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BIODIVERSITY PROFILE OF AVIAN FAUNA IN AN AGRO-ECOSYSTEM OF FAISALABAD

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Abstract

The study of avian fauna in their roosting sites is crucial for determining their status and sustainability in any habitat. This research investigated the biodiversity profile of four bird species—Rose-ringed Parakeet (Psittacula krameri), House Sparrow (Passer domesticus), House Crow (Corvus splendens), and Rosy Starling (Pastor roseus)—across eight tree species categorized by diameter at breast height (DBH) in an agro-ecosystem of Faisalabad, Pakistan. Over three months (March–May 2025 and 2025), systematic observations were conducted on trees with DBH <50 cm, 50–70 cm, and >70 cm. Pooled data showed that the highest roosting occurred in the 50–70 cm DBH class (total = 424 roosts), followed by <50 cm (360) and >70 cm (299). Salmalia malabarica supported the greatest number of roosts (n = 243), while Momordica charantia had the lowest (n = 52). ANOVA revealed significant differences among tree species ($F_{7,21}$ = 1.35, p = 0.039) and among bird species ($F_{3,21}$ = 5.16, p = 0.008). Tukey's HSD test showed that P. krameri (mean = 4.33) and C. splendens (mean = 3.53) were significantly more abundant than S. roseus (mean = 1.22). Results indicate that tree species and DBH are critical determinants of roosting site selection. Sustainable management of large, native trees is essential for maintaining avian biodiversity while mitigating crop damage by pest species. This study provides baseline data for integrated pest management and conservation planning in the region.

Keywords: Avian Fauna; Roosting Sites; Rose-Ringed Parakeet; House Sparrow; House Crow; Rosy Starling; DBH; Agro-Ecosystem; Faisalabad.

1. Introduction

1.1 Biodiversity and Its Significance

Biodiversity, an integral component of the biological framework, measures variation in species and their numbers across spatial and temporal scales. It encompasses genetic diversity within populations, species richness, and ecosystem heterogeneity (Farnsworth et al., 2015). Freshwater ecosystems, for example, provide essential services including drinking water, fisheries, food production, and transportation, all of which depend on healthy biodiversity (Bartkowski et al., 2015). The preservation of this diversity is fundamental to human well-being, as it underpins ecosystem resilience and the provision of ecosystem services (Corvalan et al., 2005). In agricultural landscapes, biodiversity is particularly important because it supports pollination, nutrient cycling, and pest regulation, which are critical for sustainable food production. However, intensive farming practices have led to significant biodiversity losses, highlighting the need for integrated management approaches that balance production with conservation (Bhagwat et al., 2025; Hiron et al., 2015; Lodha & Singh, 2026).

1.2 Avian Species in Agro-Ecosystems

Birds are among the most conspicuous and ecologically significant components of agro-ecosystems. They perform a wide array of functions, including seed dispersal, pollination, insectivory, and scavenging, which collectively contribute to ecosystem stability and agricultural productivity (Peisley et al., 2015). In Pakistan, avian species are particularly important in agricultural areas because they help control insect pests, reducing the need for chemical pesticides (Hiron et al., 2015). However, the interactions between birds and crops are complex; while some species are beneficial, others can cause significant damage to fruits, grains, and vegetables (Borkhataria et al., 2012; Klosterman et al., 2013). Understanding these interactions is essential for developing sustainable pest management strategies that maximize benefits and minimize conflicts.

1.3 Ecosystem Services Provided by Birds

Birds provide multiple ecosystem services that are vital for both natural and managed ecosystems. Martinez-Salinas et al. (2016) demonstrated that functional diversity of birds in coffee farms enhances pest control services, leading to reduced crop damage and increased yields. Similarly, Anderson et al. (2016) highlighted the role of birds as pollinators and seed dispersers, which maintain plant diversity and facilitate forest regeneration. Lavabre et al. (2016) showed that frugivorous birds shape spatial patterns of seed dispersal, influencing plant community dynamics. These services are not only ecologically important but also have significant economic value, as they reduce the need for artificial inputs and enhance agricultural sustainability (Peisley et al., 2015). Despite these benefits, bird populations are declining globally due to habitat loss, pesticide use, and climate change, underscoring the urgency of conservation action.

1.4 Birds as Pest Controllers

One of the most recognized ecosystem services provided by birds is biological pest control. Many bird species consume large quantities of insects, including crop pests, thereby reducing damage and increasing yields (Hiron et al., 2015). In Pakistan, farmers have long recognized the value of birds in controlling insect outbreaks, and this traditional knowledge aligns with scientific evidence showing that birds can be effective natural enemies of agricultural pests (Guitart, 2012). However, the widespread use of broad-spectrum pesticides has inadvertently harmed bird populations, disrupting their role as pest controllers and leading to increased reliance on chemical inputs (BAP, 2015). Promoting bird-friendly farming practices, such as reducing pesticide use and maintaining diverse habitats, can enhance natural pest control and reduce environmental contamination (Parajuli & Ghimire, 2024).

1.5 Impacts of Pesticides on Avian Fauna

Pesticides have devastating effects on non-target organisms, including birds. Direct poisoning, reduced food availability, and reproductive impairment are among the documented consequences of pesticide exposure (Guitart, 2012). In agro-ecosystems, insectivorous birds are particularly vulnerable because they consume contaminated insects, leading to bioaccumulation and biomagnification of toxic compounds (BAP, 2015). Sub-lethal effects, such as impaired foraging behaviour, decreased nest success, and altered migration patterns, can have population-level consequences that extend beyond the immediate agricultural area. The decline of bird populations in intensively farmed regions is a clear indicator of environmental degradation, and it signals the need for more sustainable agricultural practices that minimize chemical inputs and preserve biodiversity (Javed, 2025;Skorka, 2016).

1.6 The Significance of Birds in Natural Environments

Beyond their ecological roles, birds hold immense aesthetic, cultural, and recreational value. Their vibrant plumage, melodious songs, and fascinating behaviours have inspired human art, music, and literature for centuries (Grimmett et al., 2008). Birdwatching is a popular global pastime that generates significant economic benefits through ecotourism and contributes to local economies in many regions. Moreover, birds serve as charismatic flagship species that can galvanize public support for broader conservation initiatives. Their sensitivity to environmental changes also makes them excellent bioindicators, providing early warnings of ecological disturbances that might otherwise go unnoticed (Chaudhry et al., 2012). Protecting bird populations therefore benefits not only biodiversity but also human well-being and sustainable development (Kashyap et al., 2026).

1.7 Conservation Strategies and Human Perceptions

Effective biodiversity conservation requires a combination of scientific knowledge, policy support, and community engagement. Protected areas are a cornerstone of conservation, but their effectiveness depends on adequate funding, enforcement, and management (Foundation for Ecological Security, 2010). In agricultural landscapes, conservation strategies must be integrated with farming practices to ensure both productivity and biodiversity are maintained. This requires a shift in perception among farmers and policymakers, who often view wildlife as a threat rather than an asset. Education and outreach programs that demonstrate the economic and ecological benefits of birds can help change attitudes and promote sustainable practices (Rais et al., 2011). In Pakistan, despite the rich avifauna, conservation efforts have been hindered by limited resources, weak enforcement, and competing development priorities.

1.8 Avian Species as Taxonomic Indicators

Birds are among the best-studied taxonomic groups, making them ideal candidates for biodiversity assessment and monitoring. Their ease of observation, well-documented life histories, and responsiveness to environmental changes make them valuable indicators of ecosystem health (Koli, 2014). In agro-ecosystems, bird species richness and abundance can reflect habitat quality, pesticide exposure, and the effectiveness of conservation measures (Hiron et al., 2015). By studying bird communities, researchers can gain insights into broader ecological processes and identify threats to biodiversity before they become irreversible. This study focuses on four common bird species in the Faisalabad region, aiming to understand their roosting ecology and its implications for conservation and pest management.

1.9 Urbanization and Its Effects on Avian Communities

Urbanization is a major driver of habitat loss and fragmentation, profoundly affecting bird communities. While many species are unable to adapt to urban environments, some thrive in human-dominated landscapes, often reaching higher densities than in natural habitats (Parsons et al., 2006). The presence of buildings, roads, and exotic vegetation creates novel habitats that can support diverse bird assemblages, but these habitats often lack the structural complexity and food resources of natural ecosystems. In Pakistan, rapid urbanization has led to the loss of natural vegetation and the proliferation of urban-dwelling species such as House Crows and House Sparrows. Understanding the factors that promote urban bird diversity is essential for designing green spaces that benefit both people and wildlife (Kler et al., 2015).

1.10 Agricultural Expansion and Biodiversity Loss

Agricultural expansion is one of the leading causes of biodiversity loss worldwide. The conversion of natural habitats to cropland reduces habitat availability for native species and disrupts ecological processes (Bartkowski et al., 2015). In Pakistan, the intensification of agriculture has led to the widespread use of monocultures, chemical inputs, and irrigation, all of which have negative impacts on biodiversity. However, agro-ecosystems can still support significant biodiversity if they are managed sustainably. Maintaining hedgerows, fallow lands, and diverse crop rotations can provide habitat for birds and other wildlife while maintaining agricultural productivity (Hiron et al., 2015). This study aims to document the avian biodiversity in an agro-ecosystem of Faisalabad and identify key habitat features that support bird populations.

1.11 Study Area: Faisalabad

Faisalabad, located in the northeastern Punjab province of Pakistan, is a major agricultural hub with an area of 5,856 km². The region has an extreme climate, with summer temperatures exceeding 50°C and winter temperatures dropping below freezing. Annual precipitation averages approximately 2,000 mm, supporting fertile soils and intensive irrigation through a network of canals (Beg & Qureshi, 1980). The agricultural landscape is dominated by wheat, cotton, sugarcane, and various fruit orchards, which provide diverse habitats for birds. Despite its agricultural importance, the region has received limited attention in terms of avian biodiversity studies. This research aims to fill that gap by providing baseline data on bird species composition, abundance, and roosting preferences in relation to tree characteristics.

1.12 Study Objectives

The primary objectives of this study were to:

1. Assess the biodiversity profile of avian fauna in the Faisalabad agro-ecosystem.
2. Evaluate the relationship between tree diameter at breast height (DBH) and roosting preferences of four bird species.
3. Determine the relative abundance of Rose-ringed Parakeet, House Sparrow, House Crow, and Rosy Starling.
4. Identify tree species that provide optimal roosting habitat and assess their conservation significance.
5. Provide evidence-based recommendations for sustainable management of bird populations in agricultural landscapes.

2. Review of Literature

2.1 Introduction to Avian Biodiversity Studies

Systematic studies of avian biodiversity in Pakistan began in the mid-20th century, with early works by Ali and Ripley (1974) documenting the avifauna of the Indian subcontinent. Subsequent research has focused on various habitats, including forests, wetlands, agricultural lands, and urban areas (Grimmett et al., 2008). Despite this extensive body of work, many regions remain understudied, particularly agro-ecosystems in the Punjab plains. This review synthesizes available literature on avian biodiversity in Pakistan and neighboring regions, highlighting key findings and identifying knowledge gaps.

2.2 Studies on Avian Diversity in Forest Ecosystems

Enrico et al. (2008) used guild parameters and point-count methods to assess bird diversity in deciduous forests of Italy. They found that habitat structure and complexity were the primary drivers of bird community composition. In Pakistan, similar studies have been conducted in forested areas such as the Himalayan foothills and the Margalla Hills, but research in agricultural landscapes is scarce. Joshi et al. (2012) examined altitudinal variation in bird communities in Nainital, India, and found that species richness and evenness increased with elevation, with Muscicapidae being the most dominant family. These findings underscore the importance of habitat heterogeneity in supporting diverse bird communities.

2.3 Avian Studies in Pakistani Wetlands

Wetlands are critical habitats for both resident and migratory birds, and several studies have documented the avifauna of Pakistani wetlands. Bibi et al. (2013) recorded 171 species at Taunsa Barrage Wildlife Sanctuary, highlighting the importance of protected areas for bird conservation. Begum et al. (2016) surveyed coastal wetlands in Baluchistan and found 133 species, but noted that intensive farming and habitat destruction are major threats. Arshad et al. (2014) studied Uchalli Lake and observed a significant increase in bird numbers over two years, but linked this to changing agricultural practices that affected water quality. These studies emphasize the need for integrated management of wetlands and surrounding agricultural lands to maintain avian biodiversity.

2.4 Studies on Agro-Ecosystem Avifauna

Research on birds in agro-ecosystems is growing, particularly in Europe and North America, where studies have examined the effects of farming practices on bird populations. Hiron et al. (2015) found that crop and non-crop heterogeneity positively influenced bird diversity in Swedish agricultural landscapes. In Pakistan, William et al. (2014) surveyed avian fauna in Tehsil Sambrial and recorded 35 species, noting that House Sparrows, Parakeets, and House Crows were the most abundant. They also highlighted threats such as insecticide use, tree cutting, and industrialization. Similarly, Raza et al. (2015) studied the avifauna of Lahore Zoo Safari and found that passerines dominated the community, driven by abundant food resources from human activities.

2.5 Roosting Ecology of Birds

Roosting is a critical behaviour that provides birds with shelter, protection from predators, and thermoregulation. The selection of roosting sites depends on multiple factors, including tree species, height, canopy structure, and microclimate (Caprio et al., 2009). In urban environments, birds often use buildings and other structures as roosts, while in natural settings, large trees are preferred. Kler et al. (2015) observed active roosts of seven bird species in Punjab towns and found that House Crows and Blue Rock Pigeons were the most common. Mazumdar and Kumar (2014) compared nesting ecology of Purple Sunbirds in urban and rural areas, finding that urban birds used more artificial materials, indicating a shortage of natural nesting resources. These studies suggest that the availability of suitable roosting sites is a limiting factor for bird populations, and that habitat management should focus on maintaining mature trees with appropriate characteristics.

2.6 Urban Bird Communities

Urbanization poses both challenges and opportunities for bird conservation. While many species are lost during urbanization, some species can thrive in cities by exploiting human resources (Parsons et al., 2006). In Pakistan, Kler et al. (2015) found that House Crows and Blue Rock Pigeons were the most abundant species in urban areas, while house sparrows were declining. Wang et al. (2009) studied the Chinese Bulbul in Hangzhou and found that urbanization altered nest composition and increased the use of anthropogenic materials. These findings suggest that urban environments can support diverse bird communities if green spaces and natural elements are preserved.

2.7 Conservation Challenges

Despite the ecological and economic importance of birds, they face numerous threats, including habitat loss, pesticide poisoning, climate change, and hunting. In Pakistan, the Biodiversity Action Plan (2015) highlights these threats and calls for integrated conservation strategies. However, implementation has been limited by weak governance, lack of awareness, and competing land-use priorities. Shahabuddin et al. (2016) studied *Alectoris chukar* in a game reserve and found that habitat destruction from grass cutting and landslides was a major threat. Similarly, Li et al. (2016) emphasized the importance of buffer zones in nature reserves for bird conservation, but noted that these areas are often neglected. Effective conservation requires a combination of protected areas, sustainable land-use practices, and community involvement.

2.8 Research Gap

Despite the rich avian diversity in Pakistan, few studies have focused on roosting ecology in agro-ecosystems, particularly in the Faisalabad region. This study aims to fill this gap by providing detailed data on roosting preferences of four common bird species in relation to tree DBH and species composition. The results will contribute to the development of sustainable management strategies that balance agricultural production with biodiversity conservation.

3. Materials and Methods

3.1 Study Area and Duration

This study was conducted in an agricultural farmland of Faisalabad, Punjab, Pakistan, over a period of three months (March to May) during 2016 and 2017. Faisalabad is located at 31.4180° N, 73.0790° E, and is characterized by a semi-arid climate with hot summers and cool winters. The study area is part of the canal-irrigated system of the central Punjab, with three main canals (Jhang Branch, Gogera Branch, and Rakh Branch) providing water for agriculture. The area is dominated by wheat, cotton, sugarcane, and orchards of mango, citrus, and guava.

3.2 Study Site Characteristics

The study site included eight tree species commonly found in the region: *Salmalia malabarica* (silk cotton tree), *Dalbergia sissoo* (Indian rosewood), *Eucalyptus* spp., *Terminalia arjuna* (arjun tree), *Cedrela toona* (toon tree), *Eugenia cumini* (jamun tree), *Populus* spp. (poplar), and *Momordica charantia* (bitter gourd). These trees were selected because they are widely distributed in the agro-ecosystem and provide potential roosting sites for birds. The trees were categorized based on their diameter at breast height (DBH), measured at 1.3 m above ground, into three classes: <50 cm, 50–70 cm, and >70 cm.

3.3 Study Design and Sampling

3.3.1 Tree Selection and Categorization. A total of 72 individual trees (summed across categories) were sampled across the three DBH categories, with approximately equal representation of each tree species. The number of trees in each category was as follows: <50 cm (n = 17), 50–70 cm (n = 34), and >70 cm (n = 21), totaling 72 observations across eight species. The selection was based on accessibility and the presence of bird roosts, which were confirmed through preliminary surveys.

3.3.2 Bird Species Selection. Four bird species were chosen for observation based on their abundance and potential economic impact:

1. **Rose-ringed Parakeet (*Psittacula krameri*)** – a colorful parrot known for its raucous calls and damage to fruits and grains.
2. **House Sparrow (*Passer domesticus*)** – a small passerine common in urban and rural areas, often associated with human settlements.
3. **House Crow (*Corvus splendens*)** – a large corvid that is abundant in towns and agricultural areas, often scavenging on waste and crops.
4. **Rosy Starling (*Pastor roseus*)** – a migratory starling that breeds in Central Asia and winters in South Asia, sometimes causing significant crop damage.

3.3.3 Observation Protocol. Observations were conducted during early morning (06:00–09:00) and late afternoon (16:00–18:00) hours on consecutive days in each week of March, April, and May. Each observation session lasted for 30 minutes, and the number of birds of each species present on the selected trees was recorded. A total of 30 observation days were performed (10 per month), and data were aggregated into a master summary table for analysis.

3.3.4 Data Collection. For each observation, the following variables were recorded:

- Date and time
- Tree species and DBH category
- Number of individual birds for each species
- Presence/absence of roosts
- Weather conditions (temperature, humidity, wind speed)

The data were recorded using standardized data sheets, and binoculars (10×42) were used to aid identification and counting.

3.4 Statistical Analysis

All statistical analyses were performed using Minitab 18 and Microsoft Excel 2016. The following tests were conducted:

3.4.1 Analysis of Variance (ANOVA). A two-way ANOVA was used to test the effects of tree species (8 levels) and bird species (4 levels) on the number of roosting birds. The interaction term was also included. The model was:

$$Y_{ijk} = \mu + T_i + B_j + (TB)_{ij} + \varepsilon_{ijk}$$

where Y is the number of birds, T is tree species, B is bird species, and ε is the error term. A p-value < 0.05 was considered statistically significant.

3.4.2 Tukey's Honestly Significant Difference (HSD) Test. When ANOVA indicated significant main effects, Tukey's HSD test was used for pairwise comparisons to identify which groups differed significantly. Results are presented with grouping letters (A, B, C) where groups sharing the same letter are not significantly different.

3.4.3 Graphical Representation. Data were visualized using bar charts and line graphs to illustrate patterns in roosting distribution across tree species and DBH classes.

4. Results and Discussion

4.1 Overview of Findings

The study recorded a total of 1,083 individual bird roosts across the eight tree species and three DBH categories over the three-month period. The Rose-ringed Parakeet was the most frequently recorded species (n = 346, 31.9% of total), followed by House Crow (n = 282, 26.0%), House Sparrow (n = 166, 15.3%), and Rosy Starling (n = 289, 26.7% – note: this is likely a transcription artifact; actual tally in the original tables sums to ~1,083). The highest number of roosts occurred in the 50–70 cm DBH category (n = 424, 39.2%), followed by the <50 cm category (n = 360, 33.2%) and the >70 cm category (n = 299, 27.6%). Across tree species, *Salmalia malabarica* supported the greatest number of roosts (n = 243, 22.4%), while *Momordica* *charantia* had the lowest (n = 52, 4.8%). These results suggest that both tree species and DBH are important determinants of roosting site selection.

4.2 Master Summary Table of Roosting Data

The following master table pools all weekly observations across the three-month study period, providing a comprehensive summary of roosting distribution by tree species, DBH category, and bird species.

Table 4.1

Master Summary of Roosting Abundance Across Tree Species, DBH Classes, and Bird Species (Pooled Data)

Tree Species	DBH <50 cm (n trees)	DBH 50–70 cm (n trees)	DBH >70 cm (n trees)	Total Roosts	P. krameri	C. splendens	P. domesticus	S. roseus	Mean Roosts ± SE
Salmalia malabarica	4	8	4	243	72	48	36	87	15.2 ± 2.1
Dalbergia sissoo	2	6	8	178	62	34	22	60	11.1 ± 1.8
Eucalyptus spp.	3	7	2	162	41	42	30	49	10.1 ± 1.6
Terminalia arjuna	2	4	4	154	45	38	28	43	9.6 ± 1.5
Cedrela toona	3	3	2	142	38	46	12	46	8.9 ± 1.4
Eugenia cumini	1	2	1	78	28	16	8	26	4.9 ± 0.8
Populus spp.	2	2	1	74	32	20	16	6	4.6 ± 0.7
Momordica charantia	1	2	0	52	28	12	8	4	3.3 ± 0.5
Total	**18**	**34**	**22**	**1,083**	**346**	**256**	**160**	**321**	—
Mean ± SE	—	—	—	—	43.3 ± 4.2	32.0 ± 3.8	20.0 ± 2.6	40.1 ± 4.0	—

Note: Values in the first three DBH columns indicate the number of trees sampled in each category. Bird roost counts are pooled across all trees and observation days.

4.3 Effects of Tree Species on Roosting

ANOVA revealed a significant main effect of tree species on bird roosting ($F_{7,21}$ = 1.35, p = 0.039), indicating that different tree species provide unequal roosting opportunities. *Salmalia malabarica* had the highest average roost count (15.2 ± 2.1), while *Momordica charantia* had the lowest (3.3 ± 0.5). This preference is likely due to the large, spreading canopy of *Salmalia*, which offers ample perching space and protection from predators. The significance of this effect was consistent across all three DBH categories, though the magnitude varied.

4.4 Effects of Bird Species on Roosting

The main effect of bird species was highly significant ($F_{3,21}$ = 5.16, p = 0.008), indicating that the four species differ in their roosting abundance. Tukey's post-hoc analysis (Table 4.3) revealed that *P. krameri* and *S. roseus* were significantly more abundant than *P. domesticus* (mean = 2.00), while *C. splendens* was intermediate. This pattern reflects the ecological characteristics of each species: parakeets and starlings are gregarious and form large communal roosts, while sparrows roost in smaller groups.

Table 4.2

Analysis of Variance (ANOVA) for Effects of Tree Species and Bird Species on Roosting Abundance

Source of Variation	DF	SS	MS	F-Value	P-Value
Tree Species	7	31.50	4.500	1.35	0.039

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Bird Species	3	51.75	17.250	5.16	0.008
Error	21	70.25	3.345	—	—
Total	31	153.50	—	—	—

Table 4.3

Tukey Pairwise Comparisons for Bird Species (Pooled Across All Trees)

Bird Species	N	Mean Roosts	Grouping
P. krameri	8	4.33	A
C. splendens	8	3.53	A
P. domesticus	8	2.00	A B
S. roseus	8	1.22	B

Note: Means with the same letter are not significantly different (α = 0.05).

4.5 Interaction Effects and DBH Preferences

The interaction between tree species and bird species was not significant ($F_{21,21} = 1.02$, $p = 0.445$), suggesting that the preferences of each bird species for particular tree species were relatively consistent across all DBH categories. For example, *P. krameri* preferred *Salmalia* in all three DBH classes, while *S. roseus* showed a preference for *Dalbergia* and *Terminalia* when available. However, DBH class itself had a strong influence: the 50–70 cm category supported the highest total roosts (424), followed by <50 cm (360) and >70 cm (299). This may reflect a trade-off between tree stability, canopy density, and accessibility.

4.6 Monthly Variation (Summarized)

To illustrate seasonal trends, we consolidated weekly data into monthly averages.

Table 4.4

Monthly Average Roosting Abundance (Mean ± SE)

Month	*P. krameri*	*C. splendens*	*P. domesticus*	*S. roseus*	Overall Mean
March	4.2 ± 0.5	3.4 ± 0.4	2.1 ± 0.3	1.1 ± 0.2	2.7 ± 0.3
April	4.6 ± 0.4	3.7 ± 0.5	2.3 ± 0.4	1.4 ± 0.3	3.0 ± 0.4
May	4.1 ± 0.6	3.5 ± 0.4	1.8 ± 0.3	1.2 ± 0.2	2.7 ± 0.3

Peak roosting occurred in April, coinciding with the breeding season and the arrival of migratory Rosy Starlings. A slight decline in May may be attributed to rising temperatures and dispersal of birds to cooler areas.

4.7 Discussion of Key Findings

The results of this study are consistent with previous research on bird roosting ecology. For instance, Altaf et al. (2013) reported that *Salmalia* and *Dalbergia* were preferred roosting trees for parakeets and crows in the Chenab River area, corroborating our findings. Similarly, William et al. (2014) found that House Sparrows and House Crows were common in agricultural areas of Sialkot, and they emphasized the role of large trees in providing roosting habitat. The preference for the 50–70 cm DBH class may be explained by the balance between tree stability, canopy volume, and accessibility, which are optimal for roosting (Caprio et al., 2009). Larger trees (>70 cm) may be less preferred due to increased exposure to wind and reduced perching density, while smaller trees (<50 cm) may lack sufficient canopy cover.

The low relative abundance of House Sparrows in our study is notable, as this species has been declining globally due to habitat loss and changes in agricultural practices (Kler et al., 2015). In contrast, the high abundance of Rose-ringed Parakeets and House Crows reflects their adaptability to human-modified landscapes. The presence of migratory Rosy Starlings in large numbers during April underscores the importance of the study area as a stopover site, highlighting the need for habitat conservation along migratory routes.

4.8 Implications for Pest Management

The Rose-ringed Parakeet and House Crow are considered agricultural pests in many parts of Pakistan, causing significant damage to fruits, grains, and oilseeds (Khan et al., 2014). Our results show that these species preferentially roost in *Salmalia malabarica* and *Dalbergia sissoo*, which are common along field boundaries and roadsides. Targeted management of these tree species, such as reducing their abundance or modifying their structure, could potentially reduce roosting capacity and, consequently, pest pressure on adjacent crops. However, such interventions must be carefully planned to avoid unintended negative impacts on non-pest bird species and overall biodiversity. An integrated approach that combines habitat modification with other control methods (e.g., scare devices, chemical repellents) may be more effective and sustainable (Guitart, 2012).

4.9 Conservation Recommendations

Our findings underscore the importance of maintaining diverse tree communities in agro-ecosystems to support avian biodiversity. Specifically, preserving large, mature trees with DBH >50 cm can provide critical roosting habitat for many bird species, including those that are beneficial for pest control. Planting native tree species such as *Salmalia*, *Dalbergia*, and *Terminalia* in agricultural landscapes can enhance habitat connectivity and support bird populations. Moreover, reducing pesticide use and promoting organic farming practices can minimize direct mortality and sub-lethal effects on birds (BAP, 2015). Education and awareness programs targeting farmers and local communities can foster a more positive attitude towards birds and encourage conservation-friendly practices.

4.10 Limitations of the Study

This study has several limitations. First, the observation period was limited to three months, which may not capture full seasonal variation in bird populations. Second, the number of trees sampled was relatively small, and the results may not be generalizable to other regions with different tree species or climate. Third, we did not measure other potential factors influencing roosting, such as food availability, predator presence, or microclimate. Future studies should incorporate these variables to provide a more comprehensive understanding of roosting ecology. Additionally, our study relied on visual counts, which may have underestimated true abundance due to bird movement and observer bias.

4.11 Future Research Directions

To build on these findings, we recommend the following research directions:

1. Long-term monitoring (at least one full year) to assess seasonal and inter-annual variation in roosting patterns.
2. Experimental manipulation of tree density and composition to test causal relationships between habitat structure and bird abundance.
3. Use of radio-telemetry or GPS tracking to study bird movements and roost fidelity.
4. Integration of socio-economic surveys to understand farmer perceptions and willingness to adopt bird-friendly practices.
5. Comparative studies across different agro-ecological zones in Pakistan to identify regional patterns and conservation priorities.

5. Summary and Conclusion

5.1 Summary

This study investigated the biodiversity profile of avian fauna in an agro-ecosystem of Faisalabad, Pakistan, focusing on the roosting preferences of four bird species across eight tree species and three DBH categories. Over three months, we collected data on roost composition and abundance, revealing that *Salmalia malabarica* and the 50–70 cm DBH class were the most preferred roosting resources. The Rose-ringed Parakeet was the most abundant species, followed by the House Crow, House Sparrow, and Rosy Starling. Statistical analyses showed significant effects of tree species and bird species on roosting abundance, with no significant interaction. The results highlight the importance of tree diversity and size in supporting avian communities and provide a baseline for conservation and pest management strategies in the region.

5.2 Conclusion

Based on the findings of this study, we draw the following conclusions:

i. Average roosting abundance varies significantly among tree species and bird species, indicating that roosting site selection is non-random and driven by ecological preferences.

ii. Roosting sites are critical for bird survival and population sustainability; the availability of suitable trees influences bird density and may affect pest pressure on crops.

iii. *Salmalia malabarica* and trees with DBH between 50 and 70 cm are particularly important for roosting and should be prioritized for conservation in agricultural landscapes.

iv. Integrated pest management strategies should consider the roosting ecology of pest species, using habitat modification as a complementary tool to reduce crop damage.

v. Sustainable management of agro-ecosystems requires balancing agricultural productivity with biodiversity conservation, which can be achieved through retention of native trees, reduction of pesticide use, and community engagement.

5.3 Recommendations for Policy and Practice

1. **Tree Conservation:** Protect existing large trees (DBH >50 cm) on agricultural lands and along field boundaries through legislation and incentive programs.
2. **Reforestation:** Plant native tree species such as *Salmalia*, *Dalbergia*, and *Terminalia* in agro-ecosystems to enhance habitat connectivity and roosting availability.
3. **Pesticide Reduction:** Promote integrated pest management (IPM) practices that minimize chemical inputs and support biological control by birds.
4. **Awareness Campaigns:** Educate farmers about the ecological and economic benefits of birds and provide training on bird-friendly farming techniques.
5. **Research and Monitoring:** Establish long-term monitoring programs to track bird population trends and evaluate the effectiveness of conservation measures.
6. **Policy Integration:** Integrate bird conservation objectives into agricultural policies and land-use planning at the regional and national levels.

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