H, MP, MF	66	Painted Spurfowl	A, F, G, H, MF
53	Indian/Rufous Treepie	A, F, G, H	67	Pied Harrier	A, F, G, H
54	Jungle Bush-Quail (D)	A, CP, F, G, H, MP, MF	68	Purple Sun Bird	A, CP, F, G, H
55	Jungle Crow (D/M)	A, CP, F, G, H, M, MF	69	Red Munia	A, F, G, MP

Sr.	Species	Land-use type	Sr.	Species	Land-use type
56	Red-Rumped Swallow	A, F, G, H, MF	70	Spotted Dove (D/M)	A, CP, F, G, H, MP, MF
57	Red-Vented Bulbul	A, F, G, H, MP, MF	71	Spotted Owlet	A, F, G, H, MP
58	Red-Wattled Lapwing (D/M)	A, CP, F, G, H, MP, MF	72	Stork-Billed Kingfisher	A, CP, F, G, H, MF
59	Red-Whiskered Bulbul (D/M)	A, CP, F, G, H, MP, MF	73	Tickells Blue-Flycatcher	A, CP, G, H, MP, MF
60	Pigeon	A, CP, F, H	74	White-Bellied Sea-Eagle	F, G
61	Rock Pigeon	A, F, G, H, MP, MF	75	White-Breasted Waterhen	A, CP, F, G, H, MF
62	Rose-Ringed Parakeet (D/M)	A, CP, F, G, H, MP, MF	76	White-Browed Wagtail	A, F, G, H, MF
77	Rosy Starling	F, MP	80	White-Throated Fantail-Flycatcher	A, CP, F, G, H, MP
78	Rufous-Tailed Lark	A, F, G, H	81	White-Throated Kingfisher (D/M)	A, CP, F, G, H, MP, MF
79	Small Pratincole	A, F, G, MF	82	Yellow-Fronted Pied-Woodpecker	CP, F, G, MP, MF

List of the bird species sighted only in the dry season and the land-use in which they occurred

Sr.	Species	Land-use type
1	White-Rumped Vulture	G

List of the bird species sighted only in monsoon season and the land-use in which they occurred

Sr.	Species	Land-use type	Sr.	Species	Land-use type
1	Asian Paradise-flycatcher	A, G, H	7	Hoopoe	A, G, H, MP, MF
2	Bank Myna	H, MP, MF	8	Jungle Starling/ Myna	A, F, G, H, MP, MF
3	Black Bulbul	A, F	9	Large Cuckoo Shrike	A, F, G
4	Brahminy Starling	F, G	10	Pied-Crested Cuckoo	A, F, G, H
5	Brain fever Bird	A, F	11	River Tern	A, F, G
6	Brown Fish-Owl	A	12	Ruddy Shelduck	A, G
13	Common Iora	F, G	13	Singing Bush Lark	A, F, G
14	Common Redshank	A, G	24	SirkeerMalkoha	A, F,G
15	Common Rosefinch	A, F, G	25	Small Minivet	A, F, G, H, MP, MF
16	Common Sandpiper	A, G	26	Whimbrel	G
17	Common Stone Chat	A, F, G	27	White-Bellied Blue-Flycatcher	G
18	Crested Tree Swift	G	28	White-Cheeked Barbet	A, F
19	Eurasian Curlew	G	29	Yellow-Browed Bulbul	A
20	Golden fronted Leaf bird	A, F, G, H, MP, MF	30	Yellow-Fronted Barbet	F
21	Greenish Leaf Warbler	F	31	Yellow-Wattled Lapwing	A, F, G
22	Grey Hypocolius	F			

Where, A = agricultural land G = Grassland F = Forest land H = Homegarden

Sr.	Species	Land-use type	Sr.	Species	Land-use type

CP = Casuarina plantation MP = Mango plantation MF = Mangrove forest