

Original Research Article

Urban Avifaunal Diversity in Bodoland Territorial Region (BTR), Assam, India

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Abstract: The diversity of bird species in the city is one of the indicators of the health of that ecosystem. Towns have been developing rapidly in District Headquarter towns of BTR. The avian community and especially the bird diversity have been the subject of interest for many researchers. The diversity and distribution of birds in urban areas of the BTR towns has not been studied yet. We surveyed District Headquarter towns of BTR — Kokrajhar, Kajalgaon, Mushalpur, Tamulpur and Udalguri from April 2022 to June 2024 to know the avifaunal diversity and seasonal occurrence of bird species in different urban habitats. The point count method was used which involved counting the individuals of each bird species for 5 minutes within a 30 metre radius inside a 500x500 square metre grid map. Grids were selected using stratified random sampling based on habitat proportions. Ninety-four bird species belonging to forty-four families and 74 genus were recorded. We recorded highest bird species (37) in the sub-urban areas. The overall Shannon-Wiener diversity index of urban birds in BTR District Headquarter towns was 3.84. There were significant differences in avifaunal diversity among five districts headquarter towns across all the seasons. However, seasonal bird diversity showed no significant differences across land-use zones in each district, except in the residential areas of Kajalgaon and Udalguri.

Keywords: Bird Diversity, Bodoland Territorial Region, Point count, Seasons, Urban.

Introduction

Urbanization is a fundamental environmental shift that is occurring globally at an accelerated rate now (Fontana *et al.*, 2011). It creates a foundation for stabilizing the composition of avian communities (Suhonen *et al.*, 2009). Urban environments have a unique chance to study the ecological effects of significant modifications in uses of land and interactions of living organisms facilitated by humans as they emerge globally (Lepczyk *et al.*, 2014). Diverse urban

environments' physical, biological, including social components makes it more difficult to manage and conserve biodiversity (Berkowitz, 2003). Urbanization, particularly in the context of mega cities was identified as important part of causing the natural environment destructions (Haedo *et al.* 2017; Álvarez & Fors, 2009). The harm caused by urbanization to biodiversity is evident (Huang *et al.*, 2015).

Urban creatures require ability to adapt with the impact of environmental shift (McDonald *et al.*, 2013). The composition and biodiversity of biotic communities in urban areas are changed by urbanization (Bonier *et al.*, 2007). A variety of wildlife also thrived outside their natural areas (Bolwig *et al.*, 2006; Hitchmough & Dunnett, 2004). Species assemblages fluctuate whenever urbanization changes habitat; while most species cannot survive in urban areas, others can survive and even flourish there (Bonier *et al.*, 2007). The need to comprehend how the environmental changes impact the ecological processes and biodiversity that are essential to preserving the comfort of mankind including the health in city environments have been emphasized (Pena *et al.*, 2017). Birds are commonly regarded as the best model group in cities for studying the ecological impacts of urbanization (McDonnell & Hahs, 2008) and serve as bioindicators of ecosystem health (Evans *et al.*, 2009; Strohbach *et al.*, 2009). Bird diversity in cities can equal to that of natural settings (Millard, 2008). The high diversity of birds is not only found in natural areas, but it can also be found in urban areas (Gilbert, 1989; Millard, 2008). There is a positive association in the quantity and the variety of bird species with human population (Luck, 2011).

With this background, we consider bird community as a model for studying their adaptation in urban settings. We studied bird diversity and richness in the district headquarters town of Bodoland Territorial Region (BTR), Assam, India. This is a pioneer study of its kind in BTR as urban avian diversity has not been previously studied. Further, we investigated the seasonal differences of bird diversity in different urban habitats, viz. Commercial areas, Residential areas, and Sub-urban areas.

Materials and Methods

Study area

We surveyed in the district headquarter towns of BTR (26°72' -26°47' N Latitude and 89°47' - 92°18' E longitude), Assam. It has five districts—Kokrajhar, Chirang, Baksa, Tamulpur and Udalguri (Fig. 1). On the north, the BTR shares

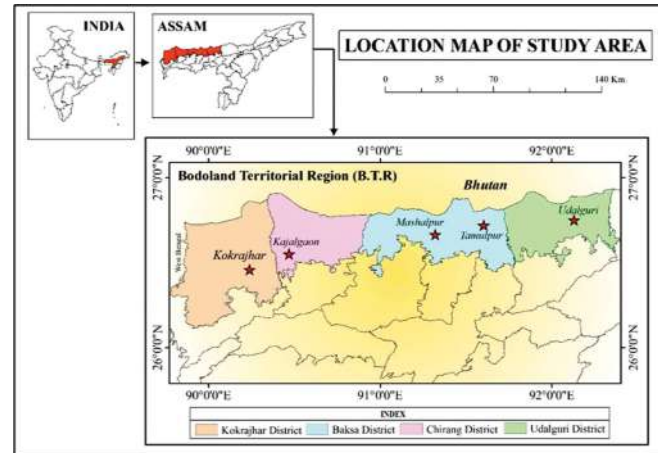


Fig. 1. Study area map of district headquarter towns of Bodoland Territorial Region.

international border with Bhutan. Kokrajhar lies in the Western most part of the region followed by Kajalgaon, Baksa, Tamulpur and Udalguri towards the East.

The district head quarter towns are Kokrajhar with 8.24 sq km (Kokrajhar district), Kajalgaon with 2.23 sq km (Chirang district), Mushalpur with 2.05 sq km (Baksa district), Tamulpur with 0.84 sq km (Tamulpur district) and Udalguri with 4.69 sq km (Udalguri district) (Figs. 2a through 2e). Among these, Kokrajhar is also capital town of the BTR. Except for Kokrajhar and Udalguri, other towns have emerged lately and their populations are less than the population of Kokrajhar town (34136 as per the 2011 census record). In fact, the three district head quarter towns have been developing built up areas of late.

For our research, we have divided each town into three distinct land-use zones on the basis of built up areas, vegetation cover and population density: Commercial Areas (CAs), Residential Areas (RAs), Sub-urban Areas (SUAs) (see also Nath *et al.*, 2019, 2022).

CAs are characterised by the presence of infrastructures like buildings, offices, market areas including shops, shopping complexes, restaurants, hotels, heavy traffics including railway station and bus terminals, and less green patches. Generally, CAs are thickly populated areas found in the core of the towns. RA includes households including both RCC buildings and Assam type houses, gardens and moderate

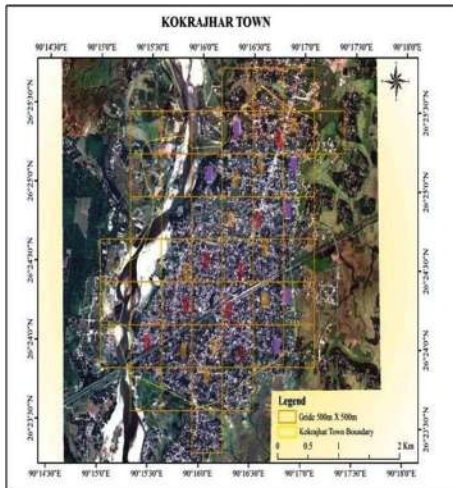


Fig. 2a.

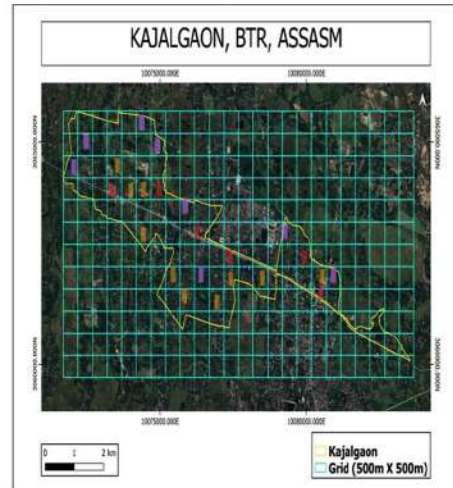


Fig. 2b.



Fig. 2c.

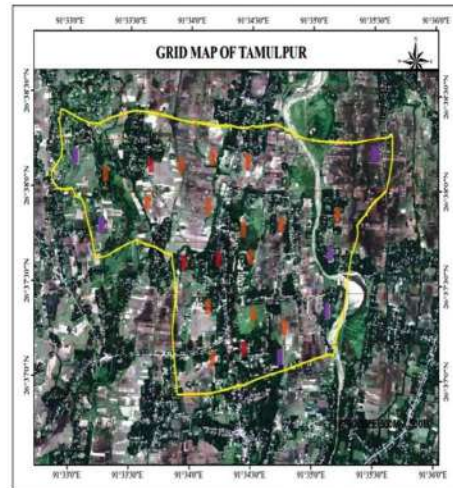


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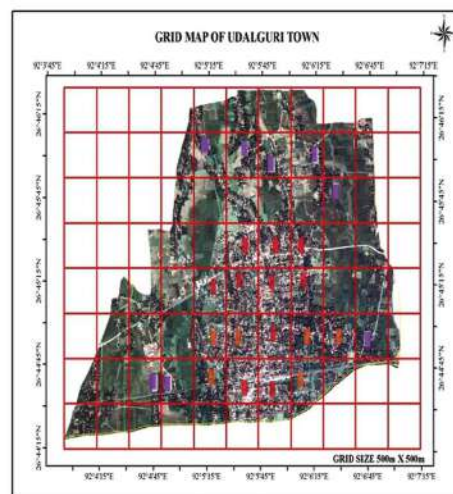


Fig. 2e.

Fig. 2. Grid maps of district headquarter towns of BTR, Assam (2a.Kokrajhar town; 2b. Kajalgaon town; 2c. Mushalpur town; 2d. Tamulpur town and 2e. Udalguri town). The markers show the stratified randomly selected grids: red = commercial areas, orange = residential areas, purple = sub-urban areas.

level of green patches. The SUA is the outer most land-use zones and located in the periphery of the towns. It consists of open areas, waterbodies, abundant green patches, and sparsely distributed houses.

Mushalpur and Tamulpur have more vegetation cover, particularly in the SUA than other towns.

Data collection

We made a grid map of 500 × 500 square metre and overlaid on the Google Earth map. We did stratified random sampling on the basis of three land-use zones, i.e., CAs, RAs and SUAs according to their share of proportion of grids in each town (Table 1). Thus there were 24 grids in each District Headquarter towns, and we randomly selected 24 points in each grid. We followed Point count method (Buckland et al., 2001) for the survey. Bird species and their number of individuals were recorded within a 30-meter radius over a 5-minute period. Observations were done early morning from 0600 to 0800 hours. We did not record the birds flying past overhead. We used a field guide book *Birds of the Indian Subcontinent* by Grimmet et al., (2016) to identify the bird species.

We collected the data seasonally (Pre-Monsoon from March to June, Monsoon from July to October & Post-Monsoon November to February) from the month of April 2022 to June 2024. Each point was surveyed once in a season, so twice in a year. Thus a total of 144 points were observed per District Headquarter town, and as a whole 720 points were surveyed in two years in BTR. The species accumulation curves of bird species in all the District headquarter towns revealed a comparable pattern of curves (Fig. 3). Species accumulation curves reached an asymptote, indicates that our sampling was adequate.

Statistical analyses

We used PAST 4.0 (Hammer et al., 2001) statistical software for analysing the data. The Shannon-Wiener diversity index of urban birds as a whole in entire district headquarter towns was calculated. We calculated the bird diversity index by the formula of Shannon-Wiener diversity index $H' = -\sum \pi_i \ln(\pi_i)$,

Table 1. Number of grids selected from different land-use zones in District Headquarter towns of

District HQ Towns	Land-use zones			Total
	Commercial	Residential	Sub Urban	
	Area	Area	Area	
Kokrajhar	8	10	6	24
Kajalgaon	7	12	5	24
Mushalpur	4	8	12	24
Tamulpur	9	5	10	24
Udalguri	11	5	8	24

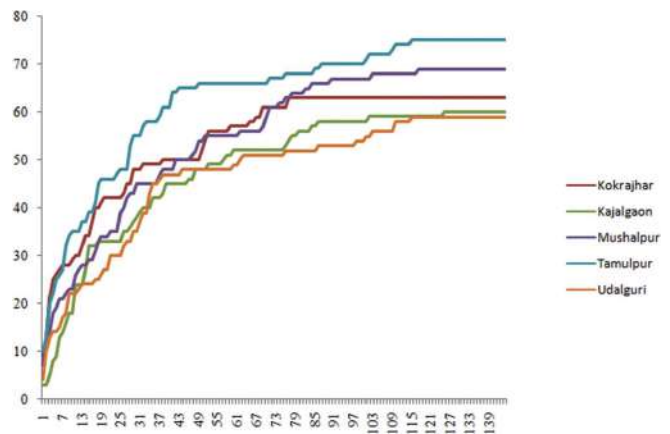


Fig. 3. Species accumulation curve of bird species recorded in District Headquarter towns of BTR Assam.

where H' represents species diversity index, \ln represents natural logarithm of species individual number, and π_i is the relative abundance of species (Shannon, 1948). We made a checklist of all the species of birds recorded during our survey for the BTR District Headquarter towns including IUCN category of conservation status. Two separate checklists on the basis of the availability of urban bird species in different BTR headquarter towns as well as in different habitats were also prepared. To check the significant differences of specific species of birds in BTR headquarter towns found among different habitats, Chi-square test was performed.

The frequency and relative abundance of all the species found were calculated with the formulae: Frequency = Number of visits in which a bird species was observed/Total number of visits × 100. This frequency was calculated collectively for all the district headquarter towns.

The species accumulation curve of birds was also plotted in the graphical form. Normal distributions of data were firstly checked. Since the data were normally distributed, one-way ANOVA was performed to check the significance in diversity of birds in commercial habitat; residential habitat and suburban habitat among different BTR headquarter towns. Further analysis was performed to know if there is any significant difference in the diversity of birds among different seasons in different places by one-way ANOVA.

Results

Ninety-four species of bird representing 44 families and 74 genus were found in BTR district headquarter towns of Assam (Table 2). Five species— *Acridotheres tristis*, *Acridotheres fuscus*, *Cypsiurus balasienis*, *Pycnonotus cafer* and *Passer domesticus* were common (100%) in urban areas. Ten species of birds were found to be winter migratory bird species: Citrine wagtail, White wagtail, Siberian stonechat, Common snipe, Chestnut-headed bee eater, Ashy drongo, Taiga flycatcher, Long-tailed shrike, Brown shrike, and Grey-headed canary flycatcher including four summer migratory bird species: Asian palm swift, Barn swallow, Common cuckoo and Asian koel. The overall Shannon-Wiener species diversity index (H') was 3.84. Among the recorded bird species, two species of parakeets—*Psittacula eupatria* and *Psittacula alexandri* were categorised as Near Threatened under the IUCN Red List, while the rest were classified as Least Concern.

Tamulpur town had the highest species of birds (75), followed by Mushalpur (69), Kokrajhar (63), Kajalgaon (60) and Udalguri (59) (Table 3). Forty-five species of birds were common to all the district headquarter towns. Some species of birds were specifically found only in particular towns and not found elsewhere. Tamulpur town hold the highest number of specific bird species (nine species: Yellow-bittern, Black-crowned night heron, Common snipe, Green-imperial pigeon, Hair-crested drongo, Zitting cisticola, Striated grassland, Verditer flycatcher and Baya weaver). Udalguri town contained the least number of specific bird species (two species: Plum-headed parakeet and Ashy-drongo).

It was found that CA had least number (four) of specific bird species: Black-kite, Oriental-turtle dove, Bank myna and Barred-cuckoo dove (Basumatary et al., 2024) than RA with six species (Common hill myna, Pale-billed flowerpecker, Taiga flycatcher, Grey-headed canary flycatcher, Crimson sunbird and Common wagtail) and SUA with 37 specific bird species (Table 4). Significantly more number of bird species that are found only in particular habitat was in SUA ($S_{c2} = 24.67$; $df = 2$; $p < 0.01$). Twenty-five species were common in all the three different habitats.

The Sorenson's similarity index was compared among different district headquarter towns (Table 5). The highest similarity was found between Kokrajhar and Kajalgaon (0.87) and the least similarity of urban birds was found between Kajalgaon and Udalguri (0.64).

The habitat-wise comparison of Shannon-Wiener diversity index of birds in all the three habitats of the district headquarter towns did not differ significantly among the seasons except for Kajalgaon ($F = 9.75$; $df = 2, 69$; $P = 0.01$) and Udalguri ($F = 7.60$; $df = 2, 27$; $P = 0.01$) in residential area (Tables 6 - 8).

However, there was significant difference in Shannon-Wiener diversity index among five district headquarter towns in all the seasons (Pre-Monsoon: $F = 2.85$; $df = 4, 235$; $P = 0.02$, Monsoon: $F = 5.31$; $df = 4, 235$; $P = 0.01$, and Post-Monsoon: $F = 7.16$; $df = 4, 235$; $P = 0.05$) (Table 9).

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Discussion

Recording of 94 species in district headquarter towns in BTR is remarkable from avian diversity point of view. As Shannon-Wiener value ranges from 1 - 5, the H' : 3.84 index of urban birds could be regarded as a good diversity index. Our result is higher than the findings by some researchers: H' : 2.52 in one of the urban areas in Kolkata (Sengupta et al., 2013); H' : 1.46 in built-up areas in

Table 2. Checklist of birds recorded in District Headquarter towns of BTR, Assam during April 2022 to June 2024(* = Near-Threatened; FQY= Frequency; RA= Relative abundance).

Family	Species	Scientific name	FQY	RA
Ciconiidae	Asian Openbill	<i>Anastomus oscitans</i>	33.33	0.003
Ardeidae	Yellow Bittern	<i>Ixobrychus sinensis</i>	3.33	0.001
	Cinnamon Bittern	<i>Ixobrychus cinnamomeus</i>	6.67	0.002
	Black-crowned Night Heron	<i>Gorsachius melanolophus</i>	3.33	0.001
	Indian Pond Heron	<i>Ardeola grayii</i>	80	0.018
	Cattle Egret	<i>Bubulcus ibis</i>	56.67	0.005
	Intermediate Egret	<i>Mesophoyx intermedia</i>	23.33	0.003
	Little Egret	<i>Egretta garzetta</i>	63.33	0.011
	Phalacrocoracidae	Little Cormorant	<i>Phalacrocorax niger</i>	73.33
Falconidae	Collared Falconet	<i>Microhierax caerulescens</i>	3.33	0.001
	Common Kestrel	<i>Falco tinnunculus</i>	3.33	0.001
Accipitridae	Black-winged Kite	<i>Elanus caeruleus</i>	13	0.002
	Black Kite	<i>Milvus migrans</i>	20	0.003
Rallidae	White-breasted Waterhen	<i>Amaurornis phoenicurus</i>	63.34	0.006
Charadriidae	Yellow-wattled Lapwing	<i>Vanellus malabaricus</i>	3.33	0.001
	Grey-headed Lapwing	<i>Vanellus cinereus</i>	10	0.002
	Red-wattled Lapwing	<i>Vanellus indicus</i>	20	0.003
Scolopacidae	Common Snipe	<i>Gallinago gallinago</i>	3.33	0.001
Columbidae	Green Imperial Pigeon	<i>Ducula aenea</i>	3.33	0.001
	Barred Cuckoo Dove	<i>Macropygia unchall</i>	3.33	0.001
	Eurasian Collared Dove	<i>Streptopelia decaocto</i>	70	0.008
	Spotted Dove	<i>Streptopelia chinensis</i>	93.33	0.056
	Oriental Turtle Dove	<i>Streptopelia orientalis</i>	10	0.002
	Yellow-footed Green Pigeon	<i>Treron phoenicopterus</i>	60	0.012
Psittaculidae	Red-breasted Parakeet*	<i>Psittacula alexandri</i>	3.33	0.001
	Plum-headed Parakeet	<i>Psittacula cyanocephala</i>	6.67	0.001
	Rose-ringed Parakeet	<i>Psittacula krameri</i>	56.67	0.011
	Alexandrine Parakeet*	<i>Psittacula eupatria</i>	50	0.010
Cuculidae	Indian Cuckoo	<i>Cuculus micropterus</i>	10	0.002
	Common Hawk Cuckoo	<i>Hierococcyx varius</i>	43.33	0.005
	Asian Koel	<i>Eudynamys scolopaceus</i>	80	0.008
	Greater Coucal	<i>Centropus sinensis</i>	3.33	0.001
Strigidae	Spotted Owlet	<i>Athene brama</i>	20	0.003
Apodidae	Asian Palm Swift	<i>Cypsiurus balasiensis</i>	100	0.014
Upupidae	Common Hoopoe	<i>Upupa epops</i>	10	0.002
Coraciidae	Indian Roller	<i>Coracias benghalensis</i>	16.17	0.003
Alcedinidae	Common Kingfisher	<i>Alcedo atthis</i>	3.33	0.001
	Pied Kingfisher	<i>Ceryle rudis</i>	6.67	0.002
	Stork-billed Kingfisher	<i>Pelargopsis capensis</i>	3.33	0.001
	White-throated Kingfisher	<i>Halcyon coromanda</i>	83.33	0.012
Meropidae	Chesnut-headed Bee-eater	<i>Merops leschenaultia</i>	10	0.002
	Green Bee-eater	<i>Merops orientalis</i>	36.67	0.003
Megalaimidae	Lineated Barbet	<i>Megalaima lineata</i>	30	0.003
	Blue-throated Barbet	<i>Megalaima asiatica</i>	96.67	0.013
	Coppersmith Barbet	<i>Megalaima emacephala</i>	73.33	0.009

Picidae	Fulvous-breasted Woodpecker	<i>Dendrocopos macei</i>	63.33	0.009
	Common Goldenback	<i>Dinopium javanense</i>	46.67	0.007
Artamidae	Ashy Woodswallow	<i>Artamus fuscus</i>	36.67	0.003
Laniidae	Brown Shrike	<i>Lanius cristatus</i>	66.67	0.007
	Long-tailed shrike	<i>Lanius schach</i>	36.67	0.003
Dicruridae	Black Drongo	<i>Dicrurus macrocercus</i>	90	0.011
	Lesser Racket-tailed Drongo	<i>Dicrurus remifer</i>	10	0.002
	Bronzed Drongo	<i>Dicrurus aeneus</i>	46.67	0.004
	Hair-Crested Drongo	<i>Dicrurus hottentottus</i>	3.33	0.001
	Ashy Drongo	<i>Dicrurus leucophaeus</i>	3.33	0.001
Rhipiduridae	White-throated fantail	<i>Rhipidura albicollis</i>	33.33	0.003
Oriolidae	Black-hooded Oriole	<i>Oriolus xanthornus</i>	80	0.009
Corvidae	Rufous Treepie	<i>Dendrocitta vagabunda</i>	53.33	0.005
	Large-billed Crow	<i>Corvus macrorhynchos</i>	80	0.009
	House Crow	<i>Corvus splendens</i>	90	0.011
Paridae	Great Tit	<i>Parus major</i>	90	0.010
Hirudinidae	Wire-tailed Swallow	<i>Hirundo smithii</i>	3.33	0.001
	Barn Swallow	<i>Hirundo rustica</i>	53.33	0.006
Pycnonotidae	Red-vented Bulbul	<i>Pycnonotus cafer</i>	100	0.344
Cisticolidae	Zitting Cisticola	<i>Cisticola juncidis</i>	3.33	0.001
	Common Tailorbird	<i>Orthotomus sutorius</i>	96.67	0.009
Locustellidae	Striated Grassbird	<i>Megaluru spalustris</i>	3.33	0.001
Phylloscopidae	Dusky Warbler	<i>Phylloscopus fuscatus</i>	50	0.005
	Greenish Warbler	<i>Phylloscopus trochiloides</i>	50	0.004
Leiothrichidae	Jungle Babbler	<i>Turdoides striata</i>	83.33	0.024
Zosteropidae	Oriental White-eye	<i>Zosterops palpebrosus</i>	56.67	0.006
Sittidae	White-tailed Nuthatch	<i>Sitta himalayensis</i>	3.33	0.001
Sturnidae	Common Hill Myna	<i>Gracula religiosa</i>	3.33	0.001
	Jungle Myna	<i>Acridotheres grandis</i>	100	0.025
	Bank Myna	<i>Acridotheres ginginianus</i>	16.67	0.002
	Common Myna	<i>Acridotheres tristis</i>	100	0.121
	Asian Pied Starling	<i>Gracupica contra</i>	80	0.059
	Chesnut-tailed Starling	<i>Sturnia malabarica</i>	90	0.029
Muscicapidae	Oriental Magpie Robin	<i>Copsychus sauluris</i>	90	0.016
	Common Stonechat	<i>Saxicola leucurus</i>	13.33	0.002
	Taiga Flycatcher	<i>Ficedula albicilla</i>	10	0.002
	Verditer Flycatcher	<i>Eumyias thalassinus</i>	6.67	0.001
Dicaeidae	Pale-billed flowerpecker	<i>Dicaeumerythro rhynchos</i>	3.33	0.001
Stenostiridae	Grey-headed Canary Flycatcher	<i>Culicicapa ceylonensis</i>	10	0.002
Nectariniidae	Purple-rumped Sunbird	<i>Leptocoma zeylonica</i>	34	0.003
	CrimsonSunbird	<i>Aethopyga siparaja</i>	43.33	0.007
	Purple Sunbird	<i>Cinnyris asiaticus</i>	30	0.006
Passeridae	Eurasian Tree Sparrow	<i>Passer montanus</i>	96.67	0.128
	House Sparrow	<i>Passer domesticus</i>	100	0.146
Ploceidae	Baya Weaver	<i>Ploceus philippinus</i>	6.67	0.001
Estrildidae	Scaly-breasted Munia	<i>Lonchura punctulata</i>	73.33	0.008
Motacillidae	Citrine Wagtail	<i>Motacilla citreola</i>	6.67	0.002
	White Wagtail	<i>Motacilla alba</i>	33.33	0.005
Campephagidae	Scarlet Minivet	<i>Pericrocotus speciosus</i>	3.33	0.001

Table 3. Occurrence of bird species in different Headquarter towns of BTR, Assam during April 2022 to June 2024.

Species	Kokrajhar	Kajalgaon	Mushalpur	Tamalpur	Udalguri
Asian Openbill	-	-	+	+	+
Yellow Bittern	-	-	-	+	-
Cinnamon Bittern	+	-	-	-	-
Indian Pond Heron	+	+	+	+	+
Black-crowned Night Heron	-	-	-	+	-
Intermediate Egret	-	-	+	+	+
Little Egret	+	+	+	+	+
Cattle Egret	+	+	+	+	+
Little Cormorant	+	+	+	+	+
Collared Falconet	-	+	-	-	-
Common Kestrel	-	-	+	-	-
Black-winged Kite	+	-	+	+	+
Black Kite	+	+	+	+	+
White-breasted Waterhen	+	-	+	+	+
Grey-headed Lapwing	-	-	+	+	-
Red-wattled Lapwing	-	-	+	+	+
Yellow-wattled Lapwing	-	-	+	+	-
Common Snipe	-	-	-	+	-
Green Imperial Pigeon	-	-	-	+	-
Barred Cuckoo Dove	+	-	-	-	-
Oriental Turtle Dove	-	-	+	-	-
Spotted Dove	+	+	+	+	+
Eurasian Collared Dove	+	+	+	+	+
Yellow-footed Green Pigeon	+	+	+	+	+
Rose-ringed Parakeet	+	+	+	+	+
Alexandrine Parakeet	+	-	+	+	-
Red-breasted Parakeet	-	+	-	+	-
Plum-headed Parakeet	-	-	-	-	+
Common Hawk Cuckoo	+	+	+	+	+
Indian Cuckoo	+	-	+	+	+
Asian Koel	+	+	+	+	+
Greater Coucal	-	+	-	-	-
Spotted Owlet	+	+	+	+	+
Asian Palm Swift	+	+	+	+	+
Common Hoopoe	+	+	+	+	+
Indian Roller	-	-	+	+	+
Pied Kingfisher	-	-	+	+	-
White-throated Kingfisher	+	+	+	+	+
Common Kingfisher	+	+	+	+	-
Stork-billed Kingfisher	-	-	+	-	-
Chestnut-headed Bee-eater	-	+	+	-	-
Green Bee-eater	+	+	+	+	+
Blue-throated Barbet	+	+	+	+	+
Lineated Barbet	+	+	+	+	-
Coppersmith Barbet	+	+	+	+	+
Fulvous-breasted Woodpecker	+	+	+	+	+

Common Goldenback	+	+	+	+	+
Ashy Woodswallow	+	+	+	+	-
Brown Shrike	+	+	+	+	+
Long-tailed shrike	+	+	+	+	+
Lesser Racket-tailed Drongo	-	-	-	+	+
Bronzed Drongo	+	+	+	+	-
Black Drongo	+	+	+	+	+
Hair-Crested Drongo	-	-	-	+	-
Ashy Drongo	-	-	-	-	+
Black-hooded Oriole	+	+	+	+	+
White-throated fantail	+	+	+	+	+
Rufous Treepie	+	+	+	+	+
Large-billed Crow	+	+	+	+	+
House Crow	+	+	+	-	+
Great Tit	+	+	+	+	+
Wire-tailed Swallow	-	-	+	-	-
Barn Swallow	+	+	+	+	+
Red-vented Bulbul	+	+	+	+	+
Zitting Cisticola	-	-	-	+	-
Common Tailorbird	+	+	+	+	+
Striated Grassbird	-	-	-	+	-
Dusky warbler	+	+	+	+	+
Greenish warbler	+	+	+	+	+
Jungle Babbler	+	+	+	+	+
Oriental White-eye	+	+	+	+	+
White-tailed Nuthatch	-	-	-	+	+
Bank Myna	+	-	-	-	-
Jungle Myna	+	+	+	+	+
Common Hill Myna	-	+	-	-	-
Common Myna	+	+	+	+	+
Asian Pied Starling	+	+	+	+	+
Chestnut-tailed Starling	+	+	+	+	+
Oriental Magpie Robin	+	+	+	+	+
Common Stonechat	-	+	-	-	-
Pale-billed Flowerpecker	+	-	-	-	-
Taiga Flycatcher	+	-	+	+	-
Verditer Flycatcher	-	-	-	+	-
Grey-headed Canary Flycatcher	+	-	-	-	-
Purple-rumped Sunbird	+	+	+	+	+
Crimson-Sunbird	+	+	+	+	+
Purple Sunbird	+	+	+	+	+
House Sparrow	+	+	+	+	+
Eurasian Tree Sparrow	+	+	+	+	+
Baya Weaver	-	-	-	+	-
Scaly-breasted Munia	+	+	+	+	+
Citrine Wagtail	+	+	-	-	+
White Wagtail	+	+	+	+	+
Scarlet Minivet	-	+	-	-	-

(Note: '+' represents presence and '-' represents absence of the species).

Table 4. Habitat-wise checklist of birds found in District Headquarters towns of BTR, Assam.

(Note: CA = Commercial area, RA = Residential area and SUA = Suburban area; '+' represents presence and '-' represents absence of bird species)

Species	CA	RA	SUA
Asian Openbill	-	-	+
Yellow Bittern	-	-	+
Cinnamon Bittern	-	-	+
Indian Pond Heron	-	-	+
Black-crowned Night Heron	-	-	+
Cattle Egret	-	-	+
Little Egret	-	-	+
Intermediate Egret	-	-	+
Little Cormorant	-	-	+
Collared Falconet	-	-	+
Common Kestrel	-	-	+
Black-winged Kite	-	+	+
Black Kite	+	-	-
White-breasted Waterhen	-	-	+
Yellow-wattled Lapwing	-	-	+
Grey-headed Lapwing	-	-	+
Red-wattled Lapwing	-	-	+
Common Snipe	-	-	+
Green Imperial Pigeon	-	-	+
Barred Cuckoo Dove	+	-	-
Spotted Dove	+	+	+
Oriental Turtle Dove	+	-	-
Eurasian Collared Dove	+	+	+
Yellow-footed Green Pigeon	-	+	+
Alexandrine Parakeet	-	-	+
Rose-ringed Parakeet	-	+	+
Red-breasted Parakeet	-	-	+
Plum-headed Parakeet	-	-	+
Common Hawk Cuckoo	-	-	+
Indian Cuckoo	-	-	+
Asian Koel	-	+	+
Greater Coucal	-	-	+
Spotted Owlet	-	+	+
Asian Palm Swift	+	+	+
Common Hoopoe	-	+	+
Indian Roller	-	-	+
White-throated Kingfisher	+	+	+
Common Kingfisher	-	+	+
Stork-billed Kingfisher	-	-	+
Pied Kingfisher	-	-	+
Chestnut-headed Bee-eater	-	+	+
Green Bee-eater	-	+	+
Blue-throated Barbet	+	+	+
Lineated Barbet	+	+	+

Coppersmith Barbet	-	+	+
Fulvous-breasted Woodpecker	-	+	+
Common Goldenback	-	+	+
Ashy Woodswallow	-	+	+
Brown Shrike	+	+	+
Long-tailed shrike	-	+	+
Lesser Racket-tailed Drongo	-	-	+
Black Drongo	+	+	+
Bronzed Drongo	-	-	+
Hair-Crested Drongo	-	-	+
Ashy Drongo	-	-	+
Black-hooded Oriole	-	+	+
White-throated fantail	-	+	+
House Crow	+	+	+
Rufous Treepie	-	-	+
Jungle Crow	+	+	+
Great Tit	+	+	+
Barn Swallow	+	+	+
Wire-tailed Swallow	-	-	+
Red-vented Bulbul	+	+	+
Zitting Cisticola	-	-	+
Common Tailorbird	+	+	+
Striated Grassbird	-	-	+
Dusky warbler	-	-	+
Greenish warbler	-	-	+
Jungle Babbler	-	+	+
Oriental White-eye	-	+	+
White-tailed Nuthatch	-	-	+
Bank Myna	+	-	-
Jungle Myna	+	+	+
Common Hill Myna	-	+	-
Common Myna	+	+	+
Chestnut-tailed Starling	+	+	+
Asian Pied Starling	+	+	+
Oriental Magpie Robin	+	+	+
Common Stonechat	-	-	+
Pale-billed flowerpecker	-	+	-
Taiga flycatcher	-	+	-
Verditer flycatcher	-	-	+
Grey-headed Canary Flycatcher	-	+	-
Purple-rumped Sunbird	-	+	+
Crimson-Sunbird	-	+	-
Purple Sunbird	+	+	+
Eurasian Tree Sparrow	+	+	+
House Sparrow	+	+	+
Baya Weaver	-	-	+
Scaly-breasted Munia	+	+	+
Citrine Wagtail	-	+	-
White Wagtail	+	+	+
Scarlet Minivet	-	-	+

Table 5. Sorenson's similarity index of bird species recorded in BTR District Headquarter towns.

Study sites	Kokrajhar	Kajalgaon	Mushalpur	Tamulpur	Udalguri
Kokrajhar	-	0.87	0.80	0.78	0.84
Kajalgaon	0.87	-	0.83	0.74	0.64
Mushalpur	0.80	0.83	-	0.82	0.81
Tamulpur	0.78	0.74	0.82	-	0.85
Udalguri	0.84	0.64	0.81	0.85	-

belonging to SUA, particularly in Mushalpur and Tamulpur might have an impact of recording some species that are not obligatory to urban habitat, and some species were recorded only in these towns. We did not record House Crow in Tamulpur. Kaur & Khera (2020) observed that House Crow has become fewer prevalent in some areas of Punjab, India. However, the causes for the absence and in less number in both the areas are not the

Table 6. Shannon-Wiener diversity index of urban birds in Commercial areas (CA) in five District Headquarter towns in the BTR in different seasons and results of one-way ANOVA, to check the significant differences among seasons.

DHQ town	Pre-Monsoon	Monsoon	Post-Monsoon	Results of ANOVA
Kokrajhar	2.57	2.43	2.38	F = 0.65; df = 2, 45; P = 0.52
Kajalgaon	2.27	2.38	2.49	F = 1.03; df = 2, 39; P = 0.36
Mushalpur	1.99	2.03	2.05	F = 2.47; df = 2, 21; P = 0.11
Tamulpur	2.81	2.83	2.78	F = 0.27; df = 2, 51; P = 0.76
Udalguri	2.22	2.22	2.24	F = 0.99; df = 2, 63; P = 0.38

Table 7. Shannon-Wiener diversity index of urban birds in Residential areas (RA) in five District Headquarter towns in the BTR in different seasons and results of one-way ANOVA, to check the significant differences among seasons.

DHQ town	Pre-Monsoon	Monsoon	Post-Monsoon	Significance
Kokrajhar	2.72	2.65	2.62	F = 1.93; df = 2, 55; P = 0.16
Kajalgaon	2.21	2.22	2.25	F = 9.75; df = 2, 69; P = 0.01*
Mushalpur	2.70	2.71	2.73	F = 0.28; df = 2, 45; P = 0.76
Tamulpur	2.27	2.28	2.26	F = 0.13; df = 2, 27; P = 0.88
Udalguri	2.71	2.71	2.73	F = 7.60; df = 2, 27; P = 0.01*

*significant

Table 8. Shannon-Wiener diversity of urban birds in Sub-urban areas (SUA) in five District Headquarter towns in the BTR in different seasons and results of one-way ANOVA, to check the significant differences among seasons.

DHQ town	Pre-Monsoon	Monsoon	Post-Monsoon	Significance
Kokrajhar	2.95	2.81	2.86	F = 0.63; df = 2, 35; P = 0.54
Kajalgaon	3.03	3.12	3.04	F = 1.57; df = 2, 27; P = 0.23
Mushalpur	3.05	3.12	3.07	F = 0.60; df = 2, 69; P = 0.55
Tamulpur	2.94	2.92	2.91	F = 0.07; df = 2, 57; P = 0.93
Udalguri	2.92	2.95	3.04	F = 1.66; df = 2, 45; P = 0.20

Rwanda (Gatesire *et al.*, 2014); and H': 2.71 in urban area of Jamshedpur (Verma & Murmu, 2015). In urban areas the diversity of bird species might also be more like the diversity of natural forests (Gatesire *et al.*, 2014). However, not all these towns are in true sense fully urban in nature having more vegetation cover in the SUAs. This green cover and proportionately the larger area

same. These towns combine components of the natural and man-made realms, might be the cause, allowing a wider array of bird species thrive here. The towns are covered in a high percentage of green space, rivulet, wide open fields covered in grass, buildings, bridges, shops, institutions and a dense canopy of large tree species (Fig. 2). Within the urban environments the presence of natural

Table 9. Results of one-way ANOVA for Shannon-Wiener diversity index of urban birds in different seasons among District Headquarter towns of BTR.

DHQ town/ Seasons	Kokrajhar	Kajalgaon	Mushalpur	Tamulpur	Udalguri	Significance
Pre-Monsoon	3.80	3.83	3.67	3.81	3.77	F = 2.85; df = 4, 235; P = 0.02*
Monsoon	3.78	3.77	3.81	3.79	3.73	F = 5.31; df = 4, 235; P = 0.01*
Post-Monsoon	3.76	3.78	3.76	3.77	3.79	F = 7.16; df = 4, 235; P = 0.05*

*significant

compositions supports significant places for survival of wildlife (Jokimaki *et al.*, 2018). On the contrary, Udalguri town had more built-up areas and very less urban composition and mosaicism in the town that might have affected the bird diversity. The thick population density, built up areas and presence of invasive species are the characteristics that have been linked to decreased bird diversity (Gagne *et al.*, 2016; Kang *et al.*, 2015; Latta *et al.*, 2013; Luck *et al.*, 2013). Houses and diversity of bird species were negatively correlated (Sengupta *et al.*, 2013). Similar results that the species diversity decreases with the increase in developed areas were found by Hunter (2007) and Blair & Launer (1997).

We found that 46 species were common to all the district headquarter towns; among which five species were recorded in every survey. Aronson *et al.* (2014) studied in 54 sites of urban areas worldwide and found that House sparrow, Barn swallow, Rock pigeon and Common starling were the most common. From our study and Aronson *et al.* (2014) it appears that House Sparrow represents the commonest urban bird species. Although we recorded the Barred-cuckoo dove among the four species that occurred specifically in CA, it was only a stray record, as the species was observed only once. It is specifically a forest bird (Grimmet *et al.*, 2016), and it is the only record of this species in Kokrajhar town (Basumatary *et al.*, 2024). In our study, CAs had least number of bird species whereas, SUAs had highest number of bird species which might be due to more mosaicism of habitat in the SUA as compared to CA (Fig 2a through 2e). The findings of 26 bird species in all the three different habitats is quite similar with the findings of Sengupta *et al.* (2013) where they compared the presence of bird species in rural and urban area and found that the omnivore bird species were present in both the habitats. La Sorte & McKinney (2007) and

Clergeau *et al.* (2006) also found only least species were found to survive in highly urbanized area. Thirty-nine species that were recorded only in SUA, might be the because of green spaces to support higher diversity and resources for various bird species (Carvalho & Toledo, 2021). Bhatt & Joshi (2011) found more diversity of bird species in rural habitat compared to non-rural areas. Fontana *et al.* (2011) and Guo *et al.* (2019) found positive correlation with green vegetation.

Karjee *et al.* (2022) found significant differences in the bird richness and abundance seasonally; winter being the highest among three seasons: summer, winter and monsoon. However, we did not find difference in bird diversity indices among three seasons, i.e., pre-monsoon, monsoon and post-monsoon in our study which might be due to more number of resident bird species

Although the study was conducted in urban area, the finding of two Near-Threatened bird species—Alexandrine Parakeet and Red-breasted Parakeet is quite notable. Similar to our study, Kale *et al.* (2018) also found two Near Threatened species—Pallid Harrier and the Alexandrine Parakeet both in rural and industrial areas.

Though Kokrajhar and Udalguri, the similar looking towns had high similarity index (0.84), but it was higher in case of Udalguri and Tamulpur (0.85), which are different in built up areas and vegetation cover. The similarity of species diversity did not follow any trend among the towns. The locations of the towns also did not have any ecological gradients to follow. However, the change of species availability along the urban gradients (Verma & Murmu, 2015). Bhatt & Joshi, (2011) also found differences in bird species similarities between low and high gradients.

Urban sites had been shown to promote survivability to species of birds that are endangered (Lepczyk *et al.*, 2017).

Some birds have been reported to be adaptable to urban environments despite of human interference (Guo *et al.*, 2019). Towns also serve as important sites for conservation of threatened species (Jokimaki *et al.*, 2018). The general interpretation of the results is that urban birds favour larger land patterns with varying degrees of urban mosaic design. They tend to assemblage according to their habitat preferences within the urban gradients. Sub-urban areas supported more number of bird species as compared to Residential and Commercial areas. The findings of two Near-Threatened species and holding ninety-seven species of birds as a whole within BTR District Headquarter towns stresses the needs of conservation efforts within the towns. By implementing proper strategies in conserving bird species might be helpful in maintaining the conservation continuously within the urban habitats. According to Sandstrom *et al.*, (2006), a sustainable urban landscape's ecological dimension must be maintained through a well-functioning network of green space. Tree diversity and availability have been given importance for preserving avian diversity in urban areas because they reduce the impact of noise pollution and give birds a place to live (Pena *et al.*, 2017).

Our study is the pioneer study of its kind in BTR, which has created a baseline database of urban avian diversity. Therefore, the same study should be repeated at regular interval with the changes in the environmental factors and land use and land cover patterns.

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