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Cover: Indian Grey Wolf *Canis lupus pallipes* and Smooth-coated Otter *Lutrogale perspicillata* sharing the territory in Chambal basin. Digital art on Procreate by Aakanksha Komanduri.

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ARTICLE

Avian community structure in a human-impacted forest landscape: insights from Amangarh Tiger Reserve, Uttar Pradesh, India

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Abstract: Habitat degradation and loss due to anthropogenic pressures are the primary threats to biodiversity, particularly in tropical forests. Monitoring bird communities provides valuable insights into the environmental status of both natural and human-modified ecosystems. In this study (February–April 2021), the point count method was used to assess avian species richness, diversity, and density in Amangarh Tiger Reserve (ATR)—a human-impacted forest area, aiming to understand its ecological importance and conservation potential. A proportionately stratified random sampling strategy was used for point count surveys across multiple habitat types. Species were identified, counted, and categorised by feeding guilds, and diversity indices were calculated. Bird density was calculated using Distance 7.3 software. A total of 110 bird species were recorded, indicating noteworthy species richness. Mixed forest exhibited the highest diversity, richness, and density (2029.7 birds/km², 95% CI: 1732.2–2378.2), likely due to its structural complexity. In contrast, teak plantations supported the lowest bird diversity, likely due to monoculture and low structural complexity. The riverbed had the lowest richness and density (1038 birds/km², 95% CI: 245.9–4381.1). Insectivores were the most abundant group, suggesting good ecological integrity of the region. This study highlights the ecological value of ATR for avian conservation, particularly the role of habitat heterogeneity and its mixed forests. Long-term monitoring is necessary to guide conservation planning and maintain the stability of bird communities in human-impacted landscapes such as ATR.

Keywords: Avian density, avian diversity, avian richness, biodiversity, birds, community ecology, distance sampling, feeding guilds, habitat heterogeneity, point count.

Abbreviations: ATR—Amangarh Tiger Reserve | CR—Carnivore | EN—Endangered | FR—Frugivore | GR—Granivore | IN—Insectivore | LC—Least Concern | NC—Nectivore | NT—Near Threatened | OM—Omnivore | PI—Piscivore | VU—Vulnerable.

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Author contributions: VPS conceived the study, designed the study, conducted the fieldwork, analysed the data, and prepared the initial manuscript. SR contributed to study design and conducted the fieldwork. MA contributed to study design and field supervision. SK contributed to statistical analysis, writing, supervision and manuscript review. AK contributed to study design, Supervision, data interpretation, and critical revision of the manuscript.

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INTRODUCTION

Birds are a highly diverse and widely distributed group of vertebrates, with more than 11,000 species found globally (BirdLife International 2023; Clements et al. 2023; Rheindt et al. 2025). India harbours remarkable avian diversity, supporting around 12% of the world's bird species (Praveen & Jayapal 2025). This remarkable avian diversity can largely be attributed to India's diverse landforms, vast altitudinal gradient, and highly varied climatic conditions, which give rise to a wide range of vegetation types and environments in the country. Birds inhabit a diverse range of environments and play a crucial role in ecosystem functioning, including pollination, seed dispersal, pest control, and nutrient cycling, making them vital components of biodiversity (Sekercioglu 2006).

Forest landscapes are undergoing rapid changes due to various anthropogenic activities, leading to modifications in vegetation structure and loss of biodiversity (Morris 2010; Haddad et al. 2015; Brancalion et al. 2025; Yang et al. 2025). Monitoring human-impacted forest landscapes is crucial for understanding the effects of these disturbances on natural ecosystems and for implementing effective corrective measures. Due to their sensitivity to environmental changes and wide distribution, birds are effective and reliable indicators of environmental health and stability and are frequently used to monitor ecosystem health (Canterbury et al. 2000; Mansfield et al. 2024; Naveen et al. 2026; Njuguna et al. 2026). Monitoring bird communities provides valuable insights into ecological dynamics and the impacts of anthropogenic pressures on natural ecosystems in a specific area; therefore, understanding the structure of bird communities is crucial for long-term environmental conservation (Gregory & Van Strien 2010; Byju et al. 2026). Species richness, abundance, and community composition are key characteristics of communities that ecologists often examine (Magurran 2004). Another important approach to understanding bird community structure is based on their feeding guilds and habitat use (Thiollay 1995; Clough et al. 2009). A guild is a fundamental concept in avian ecology, referring to a group of bird species that coexist within a community by utilising similar types of environmental resources (Balestrieri et al. 2015). Different guilds exhibit distinct tolerance thresholds and resource utilisation strategies that are shaped by the specific environmental conditions they inhabit. These variations are largely governed by multiple biotic and abiotic factors, including food availability, vegetation structure, habitat complexity, and the presence or absence of predators and competitors. Such ecological parameters play a crucial role in determining the distribution, abundance, and functional roles of guild members within an ecosystem (Katuwal et al. 2016; Mathibalan et al. 2026).

Despite their importance in monitoring the health of ecosystems, there is a notable lack of comprehensive scientific studies on birds in the human-impacted forests, especially in the Terai Arc Landscape. This landscape harbours exceptionally rich avifauna — for example, 330 species recorded in Dudhwa National Park (Javed & Rahmani 1998), and over 400 species in Terai Arc protected areas (Safi et al. 2024). However, most ornithological accounts from the Terai region have been limited to species checklists or opportunistic sightings, documenting presence but not quantifying population densities or spatial patterns. Consequently, robust studies estimating bird abundance using standardised methods, such as point counts or line transects, remain scarce, leaving critical gaps in conservation planning (Kidwai et al. 2013). Amangarh Tiger Reserve (ATR), which forms a multiple-use zone of the Corbett Tiger Reserve, is subject to various anthropogenic pressures, including livestock grazing, fuelwood extraction, and the collection of non-timber forest products by locals (Reza et al. 2024). Despite high anthropogenic pressures, ATR remains a significant forest landscape, serving not only as an important area for tiger conservation but also as a refuge for a wide range of other wildlife species, including avifauna, mammals, reptiles, and insects (Reza et al. 2024). Important mammalian species of ATR include Leopard *Panthera pardus*, Rusty-spotted Cat *Prionailurus rubiginosus*, Asian Elephant *Elephas maximus*, Sambar *Rusa unicolor*, and Chital *Axis axis*, among others. Considering its ecological value, it is an ideal site for initiating bird monitoring and ecological studies. The present study aims to assess the bird community structure in the ATR, focusing on species richness, diversity, abundance, and density. The research seeks to enhance the understanding of the bird community of the region and contribute to broader conservation initiatives.

Study Area

The study was conducted in the ATR, spanning over an area of 80.60 km^2. The reserve is located in the Bijnor district of Uttar Pradesh (Image 1). The ATR was originally part of Corbett National Park before the state of Uttar Pradesh was bifurcated. Following the bifurcation of Uttar Pradesh, a major part of Corbett National Park became part of Uttarakhand, while the

Amangarh range remained within the state of Uttar Pradesh. In 2012, the Amangarh range of Bijnor Forest Division was designated as a buffer zone of the Corbett Tiger Reserve, thereby integrating the area into the tiger reserve. Biogeographically, ATR is part of the regional subdivision (Terai Bhabar tract) of the Upper Gangetic Plains, a low-lying land stretch along the sub-Himalayan Shivalik ridges (Rodgers & Panwar 1988). The prominent vegetation in the Terai region is tropical moist deciduous forest (Champion & Seth 1968; Rodgers & Panwar 1988). The ATR vegetation can be further categorised into the following types: Sal-dominated forest, Teak plantation, mixed forest, grassland, and scrubland. The terrain is mainly plain with a mean elevation of 290 m (ranging 246–373 m), rarely becoming undulating in certain areas. The area has three major seasonal rivers and many small water channels, which become active during the monsoon and feed water to the area.

A land cover map of the ATR was prepared using a Landsat 8 (ESRIGRID; projection, UTM; datum, WGS 1984; cell size 30 m) operational land imager (OLI) image acquired on 11.iii.2021. The OLI data were processed using ArcGIS Pro 10.8.2 software (Esri, 2021), and through supervised classification, six distinct habitat types were identified within the study area (Image 2).

Methods

The study was conducted between February and April 2021, using the Point Count method (Verner 1985) to collect data for bird diversity, community structure, and abundance estimates. This method involved monitoring birds at established fixed point count stations across various habitats within the study area. Point counts were conducted by a team of two to three observers at 0600–1100 h and 1500–1900 h, as bird activity is highest during these times (Rutt et al. 2023; Singer et al. 2025). After reaching a point count station, the team waited quietly for five minutes to allow birds disturbed by their presence to resume normal activity. This acclimatisation period minimised person-induced bias and ensured random distribution of birds around the point count station. Data were collected for all birds seen around the point count station over a 10-minute observation period. Data on bird species, flock size, and radial

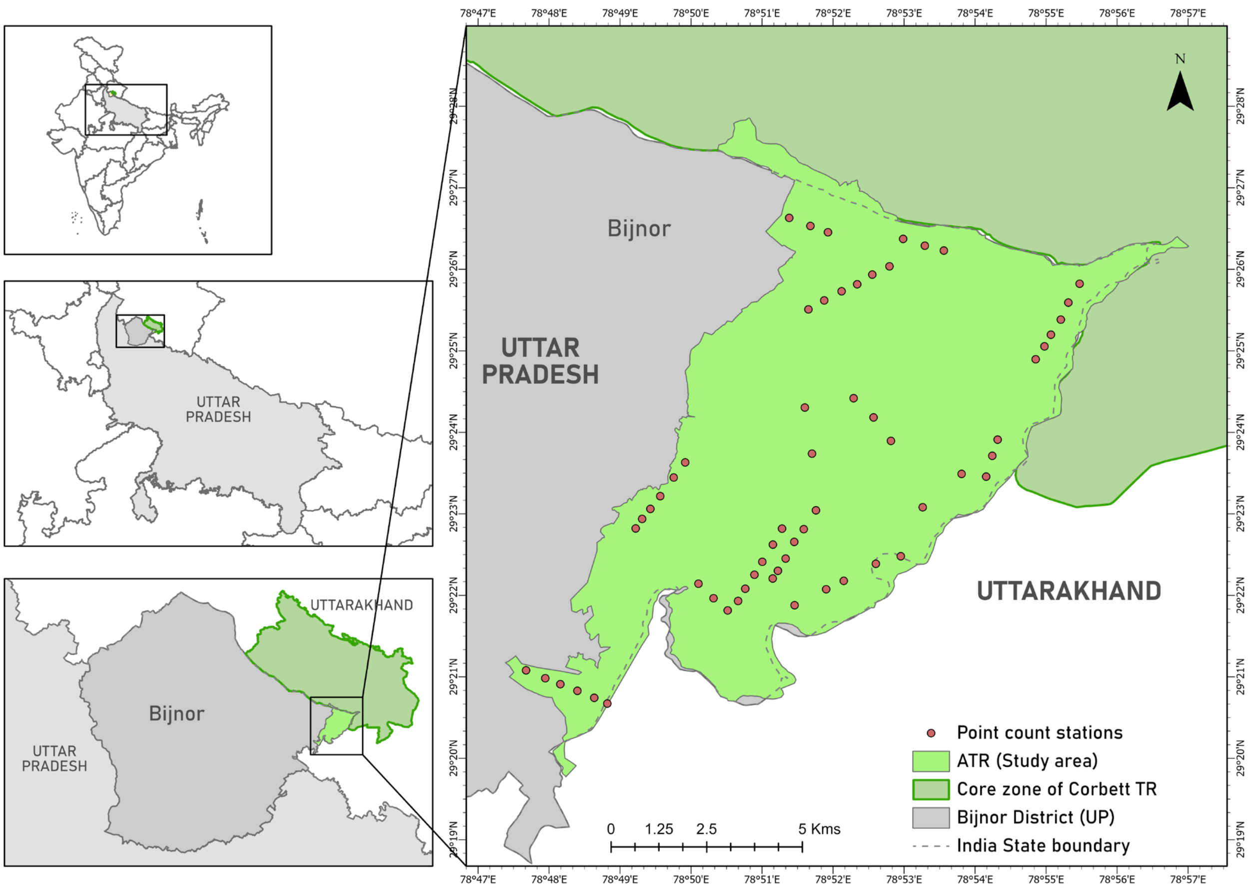

Image 1. Map of Amangarh Tiger Reserve and locations of point count stations.

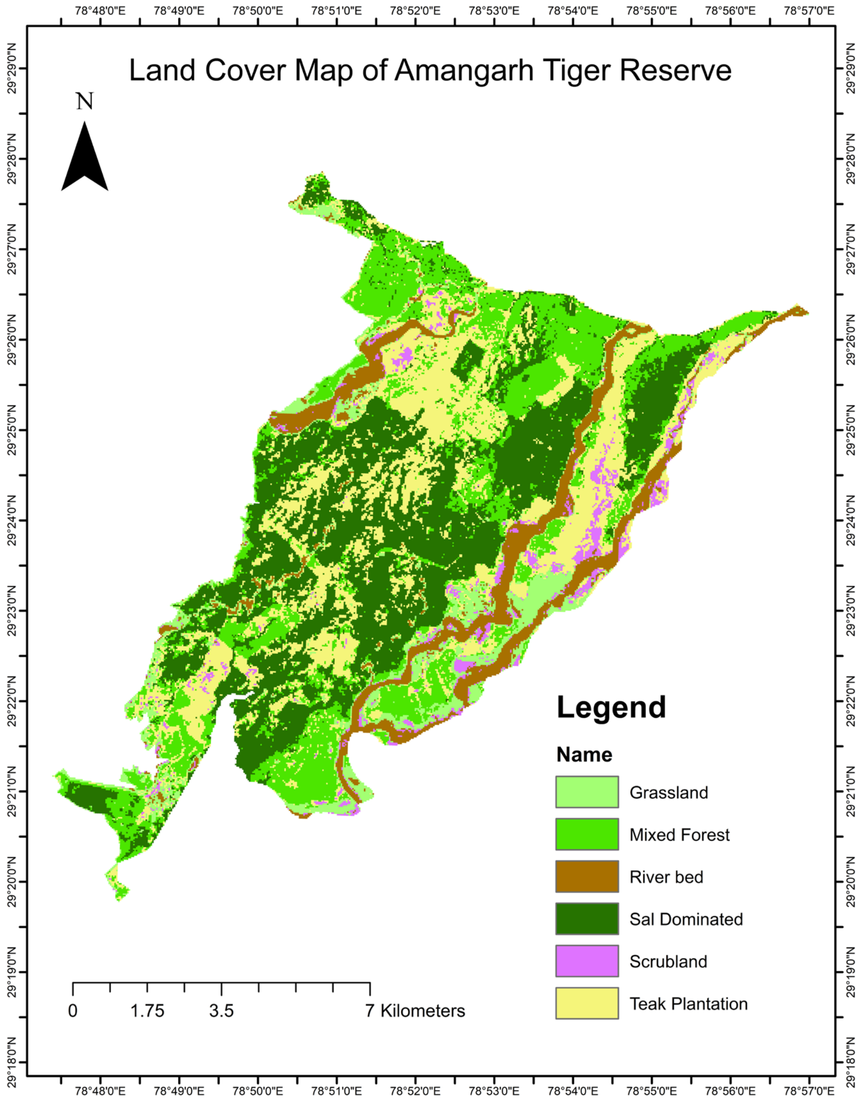

Image 2. Map showing land use land change of Amangarh Tiger Reserve.

distance (using an IR range finder) from the points were collected. Each point count station was monitored six times during the study period, three times during both evening and morning hours. Species identifications were performed by experienced observers using Grimmett et al. (2011) and Grewal et al. (2016).

A total of 60 points were laid using a stratified random sampling strategy across these six habitat types. The number of points in a particular habitat type was almost proportional to the area under that habitat type (Table 1). A minimum distance of 400 m was maintained between two adjacent points to ensure that bird detections from different points are statistically independent.

Bird density was determined using the software DISTANCE 7.3 (Thomas et al. 2010). Models with different combinations of key functions and series expansions were tried and the final model for the analysis was chosen based on Akaike's information criteria (AIC) values (Akaike 1974; Burnham & Anderson 2002), and chi-square statistics were used to determine the 'goodness of fit' of each function (Burnham et al. 1980; Buckland et al. 2001). Species diversity (Shannon-Wiener) and richness (Margalef) indices were calculated using software Past 4.03 (Paleontological Statistics Software package for education and data analysis, Hammer et al. 2001), while relative abundance and species occurrence were calculated using the following formulas:

$$\text{Relative abundance of a species} = \frac{\text{Total individuals of a species}}{\text{Total individuals of all species}} \times 100$$

$$\text{Occurrence of a species} = \frac{\text{Number of times a species recorded}}{\text{Total effort}} \times 100$$

Sixty point-count stations were monitored six times each, yielding a total effort of 360 point-count occasions. As data satisfied the assumptions of normality, a one-way ANOVA was performed to determine differences among habitat types for richness and diversity indices. Feeding guilds were determined using dietary information from EltonTraits 1.0 (Wilman et al. 2014). Species were categorised based on the predominant food items in their diet and grouped into major feeding guilds such as insectivores, frugivores, granivores, etc. In cases where no single food category was clearly dominant, species were classified into combined guilds.

Limitations of the study: The findings of the study should be interpreted in light of certain limitations. First, field surveys were conducted for a limited period and did not encompass all the seasons, particularly the monsoon season. As bird communities often exhibit seasonal variations in species composition and abundance due to migration and resource availability, the observed patterns may not fully represent avian diversity and population dynamics within the study area. Second, although distance sampling methods were employed to estimate bird density, detection probability may have varied among habitats. While the distance sampling framework accounts for imperfect detection and attempts to correct biases, residual errors associated with observer ability, vegetation density, species-specific detectability, and environmental conditions may still influence density estimates. Despite these limitations, the study provides valuable baseline information on avian diversity, community structure and density and establishes a foundation for future long-term and year-round monitoring efforts.

RESULTS

Avian diversity and ecological traits

A total of 110 species (109 identified and one unidentified) were recorded during the study, representing 14 orders and 45 families. The Passeriformes were the largest order, containing 61 bird species. Among families, Muscicapidae, with 10 species, emerged as the most species-rich family, followed by Picidae (9 species), Accipitridae (6 species), and Columbidae (6 species). The highest number of species was recorded in mixed forest (70 species), followed by Sal-dominated forest (61 species), while the minimum number of species (21 species) was recorded in riverbed (Table 2).

Among the recorded species, one species—Egyptian Vulture *Neophron percnopterus*—is 'Endangered'; two species—Great Hornbill *Buceros bicornis*, and Great Slaty Woodpecker *Mulleripicus pulverulentus* are 'Vulnerable'; two species—Cinereous Vulture *Aegypius monachus* and Red-breasted Parakeet *Psittacula alexandri*—are 'Near Threatened'; and the rest (104 species) are 'Least Concern'.

Categorisation of birds according to their feeding guilds showed that the majority of bird species belong to insectivores (n = 52, 46.85%), followed by omnivores (n = 20, 18.02%), frugivores (n = 12, 10.81%), granivores (n = 9, 8.11%), carnivores (n = 8, 7.21%), nectarivores (n = 2, 1.80%), and piscivores (n = 1, 0.90%). Five species belonged to multiple feeding guilds (Image 3).

Table 1. Proportion of different habitat types and sampling efforts in Amangarh Tiger Reserve.

Habitat type	Land cover area percentage (%)	No. of point count stations	Percentage of point count stations
Dry river	6.06	2	3
Grassland	5.26	2	3
Mixed forest	22.53	15	25
Sal dominated forest	32.10	24	40
Scrubland	10.16	4	7
Teak plantation	23.09	13	22

Bird density

Based on AIC values, the hazard-rate model with simple polynomial adjustment was selected for bird density estimation. The estimated bird density in the study area was 1,471 birds/km² (95% CI: 1313.6–1647.2), while the cluster density was 926.19 clusters/km² (95% CI: 828.7–1035.2), with a mean cluster size of 1.6 individuals and an effective detection radius (EDR) of 44.78 m (Table 3). Estimates of relative abundance and occurrence indicated that the Plum-headed Parakeet *Psittacula cyanocephala*, Rose-ringed Parakeet *Psittacula krameria*, and Yellow-throated Sparrow *Gymnoris xanthocollis* were the most common and abundant bird species in the study area (Table 4). The estimates of bird density in different habitat types showed that mixed forest had the highest density (2,029.7 birds/km², 95% CI: 1732.2–2378.2), followed by scrubland (1,928.6 birds/km², 95% CI: 1325.9–2805.1), whereas the lowest density (1,038.0 birds/km², 95% CI: 245.94–4381.1) was recorded in riverbed (Table 2).

Table 2. Density, diversity, and richness of birds across different habitat types in Amangarh Tiger Reserve.

Habitat type	No. of species recorded	EDR ± SE (m)	Density per sq km	95% Confidence interval	Diversity	Richness
Mixed forest	68	42.04 ± 0.83	2,029.7	1732.2, 2378.2	3.06	9.59
Sal dominated	60	44.50 ± 0.83	1,291.5	1075.2, 1551.3	2.47	8.29
Teak plantation	42	42.39 ± 1.06	1,243.2	985.35, 1568.7	1.88	6.48
Scrubland	32	47.68 ± 1.91	1,928.6	1325.9, 2805.1	2.79	5.29
Grassland	23	62.77 ± 2.89	1,082.0	663.40, 1764.9	2.64	4.34
River bed	20	50.74 ± 3.38	1,038.0	245.94, 4381.1	2.67	4.22

Table 3. Avian group density, average cluster size and overall density of birds in Amangarh Tiger Reserve.
D—estimate of density of birds | DS—estimate of density of clusters | EDR—effective detection radius | E(S)—estimate of expected value of cluster size.

Parameter	Point estimate	Standard error	Percent coef. of variation	95% Confidence interval	
DS	926.19	51.845	5.6	828.67	1035.2
E(S)	1.5882	1.71E-02	1.07	1.5551	1.622
D	1471	83.842	5.7	1313.6	1647.2
EDR	44.785	0.49015	1.09	43.834	45.757

Bird species diversity and richness

The overall Shannon-Wiener diversity and Margalef richness were 1.81 ± 0.06 SD and 2.72 ± 0.12 SD, respectively. Among the different habitat types, mixed forest had the highest diversity (3.06) and richness (9.59), while the lowest diversity (1.88) and richness (4.22) were recorded in teak plantations and riverbed, respectively (Table 2). An analysis of variance (ANOVA) revealed statistically significant differences among habitat types for species richness ($F(5,54) = 7.938$, $p = 1.16e-05$) and species diversity ($F(5,54) = 9.214$, $p = 2.19e-06$).

DISCUSSION

This study provides insights into the avian species richness, density, and feeding guilds of the ATR, emphasising the ecological significance of this human-impacted landscape for biodiversity conservation. The observation of 110 bird species (109 identified and one unidentified) within a relatively small area (80.60 km²) reflects considerable species richness, underscoring the importance of habitat heterogeneity in supporting avian biodiversity (Pineda-Diez de Bonilla et al. 2012). The availability of diverse habitat types, such as mixed forests, scrublands, and grasslands, provides a broad array of ecological niches, allowing various bird species with different habitat preferences and ecological requirements to thrive.

The presence of multiple feeding guilds (i.e., considerable functional diversity) can also be related to high habitat heterogeneity and the availability of diverse habitat types. The dominance of insectivores can be attributed to their adaptability and the high availability of insect prey in tropical landscapes (Pineda-Diez de Bonilla et al. 2012; Panda et al. 2021; Ahmad & Khan 2022**).** Abundance and diversity of insectivorous birds are also recognised as sensitive indicators of environmental health, as they rely on the complexity of vegetation and abundant insect populations (Kellermann et al. 2008). Empirical and experimental studies often associate these traits with greater temporal stability of ecosystem functions such as productivity, pest control, and nutrient cycling (Tilman 1996; Hooper et al. 2005; Nyffeler et al. 2018). Their high abundance in the ATR suggests that the area maintains a healthy trophic structure.

Results of diversity, richness, and density highlight the ecological value of mixed forest habitats, where the highest value of all three indices were recorded, likely due to their structural complexity. Various studies suggest that the abundance of forest birds is primarily driven by two distinct structural components: regenerating vegetation (a developing cohort of saplings, shrubs, and closing canopy) and legacy vegetation (retained biological structures such as large-diameter trees, snags,

Table 4. Relative abundance, occurrence, IUCN Red List status, and feeding guilds of birds recorded in Amangarh Tiger Reserve.

Order	Family	Common name	Scientific name	Relative abundance	Occurrence	IUCN Red List status	Feeding guild
Accipitriformes	Accipitridae	Changeable Hawk-Eagle	*Nisaetus cirrhatus*	0.03	0.28	LC	CR
		Cinereous Vulture	*Aegypius monachus*	0.06	0.56	NT	CR
		Crested Serpent Eagle	*Spilornis cheela*	0.38	3.61	LC	CR
		Egyptian Vulture	*Neophron percnopterus*	0.03	0.28	EN	CR
		Griffon Vulture	*Gyps fulvus*	0.03	0.28	LC	CR
		Crested Honey Buzzard	*Pernis ptilorhynchus*	0.03	0.28	LC	CR
		White-eyed Buzzard	*Butastur teesa*	0.06	0.56	LC	CR
Anseriformes	Anatidae	Green-winged Teal	*Anas crecca*	2.08	1.11	LC	OM
Bucerotiformes	Bucerotidae	Indian Grey Hornbill	*Ocyceros birostris*	3.44	23.33	LC	FR
		Great Hornbill	*Buceros bicornis*	0.29	1.39	VU	FR
		Oriental Pied Hornbill	*Anthracoceros albirostris*	0.23	1.11	LC	FR
Charadriiformes	Burhinidae	Indian Stone Curlew	*Burhinus indicus*	0.09	0.83	LC	CR
	Charadriidae	Red-wattled Lapwing	*Vanellus indicus*	0.2	1.94	LC	IN
		Yellow-wattled Lapwing	*Vanellus malabaricus*	0.35	3.06	LC	IN
Columbiformes	Columbidae	Common Emerald Dove	*Chalcophaps indica*	0.03	0.28	LC	FR
		Eurasian Collared Dove	*Streptopelia decaocto*	0.14	0.83	LC	GR
		Oriental Turtle Dove	*Streptopelia orientalis*	1.53	11.67	LC	GR
		Red Collared Dove	*Streptopelia tranquebarica*	0.09	0.83	LC	GR
		Spotted Dove	*Spilopelia chinensis*	3.07	28.06	LC	GR
		Yellow-footed Green Pigeon	*Treron phoenicopterus*	1.04	3.33	LC	FR
Coraciiformes	Alcedinidae	White-throated Kingfisher	*Halcyon smyrnensis*	0.09	0.83	LC	PI
	Coraciidae	Oriental Dollarbird	*Eurystomus orientalis*	0.03	0.28	LC	IN
		Indian Roller	*Coracias benghalensis*	0.67	5.56	LC	IN
	Meropidae	Blue-bearded Bee-eater	*Nyctyornis athertoni*	0.06	0.56	LC	IN
		Blue-tailed Bee-eater	*Merops philippinus*	1.39	10.28	LC	IN
		Chestnut-headed Bee-eater	*Merops leschenaulti*	0.2	1.94	LC	IN
		Asian Green Bee-eater	*Merops orientalis*	2.17	17.5	LC	IN
Cuculiformes	Cuculidae	Asian Koel	*Eudynamys scolopaceus*	0.06	0.56	LC	OM
Galliformes	Phasianidae	Grey Francolin	*Ortygornis pondicerianus*	0.4	1.67	LC	GR
		Indian Peafowl	*Pavo cristatus*	0.03	0.28	LC	OM
		Red Junglefowl	*Gallus gallus*	0.29	1.67	LC	OM
Gruiformes	Rallidae	White-breasted Waterhen	*Amaurornis phoenicurus*	0.03	0.28	LC	OM
Passeriformes	Acrocephalidae	Blyth's Reed Warbler	*Acrocephalus dumetorum*	0.32	1.11	LC	IN
	Aegithinidae	Common Iora	*Aegithina tiphia*	0.06	0.56	LC	IN
	Alaudidae	Ashy-crowned Sparrow-Lark	*Eremopterix griseus*	0.38	2.22	LC	GR
	Campephagidae	Indian Cuckooshrike	*Coracina macei*	0.06	0.28	LC	IN
		Long-tailed Minivet	*Pericrocotus ethologus*	0.38	0.56	LC	IN
		Rosy Minivet	*Pericrocotus roseus*	0.09	0.28	LC	IN
		Small Minivet	*Pericrocotus cinnamomeus*	0.09	0.56	LC	IN
	Chloropseidae	Golden-fronted Leafbird	*Chloropsis aurifrons*	0.03	0.28	LC	OM
	Cisticolidae	Ashy Prinia	*Prinia socialis*	0.09	0.83	LC	IN

Order	Family	Common name	Scientific name	Relative abundance	Occurrence	IUCN Red List status	Feeding guild
		Grey-breasted Prinia	*Prinia hodgsonii*	0.09	0.83	LC	IN
	Corvidae	House Crow	*Corvus splendens*	0.03	0.28	LC	OM
		Large-billed Crow	*Corvus macrorhynchos*	0.38	3.06	LC	OM
		Rufous Treepie	*Dendrocitta vagabunda*	0.64	5.83	LC	OM
	Dicaeidae	Pale-billed Flowerpecker	*Dicaeum erythrorhynchos*	0.09	0.83	LC	NT+FR
		Thick-billed Flowerpecker	*Pachyglossa agilis*	0.03	0.28	LC	NT+FR
	Dicruridae	Black Drongo	*Dicrurus macrocercus*	0.61	5	LC	IN
		Greater Racket-tailed Drongo	*Dicrurus paradiseus*	0.17	1.67	LC	IN
		Hair-crested Drongo	*Dicrurus hottentottus*	1.65	13.06	LC	IN
		White-bellied Drongo	*Dicrurus caerulescens*	0.17	1.67	LC	IN
	Estrildidae	Scaly-breasted Munia	*Lonchura punctulata*	0.03	0.28	LC	GR
	Fringillidae	Common Rosefinch	*Carpodacus erythrinus*	0.55	1.94	LC	GR
	Hirundinidae	Grey-throated Martin	*Riparia chinensis*	0.12	0.56	LC	IN
	Leiothrichidae	Jungle Babbler	*Argya striata*	3.5	13.33	LC	OM
	Locustellidae	West Himalayan Bush Warbler	*Locustella kashmirensis*	0.17	0.56	LC	IN
	Monarchidae	Indian Paradise Flycatcher	*Terpsiphone paradisi*	0.09	0.83	LC	IN
	Motacillidae	Grey Wagtail	*Motacilla cinerea*	0.03	0.28	LC	IN
		Tawny Pipit	*Anthus campestris*	0.06	0.56	LC	IN
		Paddyfield Pipit	*Anthus rufulus*	0.03	0.28	LC	IN
	Muscicapidae	Black Redstart	*Phoenicurus ochruros*	0.23	2.22	LC	IN
		Blue Whistling Thrush	*Myophonus caeruleus*	0.09	0.83	LC	OM
		Bluethroat	*Luscinia svecica*	0.09	0.83	LC	IN
		Grey Bush Chat	*Saxicola ferreus*	0.12	0.83	LC	IN
		Indian Robin	*Copsychus fulicatus*	0.26	2.5	LC	IN
		Oriental Magpie-Robin	*Copsychus saularis*	0.9	8.61	LC	IN
		Pied Bush Chat	*Saxicola caprata*	0.52	5	LC	IN
		Red-breasted Flycatcher	*Ficedula parva*	0.06	0.28	LC	IN
		Siberian Stonechat	*Saxicola maurus*	0.12	1.11	LC	IN
		White-rumped Shama	*Copsychus malabaricus*	0.03	0.28	LC	IN
	Nectariniidae	Crimson Sunbird	*Aethopyga siparaja*	0.12	1.11	LC	NC
		Purple Sunbird	*Cinnyris asiaticus*	1.71	12.22	LC	NC
	Oriolidae	Black-hooded Oriole	*Oriolus xanthornus*	0.87	7.5	LC	OM
		Indian Golden Oriole	*Oriolus kundoo*	0.09	0.56	LC	OM
		Maroon Oriole	*Oriolus traillii*	0.06	0.56	LC	FR
	Paridae	Cinereous Tit	*Parus cinereus*	0.93	8.06	LC	IN
	Passeridae	Yellow-throated Sparrow	*Gymnoris xanthocollis*	6.94	33.61	LC	GR
		House Sparrow	*Passer domesticus*	0.06	0.28	LC	OM
	Phylloscopidae	Blyth's Leaf Warbler	*Phylloscopus reguloides*	0.03	0.28	LC	IN
		Hume's Leaf Warbler	*Phylloscopus humei*	0.06	0.28	LC	IN
	Pycnonotidae	Black Bulbul	*Hypsipetes leucocephalus*	0.2	0.56	LC	FR+IN
		Black-crested Bulbul	*Rubigula flaviventris*	0.17	1.11	LC	FR+IN
		Himalayan Bulbul	*Pycnonotus leucogenys*	0.61	2.22	LC	FR+IN
		Red-vented Bulbul	*Pycnonotus cafer*	2.17	9.17	LC	OM
		Red-whiskered Bulbul	*Pycnonotus jocosus*	3.21	15	LC	OM

Order	Family	Common name	Scientific name	Relative abundance	Occurrence	IUCN Red List status	Feeding guild
	Sittidae	Chestnut-bellied Nuthatch	*Sitta cinnamoventris*	0.2	1.39	LC	IN
		Velvet-fronted Nuthatch	*Sitta frontalis*	0.06	0.56	LC	IN
	Stenostiridae	Grey-headed Canary-flycatcher	*Culicicapa ceylonensis*	0.12	1.11	LC	IN
	Sturnidae	Brahminy Starling	*Sturnia pagodarum*	0.84	3.33	LC	OM
		Chestnut-tailed Starling	*Sturnia malabarica*	0.32	0.83	LC	OM
		Common Myna	*Acridotheres tristis*	3.64	19.17	LC	OM
	Turdidae	Orange-headed Thrush	*Geokichla citrina*	0.06	0.56	LC	IN
	Zosteropidae	Indian White-eye	*Zosterops palpebrosus*	0.4	2.5	LC	IN
Pelecaniformes	Threskiornithidae	Red-naped Ibis	*Pseudibis papillosa*	0.2	1.11	LC	OM
Piciformes	Megalaimidae	Brown-headed Barbet	*Psilopogon zeylanicus*	2.28	20	LC	FR
		Coppersmith Barbet	*Psilopogon haemacephalus*	0.09	0.83	LC	FR
Piciformes	Picidae	Brown-capped Pygmy Woodpecker	*Yungipicus nanus*	0.14	1.11	LC	IN
		Fulvous-breasted Woodpecker	*Dendrocopos macei*	0.09	0.83	LC	IN
		Great Slaty Woodpecker	*Mulleripicus pulverulentus*	0.38	1.67	VU	IN
		Greater Flameback	*Chrysocolaptes guttacristatus*	0.17	1.39	LC	IN
		Himalyan Flameback	*Dinopium shorii*	0.2	1.67	LC	IN
		Black-rumped Flameback	*Dinopium benghalense*	0.55	5	LC	IN
		Rufous Woodpecker	*Micropternus brachyurus*	0.17	1.67	LC	IN
		Streak-throated Woodpecker	*Picus xanthopygaeus*	0.35	3.33	LC	IN
		White-naped Woodpecker	*Chrysocolaptes festivus*	0.12	1.11	LC	IN
Psittaciformes	Psittaculidae	Plum-headed Parakeet	*Psittacula cyanocephala*	32.65	174.44	LC	FR
		Rose-ringed Parakeet	*Alexandrinus Krameri*	8.39	42.22	LC	FR
		Alexandrine Parakeet	*Palaeornis eupatria*	0.06	0.28	LC	FR
		Red-breasted Parakeet	*Psittacula alexandri*	0.38	1.67	NT	FR
Unidentified	Unidentified	Unidentified		0.06	0.28		

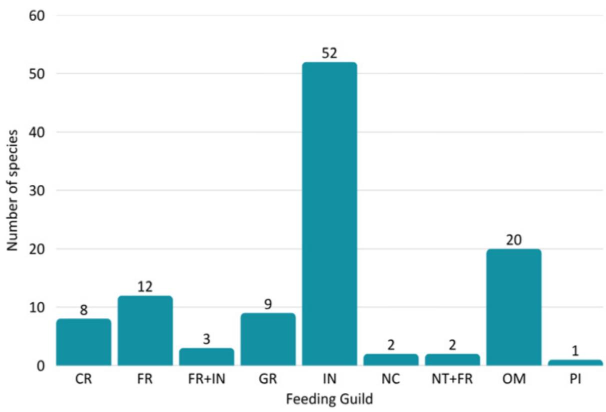

Image 3. Number of bird species belonging to different feeding guilds in Amangarh Tiger Reserve.
CR—Carnivore | FR—Frugivore | GR—Granivore | IN—Insectivore | NC—Nectivore | OM—Omnivore | PI—Piscivore.

and understory remnants) (Balestrieri et al. 2015, 2017; Czeszczewik et al. 2015; Basile et al. 2021). Mixed forests are structurally heterogeneous systems characterised by the regenerating understory layers (seedlings, saplings, and shrubs) and mature overstory trees (Gray et al. 2005; Hanle et al. 2020). Due to their high vegetation diversity, they offer more foraging opportunities, nesting sites, and microhabitats than other forest types. Additionally, vegetation complexity creates edge habitats, which tend to harbour more bird species due to the overlap of species from adjacent habitat types (Wiens 1989; Diaz 2006). Numerous studies have also highlighted that increased vegetation structure and plant diversity are strongly associated with richer and more abundant bird communities (Monkkonen 1994; Hobson & Bayne 2000a,b; Machtans & Latour 2003; Archana et al. 2024).

In contrast, the teak plantation had the lowest diversity, and the riverbed had the lowest richness and density. Teak plantations are typically monocultures with poor understory and low vegetation heterogeneity. Such structurally simplified and deciduous habitats offer fewer resources and nesting opportunities, leading to reduced avian diversity (Hartley 2002; Waltert et al. 2004). Additionally, teak forests (in the Terai) tend to lack native floral diversity, which can result in a decline in associated faunal communities, particularly specialists that depend on diverse plant-insect interactions. Riverbeds exhibited the lowest richness and density, likely because dry riverbeds generally have sparse or low vegetation (gravel, sand, and few shrubs) and no tall vegetation, offering few perches, nesting substrates, or cover. Additionally, open riverbed ground has an extreme microclimate (intense sun, heat, wind), and exposure to predators further reduces bird survival. Despite low bird richness and density, riverbeds contribute to landscape heterogeneity, further boosting the landscape-level diversity.

The abundance of generalist species, such as the Plum-headed Parakeet, in ATR indicates that some native birds are capable of adapting to human-modified environments, particularly when essential habitat features, such as food and nesting substrates, are retained. However, this also highlights the need to monitor less adaptable, specialist species, which may decline under increasing anthropogenic pressures.

Although this study establishes ATR as an ecologically important area for bird conservation, it also underscores the need for long-term monitoring to better understand temporal changes in bird communities and the impacts of human activities on biodiversity. Long-term studies would provide deeper insights into breeding patterns, seasonal migration, habitat utilisation, and the resilience of avian populations in the face of environmental change.

The present study provides quantitative estimates of avian densities within a largely understudied region of the Terai Arc Landscape. In addition, it establishes essential baseline information on the structure and composition of local bird communities and gives a comprehensive species checklist for ATR. The study also highlights the role of habitat heterogeneity in maintaining avian diversity, revealing both the conservation value of mixed forests and the limitations of monoculture teak plantations.

Based on the study findings and supporting field observations, several site-specific management interventions are recommended for ATR. Anthropogenic pressures such as livestock grazing, fodder, and fuelwood collection should be regulated to minimise habitat degradation and facilitate habitat recovery. Livestock grazing may be managed through rotational grazing practices and the promotion of stall feeding. Restoration of degraded forest patches through the planting of native mixed forest species should be prioritized to enhance structural complexity, improve resource availability, and support a diverse bird community. The management of riverine vegetation along streams and seasonal watercourses is equally important, as these habitats provide essential foraging, nesting, and refuge sites for numerous bird species. Furthermore, reducing dependence on forest resources through the promotion of alternative energy sources, energy-efficient cocking stoves, and livestock breed improvement initiatives could help in reducing fuelwood and fodder extraction pressures. Collectively, these measures would contribute to maintaining habitat heterogeneity and help conserve biodiversity in the area.

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