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IMPACT OF URBANIZATION ON THE POPULATION DENSITY OF GREY FRANKOLINS (*FRANCOLINUS FRANCOLINUS)* AND BLACK FRANCOLINS (*FRANCOLINUS PONDICERIANUS)* IN LAKKI MARWAT, PAKISTAN

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Abstract

Understanding the ecological determinants of avian population dynamics is crucial for effective wildlife management and conservation. Although black and grey francolins (Francolinus francolinus and Francolinus pondicerianus) are currently classified as species of Least Concern by the IUCN, their populations are increasingly threatened by urbanization. This study investigates the effects of urbanization on the population density of francolins in Khyber Pakhtunkhwa, Pakistan. Field observations, systematic surveys, and remote sensing techniques were employed to collect data from both urban and rural habitats with varying levels of urban development. A total of 100 field observations, 50 structured questionnaires, and 20 satellite images were analyzed over a six-month period. Local residents and hunters were interviewed to assess population trends and habitat utilization, while satellite imagery was used to examine land-use changes and habitat fragmentation. Descriptive and inferential statistical analyses (t-tests, ANOVA) revealed a significant decline in francolin population density in urbanized areas compared to rural regions. These findings highlight the adverse impact of urban expansion on francolin populations and emphasize the need for targeted conservation strategies to mitigate habitat loss and ensure the long-term persistence of these species in the region.

1. INTRODUCTION

Urbanization is a global phenomenon that has dramatically transformed natural ecosystems, resulting in habitat loss, fragmentation, and degradation (United Nations, 2020). The impacts of urbanization on wildlife populations are well-documented, with many species experiencing declines in abundance, distribution, and diversity (McKinney, 2002). Birds, being sensitive to environmental changes, are often considered effective indicators of ecosystem health, as their presence or absence reflects habitat quality and biodiversity status (Gregory et al., 2003).

In Pakistan, particularly in the province of Khyber Pakhtunkhwa, rapid urban expansion driven by economic growth, migration, and conflict has led to significant habitat modification and biodiversity loss (Government of Khyber Pakhtunkhwa, 2020). Ghandi Khan Khel, a tehsil in the Lakki Marwat District, has witnessed considerable urban development in recent years, contributing to habitat

destruction and fragmentation that threaten local wildlife populations.

Among the affected species is the francolin, a ground-dwelling bird that plays an important ecological role in seed dispersal and pollination (IUCN, 2013). The black francolin (*Francolinus francolinus*) and grey francolin (*Francolinus pondicerianus*) are both of conservation interest in Pakistan due to their declining populations, primarily caused by habitat loss, pesticide use, and overhunting (Johnsgard, 1988; Ghaemi, 1998; Mann & Chaudhry, 2000; BirdLife International, 2015). Black francolins breed from April to July, constructing well-concealed ground nests where females lay 7–12 eggs, incubating them for 18–21 days (Sharif, 2014; Khan, 2010). The species may produce two clutches per breeding season (Knorr, 2002). Despite being categorized as Least Concern by the IUCN, black francolins remain one of Pakistan's most valued game birds due to their culinary appeal and socio-economic significance, particularly among rural communities (Roberts, 1992; Riaz et al., 2011; Fuller et al., 2000; Forcina et al., 2015).

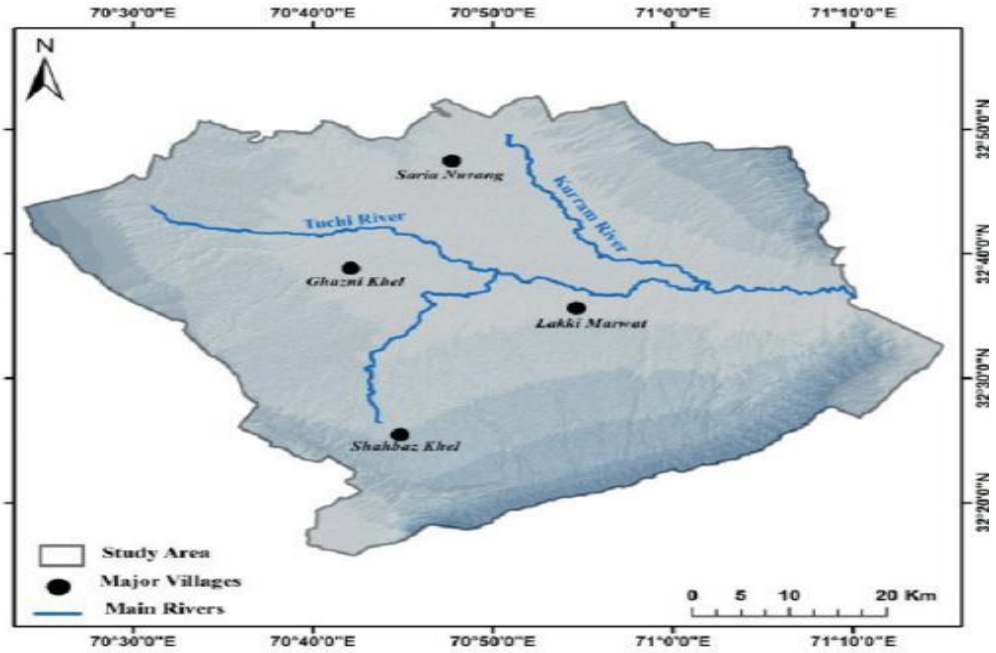
With increasing human encroachment, regional biodiversity continues to decline across natural communities (McKinney, 2002). Studies linking avian populations to vegetation structure and land-use change have predominantly focused on natural landscapes (e.g., forests and wetlands), while urbanized and peri-urban ecosystems remain underexplored (Marzluff, 2001). Understanding how urbanization affects the francolin population is thus crucial for effective wildlife management and conservation in rapidly developing regions.

This study aims to investigate the effects of urbanization on the population density of francolins in Ghandi Khan Khel, Khyber Pakhtunkhwa. Specifically, it seeks to identify the key ecological and anthropogenic factors influencing their population trends and habitat use. The findings will contribute to a better understanding of avian responses to urban expansion and support the development of conservation strategies to mitigate urban impacts on biodiversity in Pakistan.

Materials and Methods

Study Area

The study was conducted in Khyber Pakhtunkhwa, Pakistan, including the lakki City, Ghandi Khan kheel and serai Naurang covering an area of approximately 30,960 hectares. The region lies between NA-36 PK 91, 92, 93 with elevations ranging from 500 to 2,100 meters above sea level. The study area encompasses a mosaic of habitat types, including agricultural fields, scrublands, and scattered patches of natural vegetation, providing suitable environments for both black francolin (*Francolinus francolinus*) and grey francolin (*Francolinus pondicerianus*) populations. Research was carried out over a 12-month period, from February 2025 to August 2025, covering all major seasons. The climate of Ghandi Khan Khel is characterized as seasonal semi-arid, with distinct winter (November–March), dry (June–September), and monsoon (July–August) periods. The average annual rainfall is approximately 76.5 mm. The highest mean temperature(31.5 ± 1.7 °C) is typically recorded during the dry season, whereas the lowest mean temperature (1.7 ± 2.9 °C) occurs in winter . (Zippenfenig, P. 2023). These climatic variations influence vegetation structure and resource availability, thereby affecting francolin habitat use and population dynamic.(Dad, K., Khan, S., Akhtar, N., & Saeed, K. 2014).



Identification of Preferred Habitats

The quadrat sampling method was employed to identify the preferred habitats of black francolin (*Francolinus francolinus*) and grey francolin (*Francolinus pondicerianus*) across three major habitat types: agricultural lands, agroforests, and pasturelands within the study area. This method is widely used in ecological studies to assess vegetation composition, plant biodiversity, and community structure. (Mahmood, S., Mahmood, T., Rais, M., Qureshi, I. Z., & Nadeem, M. S. 2010). It involves the systematic or random placement of sampling plots (quadrats) to quantify vegetation characteristics within a defined area, providing reliable data for evaluating habitat preferences. (Sanjerehei, M. M. 2011).

In this study, three quadrats were randomly placed along the central transect of each habitat type to ensure representative sampling. The size of quadrats was standardized according to vegetation structure:

Trees:10 m × 10 m

Shrubs:5 m × 5 m

Herbs/Grasses:1 m × 1 m

These dimensions followed established ecological protocols (Khan, M. F., Awan, M. S., Nayyer, A. Q., Mehmood, K., & Khattak, M. N. K. 2015).. Within each quadrat, data on plant species composition, canopy cover, and ground vegetation density were recorded to characterize habitat features associated with francolin occurrence and abundance.

Density Assessment

To estimate the population densities of black francolin (*Francolinus francolinus)* and grey francolin (*Francolinus pondicerianus*), the line transect distance sampling method was employed. This approach accounts for variation in species detectability as a function of distance from the observer, thereby providing more accurate density estimates. (Hussain, I., & Khalil, S. 2012). A total of twelve transects, each measuring 1,000 m in length and 50 m in width, were randomly established across the three major habitat types agricultural lands, agroforests, and pasturelands.(Khan, M. T., Rehman, F. U., Noreen, S., Ullah, N., Ilyas, M., Muhammad, S., & Tariq, Z. 2024). Observations were recorded within a 25m belt on either side of the transect line, representing the effective survey width for bird detection.(Kumar, A., Sharma, D. K., Lochan, R., Dewan, S., & Negi, S. 2020). To ensure spatial independence and avoid overlapping detection zones, adjacent transects were separated by at least

100 m, with some spaced several kilometers apart, depending on habitat accessibility and terrain features. Field surveys were conducted twice daily, during dawn and dusk, corresponding to peak activity periods of francolins. The morning surveys were carried out from 05:00 to 09:00 hours in summer and 06:30 to 10:30 hours in winter, while evening surveys were conducted from 16:00 to 19:00 hours in summer and 15:00 to 18:00 hours in winter (Mahmood et al., 2010). Each survey session lasted approximately 2–3 hours, and the mean values from both sessions were used to estimate population densities per transect. Both direct sightings and indirect evidence such as feathers, fecal droppings, and calls were recorded. For each observation, the following parameters were documented: estimated bird position along the transect, altitude (m above sea level), habitat type, observation time, number of individuals detected, and total time spent per transect. All collected data were analyzed using appropriate statistical tests to evaluate spatial and temporal variations in francolin densities. Specifically, Student's t-test , Analysis of Variance (ANOVA) , and the Kruskal–Wallis test were applied to compare population densities between habitats and time periods.

Statistical Analysis

Descriptive statistics, including means and standard deviations (mean ± SD), were calculated to summarize variations in francolin population densities across different habitats and seasons. Prior to statistical testing, the normality of the data was assessed using the Shapiro–Wilk test . Since the data met the assumptions of normality, a one-way Analysis of Variance (ANOVA) was performed to determine the statistical significance of differences in population densities among habitat types and seasons. To compare interspecific differences (between black and grey francolins) within each habitat, paired sample t-tests were conducted. For a more detailed assessment of density variation and species composition, Similarity Percentage (SIMPER) analysis, Cluster Analysis, and Analysis of Similarities (ANOSIM) were applied based on the Bray–Curtis similarity index using species detection data from sampled transects. These multivariate analyses allowed for the evaluation of community-level patterns and the identification of habitat-specific similarities or dissimilarities in francolin distribution. All statistical analyses were conducted using standard ecological and statistical software packages, and significance was determined at $p < 0.05$.

Population Estimation

The population estimation of black francolin (*Francolinus francolinus*) and grey francolins (Francolinus Francolinus)at the selected study sites was conducted using the Visual Encounter Method (VEM), based on direct sightings of individuals along pre-established transects. Observations were made with the aid of 10× binoculars to detect birds present on or near the transect line. Data were collected systematically along each transect, and the number of individuals observed was recorded for subsequent density estimation.

	Observed Population					
Months	**Grey Francolins**			**Black Francolins**		
	Lakki City	**Ghandi Khan kheel**	**Serai Naurang**	**Lakki City**	**Ghandi Khan kheel**	**Serai Naurang**
January	25	41	34	30	27	41
February	23	38	31	33	31	47
March	39	56	48	45	54	62

April	42	58	50	48	59	67
May	45	63	54	50	62	71
June	24	46	36	35	40	43

Results

Population Abundance and Density of Black Francolin

The highest population abundance of black francolin was recorded in mountainous forest and associated grassland habitats (7.89 ± 0.93 individuals per transect), followed by open cultivated lands (4.56 ± 0.84). The lowest abundance was observed in wetlands and associated natural vegetation (1.00 ± 0.37). Monthly variations showed that the maximum number of individuals was recorded in April (21) and March (19), coinciding with the breeding season.

Overall, the mean population density of black francolin across all habitats was 1.06 birds/ha Among habitat types, the highest density was observed in mountainous forest and associated grassland (2.19 birds/ha), followed by open cultivated lands (0.84 birds/ha) and wetlands/natural vegetation (0.15 birds/ha).

Statistical analysis revealed significant differences in population densities among the three habitat types ($F = 20.82$, $p < 0.005$, $df = 26$). These findings suggest that habitat characteristics strongly influence black francolin abundance and distribution. The species showed a marked preference for elevated, vegetated habitats, which provide adequate cover and food resources while reducing predation risk. In contrast, wetlands with sparse vegetation and lower elevations expose individuals to greater predation pressure. Vegetation such as *Albizia lebbeck*, *Dodonaea viscosa*, *Opuntia stricta*, *Adiantum incisum*, *Parthenium hysterophorus*, and *Cymbopogon jwarancuse* dominated the less preferred wetland habitats, offering limited concealment. Dense plant cover not only provides protection from predators but also buffers individuals from harsh climatic conditions, particularly extreme cold and drought. Consequently, reduced vegetation cover may restrict both the range and population size of the species in these areas. Similar trends have been reported for black francolin populations in the Hills and other regions of Pakistan. Black francolin also holds considerable socioeconomic importance in rural communities. It is a prized game bird due to its meat quality, which is valued as both food and a traditional aphrodisiac . In Pakistan, the species is legally protected under the Punjab Wildlife Acts and Rules (1974), which regulate hunting through a licensing system and impose financial penalties for illegal capture. Effective enforcement and habitat management are therefore essential for sustainable population recovery.

Habitat Preferences of Grey Francolin

The results showed that grey francolin exhibited a significant degree of habitat selection. The species primarily utilized woody ravines and cover habitats, while completely avoiding mountain slopes, barren rocks, and open grasslands. Approximately 10–55% of individuals were observed within 25–100 m of water sources, while about 12% were detected at distances exceeding 100 mm. If These observations align with previous studies indicating that grey francolins prefer habitats with moderate vegetation cover and proximity to water sources . Grey francolins also showed behavioral adaptations such as foraging during morning and evening hours to reduce heat stress in summer. Group foraging, typically observed in groups of five individuals, may represent an anti-predator strategy to enhance vigilance and reduce individual risk.

Implications for Conservation and Management

Both black and grey francolins demonstrated a clear preference for habitats with dense or scattered vegetation. Black francolins were more abundant in herbaceous and grassy habitats, while grey francolins favored tree-rich environments. However, both species are experiencing population declines due to habitat loss, unregulated hunting, pesticide use, and poor management within community game

reserves.The findings highlight the urgent need for targeted conservation actions, including: Habitat protection and restoration in areas supporting high francolin densities. Regulation of hunting activities through enforcement of existing wildlife laws. Breeding and reintroduction programs in degraded habitats. Public awareness and community engagement to promote coexistence and reduce poaching. Long-term population monitoring to track changes and assess the effectiveness of management interventions.Engaging local communities in conservation initiatives can enhance data collection, foster stewardship, and support sustainable use of wildlife resources. The results of this study contribute valuable insights into the population dynamics, habitat associations, and conservation requirements of francolins in Khyber Pakhtunkhwa and can inform regional biodiversity management and policy planning.

Impact of urbanizatin	Population of Grey Francolins	Population of Black Francolins
Habitat loss	Number decreases	Number decreases
Fragmentation	Number decreases	Number decreases
Hunting	Number decreases	Number decreases
Predation	Number decreases	Number decreases
Degredation	Number decreases	Number decreases

Discussion

Our study revealed distinct density estimates for black and grey francolin in the Lakhi Murwat based on a year-long population assessment. Overall, the average highest density for both francolin species was found in the pasturelands. Generally, our recorded values appear to be lower compared to prior reported studies on black and grey francolin in the district LakkiMurwat, Pakistan . Research that took place in various parts of district LakkiMurwat reported population densities ranging from 1 to 8 individuals/hacter. We highlight that the focus on laying transects in the various regions of the study area is likely to provide an accurate density value . Prior studies have reported significantly higher densities of Francolins species . In comparison to our findings, higher densities have been reported both in wetlands and in agroforests .

The current study highlighted notable habitat-specific differences in the population densities of black and grey francolin, reinforcing previously observed ecological trends. The cluster analysis separated agroforest transects (T8, T9, T10, and T12) from those in agricultural lands (T6 and T7) and pasturelands (T2 and T1), indicating consistent species detection within each habitat type. However, altered transects T3 (agricultural lands) and T5 (pasturelands) suggested the presence of a transitional zone between habitat types. These findings, supported by ANOSIM and SIMPER results, revealed significant dissimilarities in species composition between the three habitats. Furthermore, grey francolin showed significantly higher population densities along transects T1, T4, and T7, situated in agricultural lands and pasturelands. These observations align with previous reports showing higher grey francolin densities in plain areas , pasturelands and wetland-adjacent wild areas . Similarly, black francolin exhibited higher densities along pastureland transects (T6 and T7). However, the literature supports that black francolin prefers more humid environments such as wetlands , moist pasturelands and mountainous forests associated with ecotones . These habitat preferences explained the high densities of grey francolin in more open and drier habitats, where black francolin appears to be less dominant. The adaptability of grey francolin to open pasturelands and cultivated fields, coupled with its generalist diets of seed, insects, and

vegetation,allows it to exploit a broader range of habitats and food resources .This study highlights the need for conservation efforts beyond ecological factors, emphasizing the importance of coordinated strategies to restore and prioritize habitats essential for sustaining francolin populations. These findings also support a broader scientific approach for seasonal habitat selection and vegetation dynamics in avian species .However, our research is limited by its spatial scope, lack of genetic data, and information on reproductive success, predation rates, and gradients of anthropogenic disturbance.In addition, the absence of tracking-based approaches restricts insights into fine-scale habitat use and movement patterns. Future research can integrate long-term monitoring across multiple reserves to capture inter-annual variability and broader ecological patterns. Additionally, molecular tools such as microsatellite or genomic analysis are recommended to assess population structure and gene flow, especially in sympatric zones.

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