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Research Article

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"Study on Avian diversity in Agro Forest landscape with special reference to Semi-Urban area of District Gwalior, Madhya Pradesh, India."

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Abstract

Semi-urban areas are a different and vastly changed area where human activities and natural ecosystems have an important impact on biodiversity conservation. This research is to check the diversity, habitat ecology, and distribution density of avian fauna present in agro-forest areas, which are mainly visible in semi-urban areas. The specialized agro-forestry technique for the cultivation of trees and agricultural crops provides habitat for avian fauna and also provides valuable ecological services. This study focuses on the different types of species present in the agro-forestry area of three different sites in Chinor tehsil of Gwalior district, where urbanization has encroached on the agro-forestry area. A multipronged approach based on field surveys and statistical analysis has been used to obtain a comprehensive understanding of the bird species living in the region. It is known from the study that information about the bird species and their habitat is found in the agro-forest landscape of the study area. Through the medium of the survey, we have found 128 bird species related to 35 families and 17 orders. It also includes some permanent and migratory species. Which have been adapted to remain livable in their agro-forestry area.

Keywords: Biodiversity, Ecological services, Conservation, Urbanization, Distribution density.

1. Introduction

Among the different types of vertebrates in the world, the greatest diversity has been identified in birds. Birds and plants both play a crucial role in almost all ecosystems, like terrestrial ones, and furnish a variety of major products and services to both urban and rural communities. The abundance of birds is displayed in both agro-forestry and agriculture. The biggest reason for this is that, apart from other environmental factors, birds also play an important role in plant reproduction. Agro forestry is defined as a land use system that integrates trees and shrubs on farmlands and rural

landscapes to enhance productivity, profitability, diversity, and ecosystem sustainability. It is a dynamic, ecologically based, natural resource management system that, through the integration of woody perennials on farms and in the agricultural landscape, diversifies and sustains production and builds social institutions (National Agro forestry Policy, 2014). India has about 28.427 million hectares of agro forest which is about 8.65 percent of the geographical area **(R**izvi *et al.,* 2022**).** The highlights of significant bird diversity in the Brahmaputra North Bank Landscape of Assam's agro-forestry systems, with variations in species richness and composition among different types of agro-forestry systems **(**Yashmita *et al*., 2016; Sharma and Kumar, 2018**).** Tea gardens were consistently noted for having higher bird species richness, while home gardens were also important habitats for a diverse avian community **(**Yahya *et al.,* 2022**).** Bird species richness and overall abundance were greater in agro-forestry orchards compared to oil palm and rubber tree plantations; this result implies the potential of agro-forestry orchards as an important habitat for farmland birds **(Ali and Naik, 2022)**. The number of birds in the agro-forest area is quite similar to that in the agricultural area. Land-use type plays a significant role in determining bird assemblages in agricultural habitats.

2. Materials and Methods

2.1. Study area: The study field is Chinor village, about 40 km away from Gwalior. It is a village panchayat located in the Gwalior district of Madhya Pradesh state, India. The latitude 25°94' and longitude 78°10' are the geocoordinates of Chinor. According to the Madhya Pradesh Forest Department, the agroforestry area in Madhya Pradesh is 23 hectares, and in this, Gwalior has about 2% participation. There are a large number of small and thorny bushes like Ber (*Zizyphus mauritiana) and* Babool (A*cacia nilotica).* Despite being a very short distance from Gwalior, there has been very little urbanization here. The area of Chinor Tahsil is approximately 498 km^2. The three sites include ASC (Agro-Silvi-Culture), AH (Agro-Horticulture), and AP (Agro-Pasture). We have studied the diversity of different species of birds at three sites in Chinor.

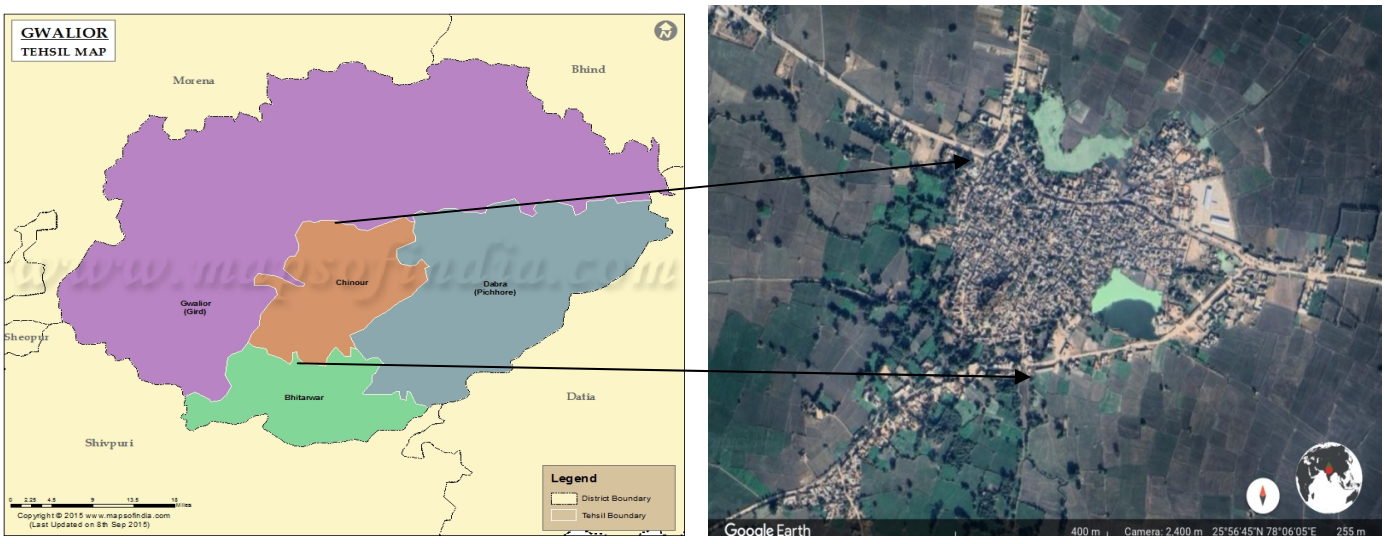

Figure 1: Map of Chinor tehsil, Gwalior, (M.P.) Source - Google

2.2. Methods: The birds' most active periods in the summer, winter, and rainy seasons are in the early morning and evening, from 6:00 a.m. to 10:00 a.m., and have been done in the interval of 3 years, i.e., 5:00 p.m. to 7:00 p.m., which is considered perfect for the survey. The operating hours during the summer season are from 4:30 to 6:30 p.m., whereas during the winter season, the

hours are from 7:00 a.m. to 6:30 p.m. April 2021 to April 2024, and the time between 7:00 a.m. and 11:00. a.m. This study has an area that was observed for recording avifauna by applying the point transect method and the line transect method. Birds were recorded according to their seasonal visits, site, location, and habitat type.

ASC site AH site AP site

Figure 2: Photographs of different agro forest landscape.

2.3. Instruments: The required photography was supported using a Kodak 12X digital zoom camera and a 7D Canon SLR camera to accurately identify records and also use binoculars (Olympus, 7 × 50) with Global Position System (GPS).

2.4. Species Identification: Birds observed during the study are classified into resident (R) and migratory (M) birds according to their month-wise position. The identification of birds was done with the help of major reference books (Ali and Futehally 2007**;** Grimmett ***et al.*, 2007).** All observations in this study were visual, and no birds were harmed by capture. Therefore, no subspecies widentified.

3. Results and Discussion

Fieldwork was conducted in agro-forest structures in semi-urban areas throughout the years 2021–2024, with a lesser intensity prior to 2022. The recent survey findings indicate the presence of a total of 128 bird species, belonging to 35 families and 17 orders (Table 1). Among these, the family Musciapidae has the highest number of bird species, with a count of 10. The comprehensive checklist in Table 1 provides details such as the order, family, common name, local name, zoological name, IUCN status, and residential/migratory status of each recorded bird species. Based on the IUCN Red Data Book, the majority of species from the study area are classified as least concern (118), accounting for 92.18% of the recorded species. Additionally, there are 6 near-threatened species (4.68%) and 2 avian species classified as critically endangered (CE) and vulnerable (V), respectively, making up 1.56% of the total. Out of the recorded species, 109 (85.15%) are residential, while 19 (14.84%) are residential migratory (Table 3 and Image 2). The abundance status of avian fauna in the study sites is estimated at uncommon 18 (14.06%), common 81 (63.28%), and fairly common 29 (22.65%) (Table 1 and Image 1). Image 4 illustrates diverse bird families found across various study locations (ASC site, AH site, and AP site).

Table 1: Checklist of Avian Fauna sighted at different Agro forestry Landscape of the Study area, IUCN Status, Abundance status and Residential Migration status.

Order	Family	Common Name	Zoological Name	IUCN Status	R/M Status	AB status	ASC	AH	AP
Accipitriformes	Accipitridae	Black Kite	*Milvus migrans*	LC	R	C	-	√	√
		Black winged kite	*Elanus caeruleus*	LC	R	C	√	-	√
		Changeable Hawk Eagle	*Spizaetus cirrhatus*	LC	R	FC	√	√	√
		Crested Serpent Eagle	*Spilornis cheela*	LC	R	FC	-	√	√
		King vulture	*Sarcogyps calvus*	CE	R	UC	√	√	√
		Long-billed Vulture	*Gyps indicus*	CE	R	UC	-	√	√
Apodiformes	Apodidae	Asian Palm Swift	*Cypsiurus balasiensis*	LC	R	C	-	√	√
		House Swift	*Apus affinis*	LC	R	C	-	√	√
Bucerotiformes	Bucerotidae	Great Hornbill	*Buceros bicolor*	NT	R	UC	√	-	-
		Orirntal Pied Hornbill	*Anthracoceros albirostris*	LC	R	C	√	√	√
	Upupidae	Common Hoopoe	*Upupa epops*	LC	R	C	√	√	-
Caprimulgiformes	Caprimulgidae	Common Indian Nightjar	*Caprimulgus asiaticus*	LC	R	FC	√	√	√
		Grey Nightjar	*Caprimulgus indicus*	LC	R	FC	√	√	√
Charadriiformes	Charadriidae	Red-wattled lapwing	*Vanellus indicus*	LC	R	C	√	√	√
		Yellow wattled lapwing	*Vanellus malabaricus*	LC	R	UC	√	√	√
	Scolopacidae	Common Greenshank	*Tringa nebularia*	LC	M	C	√	√	√
		Common sandpiper	*Actitis hypoleucos*	LC	M	C	√	√	√
		Common Snip	*Gallinago gallinago*	LC	M	FC	√	-	-
		Curlew Sandpiper	*Calidris ferruginea*	NT	M	UC	√	-	√
		Little-Stint	*Calidris minuta*	LC	M	FC	-	√	√
		Wood sandpiper	*Tringa glareola*	LC	M	C	√	√	√

Ciconiiformes	Ciconiidae	Asian Open bill	*Anastomus oscitans*	LC	R	FC	√	√	√
		Black necked Stork	*Ephippiorhvnchus Masiaticus*	NT	R	UC	√	√	√
		Lesser Adjutant	*Leptoptilos javanicus*	V	R	UC	√	-	-
		Woolly-necked stork	*Ciconia episcopus*	V	R	FC	√	√	√
Columbiformes	Columbidae	Ashy-headed green Pigeon	*Treron phayrei*	NT	R	UC	-	√	√
		Eurasian collared Dove	*Streotopelia decaocto*	LC	R	C	√	√	√
		Laughing Dove	*Streptopelia senegalensis*	LC	R	C	√	√	√
		Oriental Turtle Dove	*Streptopelia orientalis*	LC	R	C	√	√	√
		Red collared Dove	*Streptopelia tranquebarica*	LC	R	FC	√	√	√
		Rock / Common Pigeon	*Columba livia*	LC	R	C	√	√	√
		Spotted Dove	*Streptopelia chinensis*	LC	R	C	√	√	√
Coraciiformes	Alcedinidae	Common Hawk Cuckoo	*Alcedo atthis*	LC	R	C	√	√	√
		Pied Kingfisher	*Ceryle rudis*	LC	R	C	√	√	√
		White-throated Kingfisher	*Halcyon smyrnensis*	LC	R	C	√	√	√
	Coraciidae	Dollar Bird	*Eurystomus orientalis*	LC	R	C	√	√	-
		Indian Roller	*Coracias benghalensis*	LC	R	C	√	√	√
	Meropidae	Blue -tailed bee-eater	*Merops philippinus*	LC	R	C	-	√	√
		Blue-bearded Bee-eater	*Nyctyornis athertoni*	LC	R	C	-	-	√
		Green bee-eater	*Merops orientals*	LC	R	C	√	√	-
Cuculiformes	Cuculidae	Asian Koel	*Eudynamys scolopacea*	LC	R	C	√	√	√

		Banded bay Cuckoo	*Cacomantis sanneratii*	LC	R	C	-	-	√
		Common Hawk Cuckoo	*Hierococcyx varius*	LC	R	FC	√	√	√
		Drongo Cuckoo	*Surniculus lugubris*	LC	R	C	-	√	√
		Lesser Coucal	*Centropus bengalensis*	LC	R	C	√	√	√
		Pied cuckoo /Jacobin cuckoo	*Clamator jacobinus*	LC	R	FC	-	√	-
Falconiformes	Falconidae	Common Kestrel	*Falco tinnuculus*	LC	M	C	-	√	-
		Lesser Kestrel	*Falco naumanni*	LC	R	C	√	√	√
		Pied Falconet	*Microhierax melanoleucos*	LC	R	C	-	√	-
Galliformes	Phasianidae	Grey Francolin	*Francolinus pondicerianus*	LC	R	C	-	√	√
		Jungle bush Quail	*Perdicula asiatica*	LC	R	UC	√	√	√
		Peacock	*Pavo cristatus*	LC	R	C	√	√	√
		Red Jungle fowl	*Gallus gallus*	LC	R	C	-	√	√
Palecaniformes	Ardeidae	Cattle Egret	*Bubulcus ibis*	LC	R	C	√	√	√
		Greater Egret	*Casmerodius albus*	LC	R	C	√	√	√
		Grey Heron	*Ardea cinerea*	LC	M	C	√	√	√
		Intermediate Egret	*Mesophoyx intermedia*	LC	R	C	-	√	√
		Little Egret	*Egretta garzetta*	LC	R	C	√	√	√
		Night Heron	*Nycticorax nycticorax*	LC	R	FC	√	√	√
Passeriformes	Campephagidae	Large Cuckoo shrike	*Coracina macei*	LC	R	UC	-	√	-
		Large-tailed Minivet	*Pericrocotus ethologus*	LC	M	C	-	√	√
		Small Minivet	*Pericrocotus cinnamomeus*	LC	R	FC	√	-	-
	Cisticolidae	Common Tailorbird	*Orthotomus sutorius*	LC	R	C	√	-	-
		Grey Breasted	*Prinia hodgsonii*	LC	R	FC	√	-	-

	Prinia							
	Jungle Prinia	*Prinia sylvatica*	LC	R	FC	-	√	√
	Plain Prinia	*Prinia inornata*	LC	R	C	-	√	√
	Zitting Cisticola	*Cisticola juncidis*	LC	R	FC	√	√	√
Corvidae	Eastern Jungle Crow	*Corvus levailantii*	LC	R	C	√	√	√
	House Crow	*Corvus splendens*	LC	R	C	√	√	√
	Jungle Crow	*Corvus macrorhynchos*	LC	R	C	√	√	√
	Rufous Treepie	*Dendrocitta vagabunda*	LC	R	C	√	√	√
Dicaeidae	Fire-breasted Flowerpecker	*Dicaeum ignipectus*	LC	M	UC	√	√	√
	Scarlet-backet Flowerpecker	*Dicaeum cruentatum*	LC	R	C	√	√	√
	Thick-billed Flowerpecker	*Dicaeum agile*	LC	R	FC	-	√	√
Dicruridae	Ashy Drongo	*Dicrurus leucophaeus*	LC	M	FC	√	√	√
	Black drongo	*Dicrurus macrocerus*	LC	R	C	√	√	√
	Bronzed Drongo	*Dicrusus aeneus*	LC	R	C	√	√	√
	Racket tailed Drongo	*Dicrurus paradiseus*	LC	R	C	√	√	√
	Spangled Drongo	*Dicrurus hottentottus*	LC	R	C	√	√	√
Fringillidae	Common Rose finch	*Carpodacus erythrinus*	LC	M	FC	√	√	-
Leiothrichidae	Jungle Babbler	*Turdoides striata*	LC	R	C	-	√	√
Motacillidae	Grey Wagtail	*Motacilla flava*	LC	M	C	√	-	√
	Paddyfield / Oriental pipit	*Anthus rufulus*	LC	M	FC	√	√	√
	White Wagtail	*Motacilla alba*	LC	M	C	√	-	-
	Yellow wagtail	*Motacilla thunbergi*	LC	R	UC	√	√	√
Musciapidae	Black-backed Forktail	*Enicurus immaculatus*	LC	R	C	-	√	√
	Blue Rock Thrush	*Monticola solitarius*	LC	M	UC	-	√	√

		Bluethroat	*Luscinia svecica*	LC	M	FC	√	√	-
		Brown Rock-chat	*Oenanthe fusca*	LC	R	FC	-	√	√
		Common Stonechat	*Saxicola rubicola*	LC	M	C	√	√	√
		Grey-headed Canary Flycatcher	*Culicicapa ceylonensis*	LC	M	FC	√	√	√
		Indian Robin	*Copsychus fulicatus*	LC	R	C	-	√	√
		Oriental Magpie Robin	*Copsychus saularis*	LC	R	C	√	√	√
		Tickell's Blue Flycatcher	*Cyornis tickelliae*	LC	R	FC	-	√	√
		White-tailed Stonechat	*Saxicola leucurus*	LC	R	C	√	√	√
	Nectariniidae	Crimson Sunbird	*Aethopyga siparaja*	LC	R	C	√	√	-
		Purple Sunbird	*Nectarinia asiatica*	LC	R	C	√	√	√
	Passeridae	Chesnut-shouldered petronia	*Petronia xanthocollis*	LC	R	FC	√	√	√
		House Sparrow	*Passer domesticus*	LC	R	C	√	√	√
		Indian Silverbill	*Lonchura Malabarica*	LC	R	C	√	√	√
		Rock Sparrow	*Petronia petronia*	LC	R	UC	√	-	-
	Ploceidae	Baya Weaver	*Ploceus philippinus*	LC	R	C	√	√	√
	Pycnonotidae	Black-crested Bulbul	*Pycnonotus melanicterus*	LC	R	C	√	√	√
		Red-vented Bulbul	*Pycnonotus cafer*	LC	R	C	√	√	√
		Red-whiskered Bulbul	*Pycnonotus jocosus*	LC	R	C	√	√	√
	Sturnidae	Asian pied starling	*Sturnus contra*	LC	R	C	√	√	√
		Bank Mynah	*Acridotheres ginginianus*	LC	R	C	√	√	√
		Brahminy Starling	*Sturnus pagodarum*	LC	R	C	√	√	√
		Common Mynah	*Acridotheres tristis*	LC	R	C	√	√	√
		Great Myna	*Acridotheres grandis*	LC	R	C	√	√	√
		Jungle Myna	*Acridotheres fucus*	LC	R	C	√	√	√
Piciformes	Picidae	Black-rumped Flameback	*Dinopium benghalense*	LC	R	FC	-	√	√

		Brown-capped Pygmy woodpecker	*Dendrocopos nanus*	LC	R	C	√	√	√
		Fulvous-breasted Woodpecker	*Dendrocopos macei*	LC	R	C	√	√	√
		Yellow-crowned woodpecker	*Dendrocopus mahrattensis*	LC	R	C	-	√	√
	Megalaimidae	Blue-throated Barbet	*Psilopogon asiaticus*	LC	R	FC	√	√	√
		Brown-headed barbet	*Megalaima zeylanica*	LC	R	C	√	√	√
		Coppersmith Barbet	*Megalaima haemacephala*	LC	R	C	√	√	√
		Lineated Barbet	*Psilologon lineatus*	LC	R	C	√	√	√
Psittaciformes	Psittacidae	Alexandrine Parakeet	*Psittacula eupatria*	NT	R	FC	√	√	-
		Plum-headed Parakeet	*Psittacula cyanocephala*	LC	R	FC	√	√	√
		Red-breasted Parakeet	*Psittacula alexandri*	NT	R	UC	√	√	√
		Rose-ringed Parakeet	*Psittacula krameri*	LC	R	C	√	√	√
Strigiformes	Strigidae	Brown Fish Owl	*Ketupa zeylonensis*	LC	R	UC	-	√	√
		Brown Hawk-owl	*Ninox scutulata*	LC	R	UC	√	√	√
		Spotted Owlet	*Athene brama*	LC	R	UC	-	√	√
Suliformes	Phalacrocoracidae	Indian Cormorant	*Phalacrocorax fuscicollis*	LC	R	C	-	√	√
		Little cormorant	*Phalacrocorax niger*	LC	R	C	√	√	√
							95	115	109

Abbreviations: ASC - Agro Silvi Culture, **AH** - Agro horticulture, **AP** - Agro Pasture, **LC** - Least Concern, **V** -Vulnerable, **CE** - Critically Endangered, **E** - Endangered, **NA** - Not Available, **NT** - Near Threatened, **R** - Residential, **M** - Migratory, **UC** - Uncommon, **C** - Common, **FC** - Fairly Common, **AB -** Abundance Status

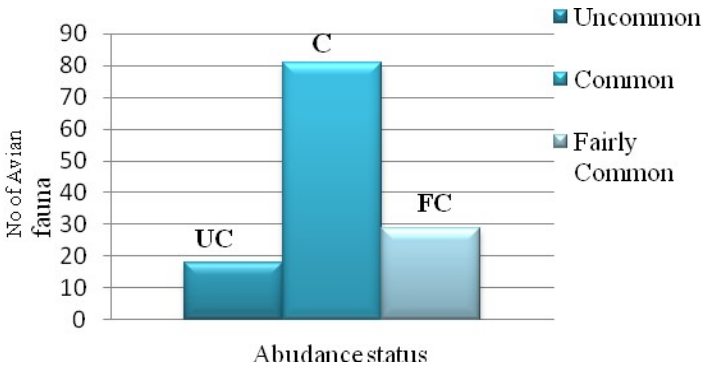

Image 1: Abundance Status of Avian Fauna

Table 2: Alpha, Beta and Gamma diversity of different study sites

Diversity	ASC	AH	AP
Alpha diversity (α)	95	115	109
Beta diversity (β)	20	6	15
Gamma diversity (γ)	128		

The Passeriformes order is the most dominant among families in the study area, with a total of 14 families. During the survey, 52 species, accounting for 40.62% of the observed species, were identified within this order. Within the Passeriformes order, the Muscicapidae family has the highest number of bird species, with 10 species representing 7.81% of the total. On the other hand, the Fringillidae, Plocidae, and Liothrichidae families have the lowest number of bird species recorded, with only 1 species each, accounting for 0.78% of the total. Apart from the Passeriformes order, the Sturnidae family has 6 species (4.68%), while the Cisticolidae, Passeridae, and Dicruridae families each have 5 species (3.90%). Additionally, the Carvidae family has 4 species (3.12%), and the Motacillidae, Campephagidae, and Pycnonotidae families each have 3 species (2.34%). The Nectariniidae family, belonging to the Order Falconiformes, has 2 avian species, representing 1.56% of the total. In the order Falconiformes, only the Falconidae family was recorded with 3 species (3.2%), while in the order Strigiformes, only the Strigidae family was observed with 3 species (3.2%). The order Bucerotiformes includes two families, Uppidae (1 species) and Bucerotidae (2 species), both of which were estimated in the survey. The Order Suliformes, Order Caprimulgiformes, and Order Apodiformes each have 2 avian species, representing 2.43% of the total, from the families Phalacrocorcidae, Caprimulgidae, and Apodidae, respectively. The Columbidae family, belonging to the order Columbiformes, is represented by 7 species (5.69%). Following this, the Phasianidae, Pasittacidae, and Ciconiidae families, included in the Galliformes, Psittaciformes, and Ciconiiformes Orders, respectively, each have 4 species (3.12%).

Within the Coraciiformes order, a total of three avian species, accounting for 2.34% of the studied species, have been identified in the Meropidae and Alcdinidae families. Additionally, within the Characidae family, two species, representing 2.43% of the avian species, have been studied. These findings indicate that the Coraciiformes order encompasses approximately 6.25% of the total avian species observed in the study areas. Moving on to the Piciformes order, four avian species, comprising 3.12% of the total species, have been recorded in the Megalemidae and Pichidae families. This suggests that the

Piciformes order contributes significantly to the avian species diversity, accounting for a notable proportion of the overall species richness. Furthermore, the family Cuculidae, family Ardeidae, and family Accipitridae, which fall under the orders Cuculiformes, Palecaniformes, and Accipitriformes, respectively, have yielded a total of six avian species, representing 4.68% of the studied species. These findings highlight the importance of these families in contributing to the overall avian species richness within the study areas. In the Charadriiformes order, which accounts for 6.25% of the avian species, two families have been recorded. The Charadriidae family comprises two species, while the Scolopsidae family includes eight species. These findings demonstrate the diversity within the Charadriiformes order and its contribution to the overall avian species richness in the study areas. It is worth noting that the proportion of species richness varies among different bird families, ranging from 1% to 10%. This indicates that certain families exhibit higher species diversity compared to others, emphasizing the importance of considering family-wise proportions when studying avian species.

Through a comparison of the three study sites, it is evident that different percentages of bird species have been identified at each site. In agro-silviculture site (ASC), 95 species, accounting for 74.21% of the total, have been recorded. In agro-horticulture, 112 species, representing 87.5% of the total, have been documented. Lastly, in agro-pasture, 109 species, making up 85.15% of the total, have been observed. These species include families such as Cervidae (3.12%), Dicruridae (3.90%), Pycnonotidae (2.34%), Plocidae (0.78%), Alcedinidae (2.34%), Caprimulgidae (1.56%), Charadriidae (1.56%), and Megalemidae (3.12%). It is worth noting that avian species have been observed across all study sites, as indicated in Table 1 and Figure 3. Interestingly, the quantity of birds in the agro-wooded area region is similar to that in the agricultural location. Throughout the study, it was found that no species belonging to the avian fauna families Fringillidae and Upupidae were recorded at the AP site. Similarly, at the agro-silviculture site, no avian species from the families Leiothrichidae and Apodidae could be identified. However, at the agro-horticulture site, avian species from all families were observed (Table 1).

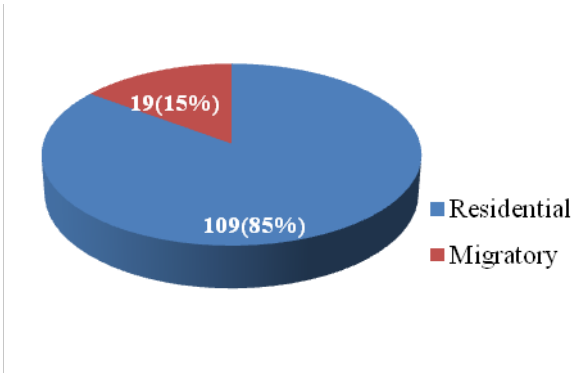

Image 2: Migratory and Residential Avian fauna

The family Sturnidae exhibits the highest abundance of birds in the ASC landscape, with a recorded number of six species (Table 1). On the other hand, the families Fringillidae, Ploceidae, Phalacrocoracidae, Falconidae, Meropidae, Strigidae, Upupidae, and Campephagidae have the least number of bird species, with only 01 species each (Table 1). In the AP landscape, the family Musciapidae has the highest number of different bird species, estimated at 9 (Table 3). Conversely, the families Bucerotidae, Coraciidae, Leiothrichidae, Ploceidae, Falconidae, Nectariniidae, and Campephagidae have the lowest number of avian fauna, with only 01 species each (Table 3). The avian fauna of the Musciapidae family, with a total of 10 species, is predominantly found at the AH site. On the other hand, the families Fringillidae, Plocedaei,

Leiothrichidae, Upupidae, and Bucerotidae have the least number of observed bird species, with only 01 species each (Table 1). The agroforestry landscape plays a vital role in providing food for birds, making agroforestry structures crucial for the conservation of local and winter migratory avian species. The study area also includes near-threatened (NT) species and avian species with uncommon (UC) abundance and resident status. These species include the ashy-headed green pigeon from the Columbidae family, the red-breasted parakeet from the Psitticidae family, the gray hornbill from the Bucerotidae family, the black-necked stork from the Ciconidae family, and the migratory bird Curlew Sandpiper from the Scolopacidae family.

Table 3 : IUCN Status of the Birds reported

S. No	Least Common	Near Threatened	Vulnerable	Critical Endangers	Total
1	118	6	2	2	128

In the ASS, AH, and AP study sites, there are several critically endangered avian species, including the king vulture and long-billed vulture from the Accipitridae family. Additionally, there are some fairly common residential avian species that are categorized as least concern by the IUCN. These include the Grey-breasted Prinia, Zitting Cisticella, and Jungle Prinia from the Cisticolidae family; Brown Rock-chat from the Musciapidae family; Tickell's Blue Flycatcher and Chesnut-shouldered Petrinia from the Passeridae family; Small Minivet from the Camphephagidae family; Thick-billed Flowerpecker from the Dicaeidae family; Red-collared Dove from the Columbidae family, Common Hawk cuckoo, Hawk Cuckoo, and Pied Cuckoo from the Cuculidae family, Night Heron from the Ardeidae family, Common Indian Nightjar and Gray Nightjar from the Caprimulgidae family, Changeable Hawk Eagle and Crested Serpent Eagle from the Accipitridae family, Plum-headed Parakeet from the Psittacidae family, Brown-capped Pygmy woodpecker from the Picidae family, and Brown-headed barbet and Asian Openbill from the Ciciniidae family (Table 1). Furthermore, among the migratory birds categorized as least concern, the Grey-headed Canary Flycatcher and Bluethroat from the Musciapidae family, White Wagtail from the Motacillidae family, Common Rosefinch from the Fringillidae family, Ashy Drongo from the Dicruridae family, and Common Snip from the Scolopacidae family are fairly common in the area.

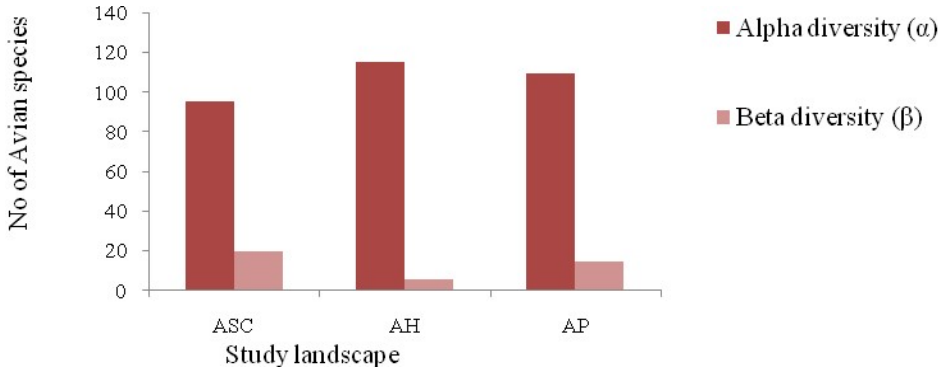

Image 3: Alpha and Beta diversity in different Agroforestry ecosystem

During the survey conducted in the study area, the Woolly-necked Stork, a vulnerable avian species belonging to the Ciconiidae family, was observed to be fairly common and residential in all three sites: ASC, AP, and AH. Similarly, the Alexandrine Parakeet, known locally as Hiraman tota, was identified as a fairly common residential avian species and categorized as Near Threatened. It was found to be present at the ASC and AH sites of the study area. The large Cuckoo shrike, a migratory avian species from the Campephagidae family, was observed in the Agro-Horticulture Site (AH) of the study landscape. This species is classified as least concern (LC) and is considered a common species. Other dominant avian faunal species observed throughout all three landscapes (ASC site, AH site, and AP site) include Megalaimidae, Charadriidae, Alcedinidae, Ploceidae, Pycnonotidae, Dicruridae, Corvidae, and Sturnidae (Table 1).

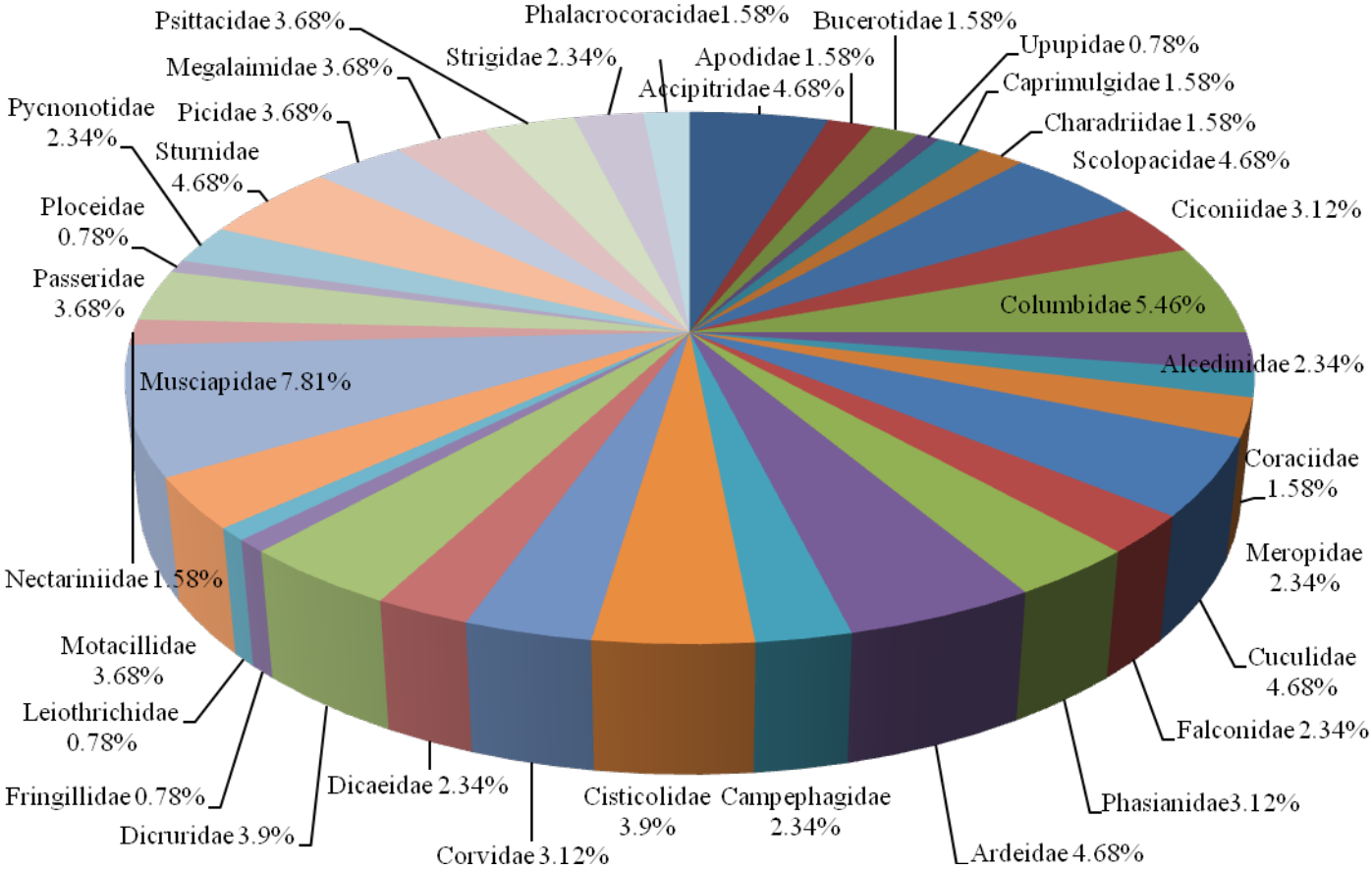

Image 4: Different families of Avian Fauna

Table 2 and Image 3 present the diversity of avian species in three different landscapes: Agro-Silvi-Culture (ASC), Agro-Horticulture (AH), and Agro-Pasture (AP). The measurement of alpha diversity (α), which refers to the diversity within habitats, yielded values of 95 (74.21%), 115 (89.84%), and 109 (85.15%) for each respective landscape. On the other hand, beta diversity (β), which represents the diversity between habitats, was observed at 20 (1.56%), 06 (0.46%), and 15 (11.71%) for the three landscapes, respectively. The overall avian species present in all habitats, known as gamma diversity (γ), was estimated to be 128.

Table 4 illustrates a comparative analysis of the avian species found in the three designated study regions (ASC site, AH site, and AP site). The data indicates that the highest bird abundance was observed in the agro pasture areas (71.55%) across three distinct categories (common, fairly common, and uncommon). It was noted that a majority of migratory birds were sighted in the AH region (15.78%) in comparison to the other study sites. Additionally, ASC site documented the highest number of common bird species, while AH site had the most unique bird sightings. In contrast, a comparative analysis of resident and migratory birds across all three study sites revealed that AP site had the largest population of resident birds (87.15%). In addition, ASC site had the highest number of uncommon bird species (12.63%) recorded, with the least uncommon bird sightings reported in AH site (10.43%). In terms of IUCN status, 91.57% of the least common birds were recorded in ASC site, while the highest number of common birds was found in AP site (94.49%). Further analysis revealed that the most critically endangered birds were found in 1.83% of AP site, while most near threatened birds were estimated in ASC site (5.26%). Conversely, the least critically endangered were observed in ASC site (1.05%) and near threatened bird species were observed in AP site (3.66%). Vulnerable bird species were most prevalent in ASC site (2.10%) and least prevalent in AH site (0.86%).

Table 4: Comparisons of different study site in different aspect

	Abundance status			R/M Status		IUCN Status			
Agro forest sites	Common	Fair Common	Uncommon	Residential	Migrant	Least Common	Critical Endangers	Near Threatened	Vulnerable
ASC	65.26%	22.20%	12.63%	84.21%	15.78%	91.57%	1.05%	5.26%	2.10%
AH	71.30%	18.26%	10.43%	86.95%	13.04%	93.04%	1.73%	4.34%	0.86%
AP	71.55%	16.51%	11.92%	87.15%	12.84%	94.49%	1.83%	3.66%	0.91%

4. Conclusion

A total of 128 bird species related to 35 families and 17 orders were identified in the agro-forest landscape of the study area. The study included both permanent and migratory bird species, showcasing the diverse avian community adapted to the agro-forestry environment. The research highlighted the importance of agro-forestry areas in providing habitat for bird species, emphasizing the valuable ecological services offered by these landscapes. The study area exhibited a rich avian diversity, indicating the significance of agro-forestry systems in supporting bird populations in semi-urban regions. These findings underscore the importance of agro-forestry areas in promoting avian diversity and conservation efforts in the semi-urban landscape of Chinor tehsil in Gwalior district.

Human activities and urbanization can have significant impacts on the biodiversity conservation of bird species in semi-urban areas. Urbanization often leads to habitat destruction and fragmentation, resulting in the loss of natural habitats for bird species. This can disrupt breeding grounds, foraging areas, and migration routes, ultimately reducing the available habitat for birds. Human activities in urban areas can contribute to pollution, including air and water pollution, which can have adverse effects on bird populations. Pollution can affect the quality of habitats, food sources, and nesting sites, leading to declines in bird diversity and abundance. Urbanization can facilitate the introduction and spread of invasive species, which can outcompete native bird species for resources and habitat. Invasive species can disrupt ecosystems and negatively impact the survival of native bird populations. Urban areas are characterized by

high levels of noise and light pollution, which can disturb bird behavior, communication, and navigation. These disturbances can affect breeding success, foraging patterns, and overall fitness of bird species in semi-urban environments. Human activities such as land development, deforestation, and agriculture can modify natural habitats, altering the availability of food, shelter, and nesting sites for birds. Changes in habitat structure can impact the diversity and distribution of bird species in semi-urban areas. Overall, human activities and urbanization can pose significant challenges to the conservation of bird species in semi-urban areas by altering habitats, introducing threats, and disrupting ecological processes essential for avian diversity and sustainability.

Agro-forestry techniques provide various ecological services for avian fauna in the study area of Chinor tehsil in Gwalior district. These services play a crucial role in supporting bird populations and promoting biodiversity conservation. Agro-forestry systems create diverse habitats by integrating trees, shrubs, and agricultural crops. This variety of vegetation provides nesting sites, shelter, and food sources for a wide range of bird species, enhancing habitat availability for avian fauna. Agro-forestry landscapes offer a diverse array of food resources for birds, including fruits, seeds, insects, and other invertebrates. The presence of different plant species in agro-forestry systems supports a rich food web, catering to the dietary needs of various bird species. Trees and shrubs in agro-forestry areas serve as important nesting sites for birds. The structural diversity of vegetation in these landscapes provides suitable locations for birds to build nests, lay eggs, and raise their young, contributing to successful breeding and population maintenance. Agro-forestry systems promote biodiversity by creating interconnected habitats that support a variety of plant and animal species. The presence of diverse vegetation types in these landscapes enhances species richness and fosters ecological interactions, benefiting avian fauna and overall ecosystem health. By integrating trees with agricultural practices, agro-forestry techniques enhance ecosystem stability and resilience. The presence of trees helps regulate microclimatic conditions, improve soil health, and mitigate environmental stressors, creating a more sustainable environment for bird species to thrive. Overall, agro-forestry techniques play a vital role in providing essential ecological services for avian fauna in the study area, contributing to habitat quality, food availability, nesting opportunities, biodiversity conservation, and ecosystem sustainability.

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