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Comparative nesting strategies of birds in high versus low vegetation areas

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Abstract

The present study assessed avian nesting site preferences in agricultural landscapes with high and low vegetation across three locations in Ludhiana district, Punjab, during 2023-2025, revealing a strong and consistent influence of vegetation structure on nesting diversity and stability. Fields retaining high vegetation supported substantially greater species richness and a wider range of nesting guilds, utilizing trees, shrubs, cavities, grasses, ground sites, water-edge vegetation, and man-made structures, whereas low-vegetation fields were uniformly dominated by a few generalist and disturbance-tolerant species relying on sheds, isolated trees, or open ground. Among the study sites, Sahauli exhibited the highest nesting diversity and inclusion of specialized guilds such as pendant and grass nesters, followed by Dhaipai and Jodhan, reflecting site-specific differences in habitat complexity. High-vegetation fields also showed greater inter-annual stability in nesting activity, emphasizing their role as reliable breeding habitats. Overall, the findings demonstrate that retention of on-farm trees, shrubs, and semi-natural vegetation is essential for maintaining avian nesting diversity and breeding stability in intensively managed agricultural landscapes of central Punjab.

Keywords: Agricultural landscape, breeding, habitat complexity, nesting, tree species, vegetation

1. Introduction

Birds, in particular, are closely tied to the structure and condition of farmland. Fields with substantial vegetation cover often provide birds with more than just space—they offer shelter, concealment, and access to food. Dense crop growth, field margins, hedgerows, and cover crops can create microhabitats that protect nests from predators and buffer them from extreme temperatures. Such structural diversity not only reduces disturbance but also tends to support higher insect abundance, which is critical during the breeding season (Bas *et al.*, 2009a; Best *et al.*, 1997; Edo *et al.*, 2024) ^[1, 3, 8]. As a result, these more complex agricultural settings frequently sustain greater nesting densities, higher species richness, and improved reproductive outcomes compared to simplified fields.

Intensively managed fields are characterized by bare soil or uniform monocultures often leave birds exposed. In such environments, nests may be more visible to predators and more vulnerable to weather extremes. Ground-nesting species are particularly at risk because they depend heavily on vegetation for camouflage and thermoregulation (Lauck *et al.*, 2023a; Blosch *et al.*, 2023a) ^[13, 5]. Across different regions of the world, studies consistently demonstrate that habitat heterogeneity and vegetation structure are central to avian reproductive success. Fallow lands and structurally diverse crop fields tend to support more nests and a wider variety of species than intensively cultivated row crops (Tilgar *et al.*, 2024) ^[22]. Moreover, nesting strategy strongly influences how birds respond to agricultural practices: species that nest on the ground are generally more sensitive to habitat simplification than those nesting in shrubs or trees (Li *et al.*, 2023a) ^[15].

Despite this growing global understanding, region-specific research in South Asia remains limited. In the Indo-Gangetic Plains, particularly in Punjab, agricultural intensification has reshaped the rural landscape. Mechanization, widespread monocropping, removal of non-crop vegetation, and increasing input use have simplified field structure and reduced habitat diversity. Yet studies from nearby regions suggest that agricultural fields and surrounding heterogeneous elements—such as fallow patches, field margins, and rural infrastructure—still play an important role in maintaining avifaunal communities

(Mukhtar *et al.*, 2025; Kumar & Sahu, 2016) ^[19, 12].

Punjab's dominant rice-wheat rotation further influences seasonal vegetation patterns, often leaving fields with limited ground cover during critical breeding periods. Practices such as stubble burning and repeated tillage can intensify this effect, potentially threatening ground-nesting and low-vegetation-dependent species. Emerging evidence from neighboring areas also indicates that bird communities are shaped not only by crop type but by finer habitat features, including vegetation structure, field configuration, and even nearby cattle sheds (Grewal *et al.*, 2023) ^[9].

In one of India's most productive yet ecologically strained agroecosystems, understanding these dynamics is increasingly important. Exploring how birds select nesting sites in vegetated versus bare agricultural settings can provide valuable insights for balancing agricultural productivity with biodiversity conservation.

2. Methodology

2.1 Study area

The study was conducted in the agricultural landscapes by selecting fields in three villages namely Dhaipai (L1), Sahauli (L2) and Jodhan (L3) of district Ludhiana in Punjab, India, a region having intensive rice-wheat cropping systems. Mechanical and monoculture practices along with deforestation in agriculture in this region has created varying levels of vegetation structure across fields, ranging from densely or highly vegetated (HV) field area to low vegetated (LV) field area with minimal ground cover. To assess how vegetation influences avian nesting and breeding ecology, fields were categorized into two primary habitat types: (1) vegetated fields with substantial crop growth, field margins, or residual cover, and (2) simplified or bare fields with limited structural complexity or low vegetation. Surrounding habitat features like building structures were also noted.

2.2 Study design and nest searching

Fields were selected randomly at each location having representation of both high and low vegetation while maintaining spatial independence to reduce pseudo replication. Surveys were conducted during the primary breeding season (March to July), coinciding with peak

Nesting activity of farmland birds in northern India in 2022-23 and 2023-24. Nest searches were performed using line transect method; observers walked parallel transects spaced approximately 5-10 meters apart, carefully scanning for nesting activity in vegetated fields (Verner 1985) ^[23]. In low vegetation field areas, nests were located by visual observations. This combination of systematic searching and observation is widely used in farmland bird studies to maximize detection probability while minimizing disturbance (Best *et al.*, 1997; Bas *et al.*, 2009b) ^[3, 2]. Each nest was located and observed by minimizing disturbances; nests were approached cautiously for species identification and the nesting parameters like number of nests, nest height were recorded. Tree types preferred by birds for nesting sites were identified in studied fields.

2.3 Nest monitoring and breeding observations

Nests were monitored at intervals of five to seven days at studied locations. During each visit, clutch size, number of hatchlings, and chick development stage were recorded. Monitoring intervals were selected to balance data accuracy with minimal disturbance risk, consistent with established nest survival methodologies (Lauck *et al.*, 2023b; Blosch *et al.*, 2023b) ^[14, 5]. Nesting strategy (ground, shrub, or tree nesting) was documented for each species, given that ground-nesting birds are generally more sensitive to habitat features and agricultural intensification (Li *et al.*, 2023b) ^[16].

3. Results and Discussion

A total of 21 bird species were recorded nesting in agricultural fields with five species common to both high and low vegetation areas (Table 1 and 2). High vegetation fields had eleven tree species namely *Mangifera indica*, *Arecaceae* spp., *Acacia nilotica*, *Melia azedarach*, *Syzygium cumini*, *Morus alba*, *Eucalyptus globulus*, *Populus* spp., *Zizyphus mauritiana*, *Dalbergia sissoo*, *Ficus religiosa* including *Saccharum spontaneum*/wild grasses; in addition to possible nesting sites like shrubs around water body and man-made structures like sheds. These were utilized by bird species with different types of nesting requirements.

Table 1: Avian nesting site preferences in high vegetation agricultural fields at three selected locations in Ludhiana district during 2023-2025

S. No.	Species Name	Nesting site	Dhaipai (L1HV)		Sahauli (L2HV)		Jodhan (L3HV)	
			2023-24	2024-25	2023-24	2024-25	2023-24	2024-25
1.	Asian Koel	<i>Mangifera indica</i>	-	-	✓	✓	-	-
2.	Baya Weaver	<i>Arecaceae</i> spp.	-	-	✓	✓	-	-
3.	Black-winged Stilt	Ground nest	-	-	✓	✓	-	-
4.	Blue Rock Pigeon	Building structure	✓	✓	✓	✓	✓	✓
5.	Cattle Egret	<i>Acacia nilotica</i>	✓	✓	✓	✓	-	-
		<i>Melia azedarach</i>	-	-	-	-	✓	✓
6.	Common Moorhen	Ground nest	✓	✓	✓	✓	-	-
		<i>Acacia nilotica</i>	-	-	✓	✓	-	-
7.	Common Myna	<i>Melia azedarach</i>	✓	✓	✓	✓	✓	✓
		<i>Syzygium cumi</i>	-	-	✓	✓	-	-
8.	Eurasian Collared Dove	<i>Morus alba</i>	✓	✓	✓	✓	✓	✓
9.	House Crow	<i>Melia azedarach</i>	✓	✓	-	-	-	-
		<i>Eucalyptus globulus</i>	-	-	✓	✓	✓	✓
		<i>Populus</i> spp.	-	-	-	-	✓	✓
10.	Indian Peafowl	Shrubs	✓	✓	✓	✓	-	-
11.	Indian Silverbill	<i>Zizyphus mauritiana</i>	-	-	✓	✓	-	-

12.	Laughing Dove	<i>Morus alba</i>	✓	✓	-	-	-	-
		<i>Melia azedarach</i>	-	✓	-	-	✓	✓
		<i>Dalbergia sissoo</i>	-	-	-	✓	-	-
		Building structure	-	-	-	-	-	✓
13.	Pariah Kite	<i>Eucalyptus globulus</i>	-	-	✓	✓	-	-
14.	Purple Sunbird	<i>Acacia nilotica</i>	-	✓	✓	✓	-	-
		<i>Zizyphus mauritiana</i>	✓	✓	✓	✓	-	-
15.	Red-vented Bulbul	<i>Zizyphus mauritiana</i>	✓	✓	-	-	-	-
		<i>Melia azedarach</i>	-	-	-	-	✓	✓
16.	Red-wattled Lapwing	Ground nest	✓	✓	✓	✓	✓	✓
17.	Rose-ringed Parakeet	<i>Morus alba</i>	✓	✓	-	-	-	-
		<i>Dalbergia sissoo</i>	✓	✓	-	-	-	-
		<i>Mangifera indica</i>	-	-	✓	✓	-	-
		<i>Melia azedarach</i>	-	-	-	-	✓	✓
18.	Spotted Owllet	<i>Dalbergia sissoo</i>	✓	✓	-	-	✓	✓
		<i>Morus alba</i>	-	-	✓	✓	-	-
19.	Streaked Weaver	<i>Saccharum spontaneum</i>	-	-	✓	✓	-	-
20.	White-breasted Waterhen	Shrubs	✓	✓	-	-	-	-
		<i>Acacia nilotica</i>	-	-	✓	✓	-	-
21.	Yellow-legged Green Pigeon	<i>Ficus religiosa</i>	-	-	-	✓	-	-

High Vegetation denoted as HV

Table 2: Avian nesting site preferences in low vegetation agricultural fields at three selected locations in Ludhiana district during 2023-2025

S. No.	Species Name	Nesting site	Dhaipai (L1LV)		Sahauli (L2LV)		Jodhan (L3LV)	
			2023-24	2024-25	2023-24	2024-25	2023-24	2024-25
1.	Blue Rock Pigeon	Building structure	✓	✓	✓	✓	✓	✓
2.	House Crow	<i>Eucalyptus globulus</i>	-	-	✓	✓	✓	✓
		<i>Populus deltoides</i>	-	-	✓	✓	✓	✓
3.	Purple Sunbird	<i>Acacia nilotica</i>	-	✓	-	-	-	-
		<i>Zizyphus mauritiana</i>	-	-	✓	✓	-	-
4.	Red-wattled Lapwing	Ground Nest	✓	✓	✓	✓	✓	✓
5.	Rose-ringed Parakeet	<i>Melia azedarach</i>	-	✓	✓	✓	✓	✓

Low Vegetation denoted as LV

At L1HV in both the studied years, 14 species of birds were found nesting as compared to 4 species in L1LV. Out of these 14 species, there were 3 species of tree cavity nesters, one species of ground nester, 6 species of open nesters on trees and 2 species of water dependent birds, one species of shrub vegetation nester and one species using built structure to construct nest. Presence of Common Moorhen and White-breasted Waterhen highlighted that water bodies are integral part of agricultural landscapes. Most of species nesting in high vegetation agricultural fields was recorded in both study years indicating the temporal stability due to habitat features. This type of vegetation and habitat features enabled the coexistence of species with contrasting nesting preferences, such as cavity nesters (Common Myna, Rose-ringed Parakeet, Spotted Owllet), shrub and tree nesters (Purple Sunbird, Red-vented Bulbul), ground nesters (Red-wattled Lapwing), shrubs (Indian Peafowl) and water-associated breeders (Common Moorhen and White-breasted Waterhen).

The observations from L2HV during 2023-2025 showed the nesting of 20 bird species including 7 species (Asian Koel, Baya Weaver, Black-winged Stilt, Indian Silverbill, Pariah Kite, Streaked weaver and Yellow-legged Green Pigeon) found exclusively in the study area. There were generalist and disturbance-tolerant species such as Blue Rock Pigeon, House Crow, Purple Sunbird, Red-wattled Lapwing, and

Rose-ringed Parakeet in L2LV, which were dependent on man-made structures, isolated trees, or open ground for nesting.

At L3HV, there was recorded nesting of 10 species of birds which was comparatively lesser than L1HV and L2HV. Out of these 10 species, there were 5 species of open nesters on trees, 3 species of tree cavity nesters, one species of ground nester and one species using built structure to construct nest. In contrast, L3LV fields were dominated by a limited set of generalist species namely Blue Rock Pigeon, House Crow, Red-wattled Lapwing, and Rose-ringed Parakeet. Across all three study locations and over two consecutive breeding seasons in the present study, fields with high vegetation consistently supported significantly greater nesting species richness, a wider range of nesting structures. Low vegetation resulted in a sharp decline in nesting opportunities and led to the dominance of a few generalist species only.

In the study area, nesting of 21 avian species belonging to 10 orders was found. Majority of species were belonging to orders Passeriformes (7 species) and Columbiformes (4 species). Depending upon the types of nests, simple, closed and cup nests were made by 61.90, 14.29 and 4.76% bird species whereas 19.05% species were cavity nesters (Table 3).

Table 3: Avian species and their nest types observed at selected locations of Ludhiana from 2023-2025

S. No.	Species Name	Scientific Name	Order	Type of Nest			
				Simple	Closed	Cavity	Cup
1.	Asian Koel	<i>Eudynamys scolopacea</i>	<i>Cuculiformes</i>	✓	-	-	-
2.	Baya Weaver	<i>Ploceus philippinus</i>	<i>Passeriformes</i>	-	✓	-	-
3.	Black-winged Stilt	<i>Himantopus himantopus</i>	<i>Charadriiformes</i>	✓	-	-	-
4.	Blue Rock Pigeon	<i>Columba livia</i>	<i>Columbiformes</i>	✓	-	-	-
5.	Cattle Egret	<i>Bubulcus ibis</i>	<i>Pelecaniformes</i>	✓	-	-	-
6.	Common Moorhen	<i>Gallinula chloropus</i>	<i>Gruiformes</i>	✓	-	-	-
7.	Common Myna	<i>Acridotheres tristis</i>	<i>Passeriformes</i>	-	-	✓	-
8.	Eurasian Collard Dove	<i>Streptopelia decaocto</i>	<i>Columbiformes</i>	✓	-	-	-
9.	House Crow	<i>Corvus splendens</i>	<i>Passeriformes</i>	✓	-	-	-
10.	Indian Peafowl	<i>Pavo cristatus</i>	<i>Galliformes</i>	✓	-	-	-
11.	Indian Silverbill	<i>Euodice malabarica</i>	<i>Passeriformes</i>	-	-	✓	-
12.	Laughing Dove	<i>Spilopelia senegalensis</i>	<i>Columbiformes</i>	✓	-	-	-
13.	Pariah Kite	<i>Milvus migrans</i>	<i>Accipitriformes</i>	✓	-	-	-
14.	Purple Sunbird	<i>Cinnyris asiaticus</i>	<i>Passeriformes</i>	-	✓	-	-
15.	Red-vented Bulbul	<i>Pycnonotus cafer</i>	<i>Passeriformes</i>	-	-	-	✓
16.	Red-wattled Lapwing	<i>Vanellus indicus</i>	<i>Charadriiformes</i>	✓	-	-	-
17.	Rose-ringed Parakeet	<i>Psittacula krameri</i>	<i>Psittaciformes</i>	-	-	✓	-
18.	Spotted Owlet	<i>Athene brama</i>	<i>Strigiformes</i>	-	-	✓	-
19.	Streaked Weaver	<i>Ploceus manyar</i>	<i>Passeriformes</i>	-	✓	-	-
20.	White-breasted Waterhen	<i>Amaurornis phoenicurus</i>	<i>Gruiformes</i>	✓	-	-	-
21.	Yellow-legged Green Pigeon	<i>Treron phoenicoptera</i>	<i>Columbiformes</i>	✓	-	-	-

The comparative analysis of nesting and reproductive parameters at all the locations during 2023-2025 revealed noticeable variations in species distribution, nesting characteristics, and breeding success. Among the three study sites, L2 exhibited comparatively higher species richness and nesting activity, followed by L1, whereas L3 showed relatively moderate nesting density. Nest height variation was largely species-specific rather than strictly location-dependent; however, L2 recorded slightly greater average nest heights in canopy-nesting species such as House Crow and Pariah Kite, indicating the presence of relatively taller trees (Table 3). At all sites, tree-nesting species generally built nests at heights ranging from 3-5 m above ground level. In contrast, ground-nesting birds such as the Red-wattled Lapwing and Indian Peafowl nested directly on open land surfaces. The average clutch size remained relatively consistent among locations, typically ranging between 2-4 eggs, with only minor variations.

Reproductive success parameters further showed variation among the three locations. Hatching success was generally high (above 80%) for cavity and tree-nesting birds across all

sites, particularly in Rose-ringed Parakeet and Spotted Owlet, which demonstrated near-complete hatching success in multiple locations (Table 4). L2 exhibited comparatively higher overall hatching and fledgling success percentages for several species, including Baya Weaver and Purple Sunbird, indicating favourable breeding conditions. L1 showed stable and moderately high reproductive success in urban-adapted birds such as Blue Rock Pigeon and House Crow. Conversely, L3 recorded slightly reduced fledgling success in certain species, particularly among ground nesters.

Fledgling success trends indicated that arboreal and cavity-nesting species maintained higher survival rates (often above 80%) compared to ground nesters such as Red-wattled Lapwing, where fledgling success ranged between approximately 46-55% across sites. This trend suggests greater vulnerability to predation and anthropogenic disturbances in exposed habitats. Common Moorhen and White-breasted Waterhen demonstrated comparatively better reproductive performance in sites where water bodies were present in the vicinity, particularly in L2 and L1.

Table 4: Nesting parameters of different avian species at selected locations of Ludhiana from 2023-2025

S. No.	Name of Bird Species	Number of nests			Nest height (m)			Average Clutch size		
		Studied Locations								
Dhaipai	Sahauli	Jodhan	Dhaipai	Sahauli	Jodhan	Dhaipai	Sahauli	Jodhan		
1.	Asian Koel	-	2	-	-	6.50	-	-	2.00	-
2.	Baya Weaver	-	10	-	-	4.25	-	-	4.50	-
3.	Black-winged Stilt	-	2	-	-	-	-	-	3.50	-
4.	Blue Rock Pigeon	8	6	5	3.07	3.25	3.13	2.00	2.50	2.40
5.	Cattle Egret	9	10	7	3.85	4.25	3.75	3.00	3.50	3.40
6.	Common Moorhen	4	3	-	1.40	1.25	-	4.00	3.25	-
7.	Common Myna	4	7	5	4.65	4.50	4.25	4.00	3.75	4.00
8.	Eurasian Collared Dove	1	1	2	3.20	3.10	3.15	2.00	2.00	1.50
9.	House Crow	4	5	5	6.95	7.00	6.85	3.25	2.75	3.00
10.	Indian Peafowl	3	2	-	*	*	-	3.00	2.00	-
11.	Indian Silverbill	-	3	-	-	2.23	-	-	4.33	-
12.	Laughing Dove	4	3	3	4.15	3.75	3.50	2.00	2.25	2.00
13.	Pariah Kite	-	4	-	-	8.50	-	-	1.50	-
14.	Purple Sunbird	5	4	-	3.07	2.50	-	2.40	2.00	-
15.	Red-vented Bulbul	1	-	1	2.16	-	2.25	2.50	-	2.60
16.	Red-wattled Lapwing	8	6	5	*	*	*	3.50	4.00	3.75
17.	Rose-ringed Parakeet	5	6	5	4.90	4.65	4.75	3.75	3.50	3.80
18.	Spotted Owllet	1	1	1	3.80	3.50	3.75	3.00	3.50	3.00
19.	Streaked Weaver	-	3	-	-	1.77	-	-	3.00	-
20.	White-breasted Waterhen	1	2	-	1.50	1.50	-	4.00	3.50	-
21.	Yellow-legged Green Pigeon	-	1	-	-	3.25	-	-	2.00	-

* Indicates ground nest

Table 5: Reproductive success parameters of different avian species at selected locations of Ludhiana from 2023-2025

S. No.	Name of Bird Species	Incubation period (days)			Hatching success (%)			Fledgling success (%)		
		Studied Locations								
Dhaipai	Sahauli	Jodhan	Dhaipai	Sahauli	Jodhan	Dhaipai	Sahauli	Jodhan		
1.	Asian Koel	-	13.20	-	-	37.5	-	-	50.00	-
2.	Baya Weaver	-	14.50	-	-	85.00	-	-	90.00	-
3.	Black-winged Stilt	-	25.20	-	-	65.00	-	-	40.50	-
4.	Blue Rock Pigeon	16.00	15.80	16.20	75.00	78.00	72.50	75.00	80.00	70.00
5.	Cattle Egret	15.75	15.50	16.00	88.00	90.00	85.00	80.00	80.00	78.00
6.	Common Moorhen	17.25	17.30	-	86.00	88.00	-	92.50	95.00	-
7.	Common Myna	15.30	16.00	15.10	80.00	85.00	82.50	80.00	85.00	80.00
8.	Eurasian Collared Dove	14.10	14.00	13.80	100.00	95.00	90.00	50.00	55.00	55.00
9.	House Crow	16.00	15.80	16.20	80.00	82.00	78.00	92.00	94.00	88.00
10.	Indian Peafowl	17.00	17.20	-	85.00	82.00	-	80.00	85.50	-
11.	Indian Silverbill	-	13.70	-	-	88.00	-	-	83.00	-
12.	Laughing Dove	12.75	12.80	13.00	87.50	90.00	85.00	87.50	85.00	78.00
13.	Pariah Kite	-	30.00	-	-	70.00	-	-	65.00	-
14.	Purple Sunbird	12.60	12.40	-	93.00	95.00	-	83.00	88.00	-
15.	Red-vented Bulbul	12.00	-	12.80	100.00	-	95.00	100.00	-	85.00
16.	Red-wattled Lapwing	23.88	23.60	24.00	55.00	60.00	52.80	46.88	55.00	50.00
17.	Rose-ringed Parakeet	17.75	17.10	18.00	100.00	100.00	98.00	87.50	90.00	85.00
18.	Spotted Owllet	23.00	22.80	23.30	100.00	100.00	90.00	95.00	100.00	90.00
19.	Streaked Weaver	-	15.00	-	-	88.00	-	-	82.00	-
20.	White-breasted Waterhen	16.00	15.80	-	95.00	100.00	-	75.00	80.00	-
21.	Yellow-legged Green Pigeon	-	13.80	-	-	90.00	-	-	82.00	-

4. Discussion

The data has shown that agricultural fields with high vegetation and structural diversity supported higher number of avian species as compared to the low-vegetation fields at all the locations. It has indicated dependence of bird species on vegetation structures for nesting sites. Xu *et al* (2022) ^[25] observed that the tree diversity significantly affected bird diversity in urban mountain parks. Liu (2025) ^[17] had

observed that the vegetation structural complexity especially the dense tree canopy is an important deciding factor that influences the selection of nesting sites by birds. Structural heterogeneity in vegetation in different habitats often affects the abundance, distribution, diversity and richness of the bird community (Kukreti 2020) ^[11]. A positive correlation between plant species diversity, foliage high density and bird species diversity has been reported by many workers

(Joshi *et al.*, 2012) ^[10]. Spatial variation in nesting activity and species richness among the three locations can be attributed to differences in habitat heterogeneity and resource availability. Ecologically complex habitats with greater vegetation stratification are widely known to support higher avian diversity and breeding densities, as they provide a variety of nesting substrates and foraging opportunities (Tews *et al.*, 2004)^[21]. Studies have consistently shown that areas with higher structural diversity promote niche differentiation and reduce interspecific competition, thereby enhancing species coexistence and reproductive activity.

An ideal nesting site is a high-quality, strategic location that offers enhanced safety from predators, provides durable and stable materials for constructing a secure nest, and is in close proximity to abundant, nutrient-rich foraging habitats that facilitate successful rearing of the brood. The present study conclusively demonstrated that vegetation structure is the single most critical determinant of avian nesting diversity within agricultural landscapes of the Ludhiana region. Xu *et al.* (2024)^[24] also highlighted the critical role of dense canopy structure, including its horizontal and vertical distribution and variation, in predicting avian diversity. A comprehensive study by Ding *et al.* (2023)^[6] revealed no significant preference for specific tree species, but the height of tree and tree coverage appeared as the important factors influencing nest site selection. Variation in nest height, particularly among canopy-nesting species, reflects adaptive strategies to minimize predation risk and environmental stress. Elevated nesting in taller trees has been associated with reduced predation pressure and increased breeding success, especially in urban and semi-urban habitats.

Douini *et al.* (2023) ^[7] reported maximum number of nesting species belonging to order Passeriformes in the study area having dense vegetation, and the results are aligned with our findings in present study. Reproductive success in birds is heavily determined by the selection of safe nesting site, and several birds have been reported to choose those sites for nesting which reduce the risk of predation (Mainwaring *et al.*, 2014) ^[18]. Consequently, nesting strategy plays a critical role in determining reproductive success, with arboreal and cavity nesters generally exhibiting higher survival rates than ground nesters. Environmental conditions may influence survival rates of offspring, but clutch size itself tends to remain relatively stable unless extreme ecological pressures are present. Differences in hatching and fledgling success among locations highlight the role of habitat quality in determining reproductive outcomes. Higher reproductive success in favourable habitats is often linked to increased food availability, better nesting cover, and lower disturbance levels. The observed patterns reinforce the role of habitat structure and resource availability as key drivers influencing breeding outcomes across different landscapes.

5. Conclusion

Overall, the collective comparison indicates that L2 provided relatively more suitable breeding conditions in terms of vegetation diversity and habitat heterogeneity, followed by L1, while L3 showed comparatively moderate reproductive performance. Tree cavity nesters and colonial nesting species demonstrated greater reproductive stability across all sites, whereas ground-nesting birds remained

more susceptible to environmental pressures. These findings underscore the significant influence of habitat structure and protection status on nesting success and reproductive output of avian species in the study region.

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7. Declarations

The authors declare no competing interests.

Author contribution: The paper was conceived and designed by Tejdeep Kaur Kler and Nisha Vashishat. Both the authors have read and approved the final manuscript.

8. References

Here are your references formatted in the Vancouver style. Following your requirements: scientific names are in italics, journal names are in plain text, and full page ranges are provided where available.

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