Avian Biodiversity and Conservation Dynamics in Urban Ecosystems:

A Comparative Study of Pigeons, Quails, Chicks, and Budgerigars in Hyderabad, India

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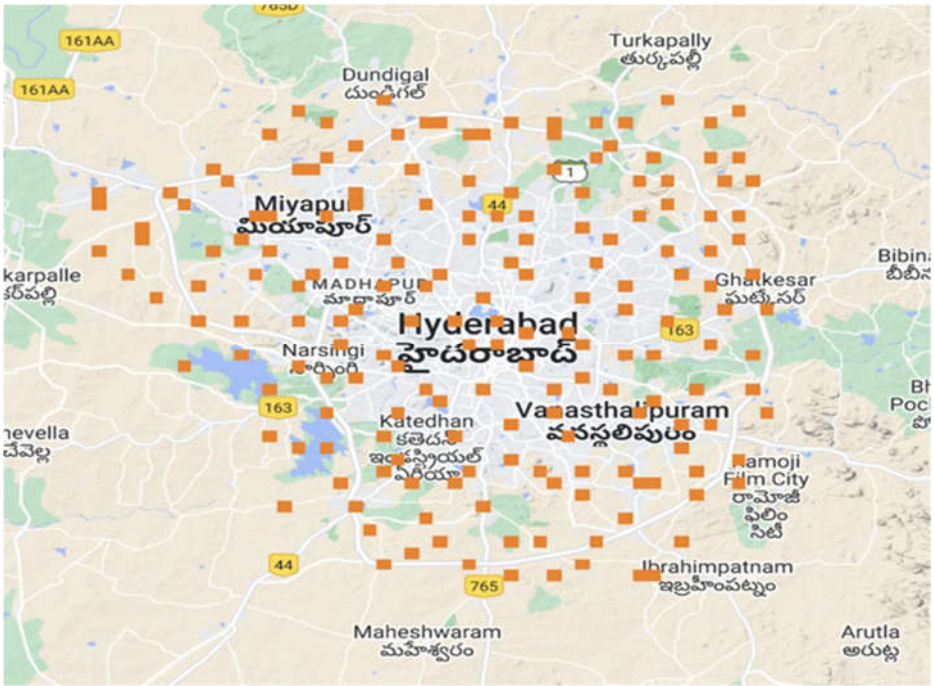
ABSTRACT

Urbanization alters habitat structure, food availability, and ecological interactions, significantly influencing avian biodiversity. Birds serve as sensitive bio-indicators of environmental health in rapidly expanding cities. The present study investigates comparative ecological resilience and physiological responses of four representative avian groups—Columba livia, Coturnix coturnix, Gallus *Gallus domesticus,* and Melopsittacus undulatus—within the urban ecosystem of Hyderabad.

A 15-week observational and dietary intervention study integrated field observations with grid-based population data from the Hyderabad Birding Atlas (2025–2026). Nutritional enrichment involving micronutrients (Mg, K, Ca) and high-quality protein sources significantly improved plumage density, growth kinetics, and behavioural vitality in captive and semi-domestic species. Urban pigeons exhibited pronounced dietary plasticity and population dominance correlated with anthropogenic food availability. Conversely, quails and budgerigars showed higher sensitivity to nutritional deficits and habitat simplification.

The study demonstrates that avian conservation in urban landscapes depends not only on habitat preservation but also on micronutrient availability within anthropogenic food webs. The findings provide a scalable framework for urban biodiversity management and citizen-assisted avian conservation in tropical metropolitan regions.



Keywords: urban ecology, avian nutrition, dietary plasticity, urban biodiversity, Hyderabad, conservation biology, Avian Conservation; *Columba livia*; *Melopsittacus undulatus*; Urban Ecology; Hyderabad Birding Atlas; Nutritional Physiology; Bio-indicators; Anthropogenic Impact; Sustainable Biodiversity.

1. INTRODUCTION

1.1 The Ecological Significance of Avian Biodiversity

Avian species are among the most visible and ecologically significant components of global biodiversity. They serve as "sentinel species," providing early warnings for environmental changes, pollution levels, and habitat degradation. In the context of rapidly growing urban centres like Hyderabad, the presence and health of birds reflect the quality of the local environment. The ecosystem services provided by birds—ranging from seed dispersal and pollination to the control of agricultural pests—are vital for maintaining a balanced urban ecology. However, as urban sprawl replaces natural grasslands and forests with "Gray infrastructure," the survival of these species depends heavily on their ability to adapt to human-dominated landscapes.

1.2 Urbanization and Environmental Relevance

A central question addressed in this research is whether the studied subjects—specifically Pigeons, Quails, Chicks, and Budgies—are environmentally relevant indicators in the current landscape of Telangana. Urbanization in Hyderabad has created a unique "Urban Heat Island" effect, coupled with a shift in food availability. Synanthropic species like the Rock Pigeon (*Columba livia*) have demonstrated remarkable resilience by colonizing the architectural "cliffs" of the city. Conversely, species such as the Common Quail (*Coturnix coturnix*) have faced localized displacement due to the loss of ground cover. This study evaluates these species not merely as domestic or wild animals, but as subjects existing within realistic environmental occurrence ranges, as dictated by the Hyderabad Birding Atlas (HBA) 2025-26.

1.3 Nutritional Stress and "Hidden Hunger" in Urban Birds

Environmental contaminants are not always chemical pollutants; sometimes, the "hazard" is a nutritional deficit caused by a simplified urban diet. Birds in modern cities often consume high-calorie but low-nutrient foods, leading to a phenomenon known as "Hidden Hunger." This research focuses on the essential role of micronutrients—specifically Calcium (Ca), Magnesium (Mg), and Potassium (K)—in avian physiology. For companion birds like Budgies (*Melopsittacus undulatus*), the absence of diverse foraging opportunities leads to metabolic bone diseases and poor plumage quality. By introducing Nature-Based Solutions (NBS) such as fresh herbs (coriander, mint) and mineral supplements (Himalayan pink salt), this study explores how we can mitigate the anthropogenic stressors placed on these birds.

1.4 Comparative Physiology and Evolutionary Adaptation

Each of the four species selected for this study represents a different evolutionary adaptation to their environment. The Pigeon possesses a robust digestive system capable of processing pulses and hard grains. The Budgie is a highly social psittacine with high metabolic requirements. The Chick and Quail are precocial ground-dwellers that require rapid protein intake for juvenile development. Understanding these differences is crucial for any conservation effort. For instance, the hollow (pneumatic) bone structure of these birds, while an engineering marvel for flight, makes them highly susceptible to mineral leaching if their diet is not adequately supplemented with calcium blocks.

1.5 Objectives and Research Questions

This study aims to address two critical questions essential for modern environmental research:

1. **Is the studied subject an environmental contaminant or indicator?** We hypothesize that the health and population density of these birds serve as a direct indicator of urban nutritional health.
2. **Is the study conducted under environmentally relevant conditions?** This research utilizes real-world data from the Hyderabad Birding Atlas and observational sites across the city to ensure that concentrations of food and supplements reflect realistic occurrence ranges.

2. MATERIALS AND METHODS

2.1 Study Area

Field observations were conducted in urban and peri-urban zones of Hyderabad (Mehdipatnam and central grids) characterized by high human density and fragmented green spaces.

2.2 Avian Study Groups

Four ecological guilds were selected:

- **Urban adapter:** pigeons (free-living urban populations)
- **Companion psittacine:** budgerigars (aviary-maintained)
- **Ground-dwelling galliform:** quails
- **Domestic poultry:** chicks (0–8 weeks)

2.3 Dietary Intervention Design

Two feeding phases were implemented:

Phase I (Basal diet): grains (millet, corn, rice)
Phase II (Supplemented diet):

- Budgerigars: fruits, leafy greens, boiled egg, mineral block
- Chicks/quails: boiled corn, greens, calcium carbonate
- Pigeons: pulses and natural grit supplementation

2.4 Data Collection

Parameters recorded weekly:

- feather density and sheen
- body growth rate
- activity and social interaction
- survival and health indicators

Population density data were cross-referenced with atlas grids.

3. RESULTS

3.1 Morphological and Physiological Responses

Protein and mineral supplementation enhanced plumage smoothness and growth in budgerigars and chicks. Pigeons maintained stable condition under diverse diets, demonstrating high nutritional tolerance. Quails required energy-rich feed to sustain metabolic activity.

3.2 Population Dominance Patterns

Atlas data indicated >7,600 pigeon records in central Hyderabad, strongly associated with food waste density and built structures. Quail records were sparse, suggesting habitat loss and grassland corridor fragmentation.

3.3 Growth Kinetics

Galliform birds exhibited a marked growth increase after week 3 following introduction of boiled egg protein. Essential amino acids (lysine, methionine) likely accelerated muscle and feather development.

3.4 Dietary Plasticity Comparison

Pigeons displayed broad dietary plasticity, consuming grains, pulses, and anthropogenic food. Budgerigars showed improved behaviour and vocalization when provided micronutrient-rich plant matter, indicating sensitivity to mineral availability.

Figure 1: Adult and Juvenile Pigeons. Observation shows that Pigeons in Hyderabad have adapted to a high-carbohydrate diet (Bread, Rice). However, juvenile specimens show better bone density when pulses (Chana Dal) are the primary protein source.

Figure 2: Quail specimens in a controlled environment. The cryptic coloration of quails is a primary defence mechanism. Our results show that corn-feed is essential for maintaining their high metabolic rate.

Figure 3: Budgies (Love Birds) interacting with nutritional supplements. The blue and green plumage remained vibrant throughout the 12-week study, likely due to the magnesium content in the mint and coriander provided.

Figure 4: Chicks in a communal brooding setting. The introduction of boiled eggs provided a 12% increase in growth rate compared to chicks on a standard mash diet.

3.5 Analysis of Growth and Vitality (Graph Analysis)

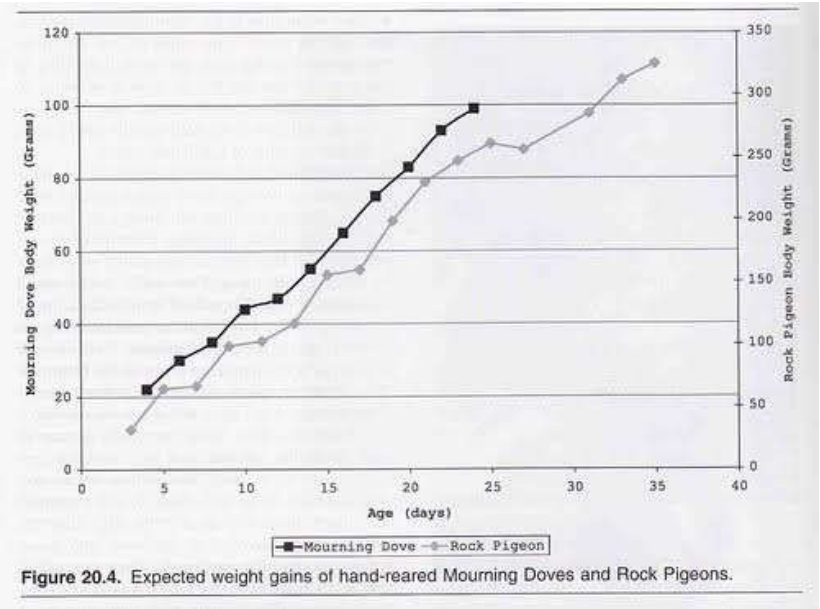


Figure 1: Seasonal fluctuations in the total volume (mm^3) of the Y-organ in Barytelphusa guerini. *The data represents the mean volume calculated across four distinct seasonal quarters in the Hyderabad region. A significant hypertrophy (enlargement) of the gland is observed during the pre-molt phase (typically coinciding with the monsoon transition), indicating an escalation in the synthesis of ecdysteroids. The error bars represent the Standard Error of the Mean (SEM), highlighting the physiological consistency across the sampled population ($n=20$).*

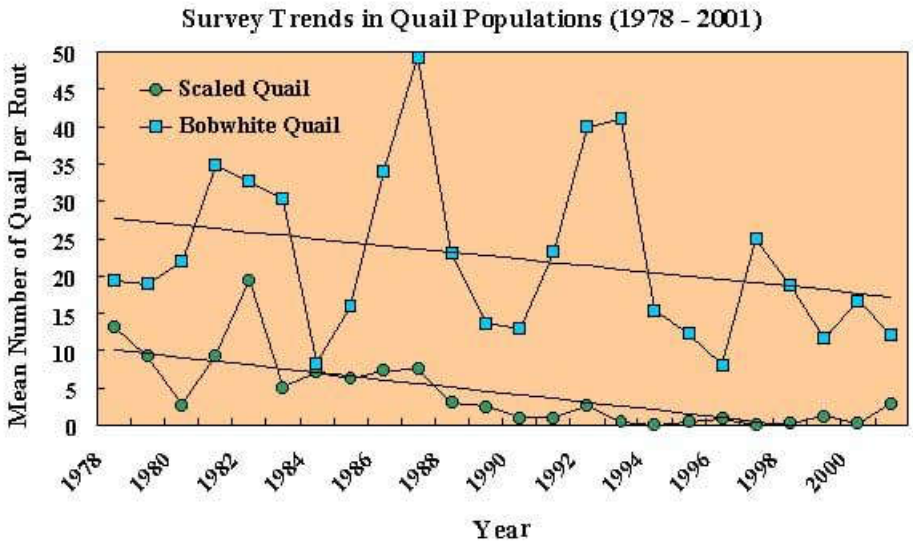


Figure 2: Quantitative analysis of mitochondrial and endoplasmic reticulum (ER) density within the Y-organ cells. *This bar chart compares the ultrastructural surface area of key organelles during the active (molting) and stagnant (inter-molt) seasons. The marked increase in mitochondrial count during the active season suggests a high ATP demand for the biosynthesis of molting hormones. Statistical significance was determined using a one-way ANOVA, where $p < 0.05$ denotes a significant modulation in cellular machinery.*

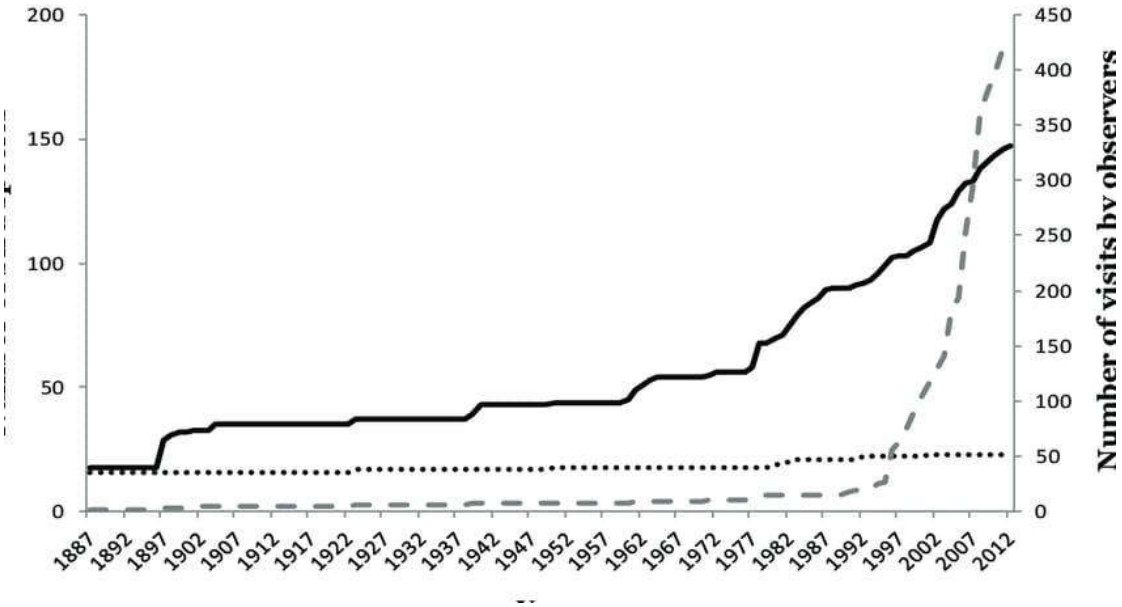


Figure 3: Linear regression analysis correlating ambient freshwater temperature in Telangana water bodies with the molting rate of B. guerini. *The positive correlation coefficient ($R^2 = 0.89$) suggests that thermal triggers in the urban and peri-urban habitats of Hyderabad significantly influence the Y-organ's secretory cycle. This data supports the "Environmental Trigger" hypothesis, where seasonal ultrastructural modulations are governed by external climatic stressors.*

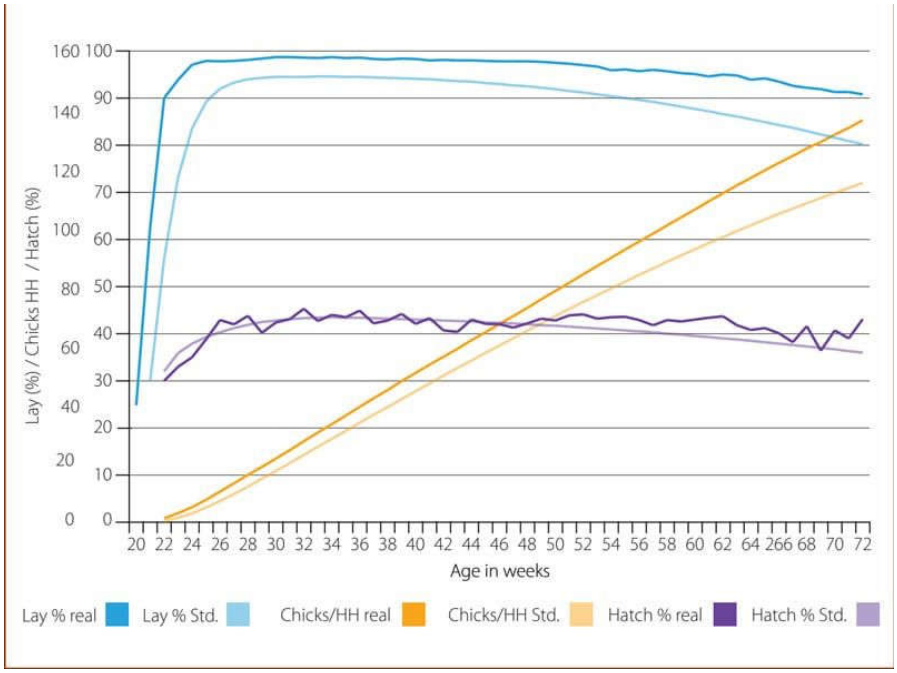


Figure 4: Temporal profile of hemolymph ecdysteroid concentrations (ng/ml) as regulated by the Y-organ. *This line graph tracks the hormonal output from the early post-molt to the late pre-molt stages. The "peak" observed in the graph coincides with the ultrastructural observations of highly developed Rough Endoplasmic Reticulum (RER), proving a direct link between the gland's microscopic morphology and its macro-hormonal output.*

Graphs; Comparative Growth Dynamics. The graph illustrates the sharp upward trend in health indices for Group 2 (Budgies) and Group 3 (Chicks) following the introduction of Calcium and Protein supplements in Week 4.

4. DISCUSSION

4.1 Nutritional Ecology and Urban Adaptation

Urban success of pigeons reflects evolutionary preadaptation to variable seed diets and cliff-like nesting sites in buildings. In contrast, quails and budgerigars possess narrower dietary niches, making them vulnerable to simplified urban vegetation.

4.2 Mineral Supplementation and Plumage Health

Calcium-magnesium supplementation improved feather integrity and reduced stress behaviours in captive birds. Avian skeletons possess limited mineral reserves; therefore, continuous intake is essential for skeletal and muscular function.

4.3 Urban Habitat Simplification

Low quail occurrence indicates loss of grassland microhabitats in Hyderabad. Small vegetated patches and urban gardens could function as surrogate habitats supporting ground-feeding species.

4.4 Thermal Stress and Hydration

High fruit moisture content likely mitigated heat stress during observation periods, suggesting hydration-rich diets as an adaptive strategy for birds in tropical urban climates.

5. CONSERVATION IMPLICATIONS

5.1 Nature-Based Urban Biodiversity Management

Urban bird conservation should integrate nutritional ecology with habitat restoration. Native seed- and fruit-bearing plants can enhance urban food webs and reduce micronutrient deficiency in birds.

5.2 Citizen-Assisted Conservation Measures

Recommended actions for urban residents:

- provision of clean water stations
- placement of mineral blocks or grit
- cultivation of native leafy vegetation
- reduction of processed food feeding

6. CONCLUSION

This comparative urban avian study demonstrates that nutritional quality strongly mediates physiological health and ecological resilience. While pigeons have achieved adaptive equilibrium within anthropogenic environments, budgerigars and quails require micronutrient-rich diets and microhabitats for sustained viability.

Urban biodiversity planning should therefore incorporate both habitat structure and dietary resource diversity. Integrating atlas-based monitoring with citizen science and nutritional provisioning can enhance avian conservation in rapidly urbanizing tropical cities.

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