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Research Article

# Impact of Anthropogenic Noise on Bird Abundance in Urban Environment in Makurdi, Benue State Nigeria

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***Abstract***— Anthropogenic noise is a pervasive feature of urban environments, posing significant challenges to avian populations by interfering with communication, foraging, and reproductive behaviors. This study examines the impact of noise pollution on bird abundance, species diversity, and behavior across different urban land-use types in Makurdi, Nigeria. Using point count surveys and noise measurements, 30 locations within commercial centers, residential areas, and urban parks were analyzed. Results revealed a strong negative correlation between noise levels and bird abundance, with the highest noise levels recorded in commercial centers and the lowest in urban parks. Bird behavior was notably disrupted in high-noise areas, with reduced feeding, vocalization, and social interaction. The findings highlight the critical need for integrating noise mitigation strategies into urban planning to conserve bird populations in rapidly urbanizing environments.

***Keywords***— Noise pollution, Bird abundance, Urban environments, Species diversity, Behavioral disruption, Urban parks, Ecological conservation

## 1. Introduction

Anthropogenic noise, primarily stemming from motorized traffic, is widespread in urban areas and near major roads. This type of noise can interfere with animal communication by masking acoustic signals [6] and adversely affect the abundance [3] of certain species in noisy habitats. Since urban noise predominantly consists of low-frequency sounds, it has been proposed that animals using higher-frequency acoustic signals may be less impacted and, therefore, more adaptable to urban environments. With increasing urbanization, avian habitats are becoming scarce, negatively affecting communication, territorial behavior, foraging, and reproduction across animal communities. Anthropogenic noise acts as a pollutant, altering the way animals communicate acoustically. Some species modify their vocalizations to cope with environmental noise. Urbanization also introduces a combination of environmental stressors, including chemical pollution, artificial light at night, noise pollution, and human disturbances [2]. Urban populations often show altered stress responses compared to forest-dwelling populations. Among these stressors, noise pollution is particularly significant due to its ubiquity, arising from road, rail, air traffic, industrial, and commercial activities. While assessing its effects on wildlife is complex, increasing evidence highlights the detrimental impact of anthropogenic noise on ecosystems and wildlife, with sensitivity varying across taxa [7]. Urban noise often features frequent high-intensity events and elevated, homogenized background sound levels. This can disrupt avian populations at various biological levels, including behavior. The widespread negative impacts of anthropogenic noise on avian body condition, physiology, and reproductive success observable across different species indicate that noise pollution serves as a chronic and pervasive stressor[4]. Noise pollution is, therefore, likely to have both immediate and long-term impacts on free-living bird populations in urban environments..This study seeks to investigate the impact of anthropogenic noise on urban bird populations. Specifically, it aims to assess noise levels in urban areas, examine their relationship with bird abundance, and evaluate how varying noise intensities influence bird communication, feeding, breeding, and other behaviors.

## 2. Related Works

Urbanization can be defined as the process characterized by city growth and associated structures to the detriment of rural spaces[22]. Urbanization negatively affects avian evolutive and taxonomic diversity because some species are excluded from urban areas), and because the density of bird species in cities is often lower compared to other areas[9]. However, other studies found that avian functional diversity is higher in the urban than in rural or semi-natural environments, due to

 

potentially higher habitat diversity. On the other hand, species that have been living in cities for a long time show relatively larger population densities in urban as compared to rural habitats[20]. However, even if numerous avian species conquered the urban environment, it is a challenging environment that differently affects species depending on their ecological and life history traits. The question of the urban environment as a suitable habitat for bird species remains unresolved. Indeed, theory suggests that animals should select their breeding habitat such that fitness is maximized. Nonetheless, numerous studies found a mismatch between habitat preferences and fitness outcomes[12]. Urban environments tend to act as ecological traps, with features favorable to adult survival like warmer weather and milder winters in the city than in surrounding rural habitats[18] and higher availability of resources (food and nesting opportunities)[11]. The study of paired populations of birds has shown that urban populations are characterized by an advanced reproductive phenology and reduced reproductive success due to smaller clutch size, lighter fledgling body mass and fewer fledged offspring. Urbanization changes habitat and increases habitat fragmentation which particularly impacts bird species when native vegetation is replaced by crops or urban structures creating barriers to species dispersion. In the remaining vegetation patches, native species are often replaced by exotic decorative species. The change in vegetation composition has consequences on food quantity and quality available for insectivore species as it induces a change in insect communities. Together with anthropogenic sources of food[11] this altered food quality and quantity in urban environments may lead to compensatory changes in parental investment in nestling feeding ), which may have consequences on adult survival and reproductive success. The total-foliage hypothesis also suggests that vegetation is an important feature in the habitat for birds because it should reduce predation, a denser vegetation coverage providing better protection from predators. A recent study found that a higher proportion of grass cover and a higher tree density in the city were beneficial and increased diversity and abundance of birds over seasons[21]. Habitat modifications observed in urbanized areas may thus affect species through resources and interspecific interaction, but green patches could help maintain avian biodiversity in cities.

### 2.1 Environmental Stressers In Urban Communities

Urbanization is also characterized by several and simultaneous environmental stress factors that have consequences at behavioral and physiological levels for species living in cities: chemical pollution, artificial light at night, noise pollution and human disturbances. Indeed, urban populations exhibit an altered response to stress compared to forest populations. Among these stress factors, noise pollution is of particular interest because of its ubiquitous nature, as it results from any anthropogenic noise caused by human activities: road traffic, rail traffic, air traffic, and industrial and commercial activities. Assessing the effects of noise pollution on wildlife is challenging, but growing scientific research provided evidence that anthropogenic noise is detrimental to natural ecosystems and wildlife, despite different sensitivity across taxa . Anthropogenic noise in the urban environment is often characterized by an increased number of high-intensity noise events and elevated and homogenized background sound levels. It can disrupt avian populations at different biological levels, including behavior. It has been reported for example that exposure to peak noise levels near an airport increased antipredator vigilance behavior and decreased the time spent on foraging activities, altering the birds' time, and thus potentially energetic, budget. Noise pollution induces a change in song patterns and vocal communication, with great tits (Parus major) singing with a higher minimum frequency, shorter and faster songs in urban areas compared to rural areas. Similar observations were done in white-crowned sparrows (Zonotrichia leucophrys nuttalli) populations[14]. These modifications in song patterns are hypothesized to counteract the masking of song and vocal communication by the low-frequency background noise in cities, but some studies found that it is not enough for alarm calls to be heard over traffic noise. In addition to impaired sexual selection and antipredator behavior, this disruption of acoustic communication could have further consequences for bird species providing biparental care and living in the urban environment. Indeed, vocal communication between male and female is known to be crucial for pair synchronization, during incubation and nestling feeding activities, and to affect breeding success [17]. Noise pollution may therefore have direct negative effects on avian reproduction through behavioral changes or impairments.

### 2.2 Adverse Effects Of Noise Pollution on Birds' Body Condition and Physiology

Noise pollution also has adverse effects on birds' body condition and physiology, with indirect consequences on reproductive success. Chronic exposure to low-frequency noise in house sparrows (Passer domesticus) reduced fitness as a result of producing fewer fledglings, of lower body mass and lower probability to recruit in the population (Schroeder et al., 2012). In another study, however, experimental exposure to traffic noise during growth resulted in reduced nestling telomere lengths in the absence of any effect on corticosterone levels, body condition or fledging success [19]. In tree swallow (Tachycineta bicolor) populations, exposure to traffic noise positively correlated with increased basal cortisol levels and with greater telomere attrition, potentially reducing post-fledging survival. In a study of three passerine species, an increase in noise exposure was associated with a decrease in baseline plasma corticosterone in females and nestlings, and an increase in stress-induced nestling corticosterone response. Finally, in great tits, increasing background noise levels were associated with an increase in nestlings' plasma haptoglobin levels, an indicator of physiological condition and health, reflecting increased inflammatory processes[23], and with a reduction in telomere length in small brood members. The fact that these negative effects of anthropogenic noise on bird body condition, physiology and reproductive success can be detected at the community level in different species suggests that noise pollution acts as a chronic and unavoidable stressor. Noise pollution is therefore likely to have short-and long-term

 

consequences on free-living bird populations in cities. Although the number of urban ecology studies investigating the effects of habitat quality and pollutions on birds is increasing, the vast majority of them contrast urban versus rural populations, and seldom investigate how varying levels of habitat quality and environmental stressors affect reproductive life history traits and reproductive success within the urban habitat. In addition, the potential interactive effects of habitat quality and environmental stressors are rarely investigated. In this study, we investigated if noise pollution in city parks affects the distribution and reproductive phenology, investment and success and if vegetation cover could mitigate these effects in two model species widely studied in evolutionary and environmental research that are common in the urban environment, the great tit (Parus major) and the blue tit (Cyanistes caeruleus). Previous studies comparing urban and nearby rural populations across Europe reported that urbanization has negative effects on the reproductive success of these species [13] and drive phenotypic differences[10] when compared to rural populations. However, which environmental factors underlie these patterns and at which stage of reproduction they act is not precisely known. In particular, studies investigating how the degree of vegetation cover within a territory may influence breeding success in the urban habitat are lacking. One study investigated the relationship between two stressors in the urban environment (noise and artificial light at night) and birds' physiology[23]. Other studies experimentally investigated the combined effect of two stressors (noise and artificial light at night) on activity patterns[15], or of a stressor (artificial light at night) and a mitigating factor (spring temperature) on the timing of reproduction,[16] but they were conducted in captivity or in a forest environment, respectively.

## 3. Materials and Methods

### 3.1 Study Area

Makurdi is situated on both banks of the Benue River, bordered to the west by Keana, to the north by Lafia and Doma Local Government Areas in Nasarawa State, to the east by Guma Local Government, and to the south by Gwer and Gwer-West Local Governments. Located at latitude 7°43'60" N and longitude 8°31'60" E of the Greenwich Meridian, Makurdi serves as both the local government headquarters and the state capital. The area is divided into 11 council wards and has an estimated population of 500,797 individuals [8]

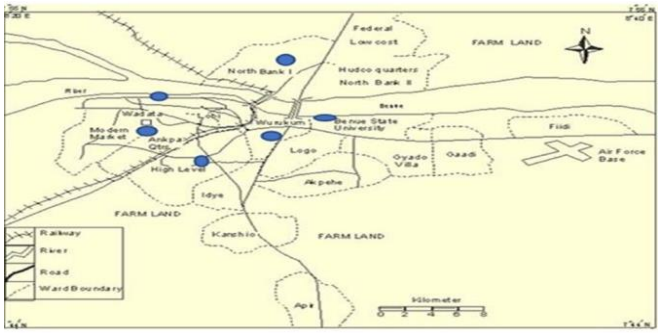


**Figure: 1. Map of Makurdi Local Government Area**
**Source: Benue State Ministry for Lands and Survey**

### 3.2 Climate

The climate of Makurdi Local Government Area, where the study is located, features two distinct seasons a dry season from November to April and a rainy or wet season from May to October, with peak rainfall typically occurring between late July and September. Temperatures are highest during the dry season and lowest during the rainy season, with mean monthly maximum temperatures ranging from 39.4°C to 30.6°C and mean monthly minimum temperatures ranging from 26.7°C to 18.4°C. The area receives an average annual rainfall of approximately 1,238 mm, and the relative humidity generally exceeds 78% [5].

### 3.3 Data Collection

Field work covered Three land use types in urban settlements, namely: (1) Commercial centres (2) Residential areas (3) Urban Park . The study sites were visited fortnightly for three months.

### 3.1 Bird Surveys

Bird Survey was conducted using the Point Count Method as adopted by [1] was used to assess bird abundance, Point counts or predetermined locations were established across various land use types sampled within urban settlements. A minimum distance of 500m was maintained between each counting point. A total of 30 counting points were utilized, comprising 10 stations per land use type. Upon reaching the sites, observed bird species were recorded within a predetermined timeframe (15 minutes). surveys should be conducted at regular intervals, such as early morning when birds are most active, conduct surveys during early morning (6:00 am – 9:00 am) when bird activity peaks. use binoculars to observe birds from a distance, ensuring accurate identification without disturbing them.

### 3.2 Noise Level Measurement

A sound level meter was used to measure noise levels at each site. The sound level meter positioned at a fixed location within the study area to ensure that it is held at ear level (approximately 1.5 meters from the ground) and pointed in the direction of the noise source to ensure the environment around the meter is free from physical obstructions that might reflect or block sound waves, the meter was set to the A-weighting filter (dBA) to simulate how human ears perceive sound across different frequencies, as this is a common setting for environmental noise assessments.Noise measurements was taken at consistent intervals (every minute) for a designated period (15 minutes per site). Average, Maximum, and Minimum noise levels in decibels (dB) was measured for each site, and the data logged accordingly. Noise Levels was measured at Different Times of the Day (Morning and Evening), Morning ( 6:00 AM – 9:00 AM) and Evening (5:00 PM – 6:00 PM) when traffic peaks again as people return home from work, and nightlife activity may also contribute to noise levels. These different times represent peak and off-peak noise periods, giving you a comprehensive view of noise fluctuations throughout the day. Ensure measurements are taken at similar weather conditions to avoid confounding effects like wind or rain. During the bird count at each point,the noise level was measured

 

simultaneously using a sound level meter . this ensures that noise data is directly linked to bird observations, providing insight into how noise impacts bird abundance and diversity, the exact time of each measurement for both bird species and noise levels was noted to maintain consistency in data collection. including information on bird behavior (feeding, calls, flying) to assess how noise might be affecting these activities. by collecting bird abundance, species identification, and behavioral data alongside noise levels, you can evaluate how different levels of noise impact bird populations and behaviors in the urban environment.

### 3.4 Data Analysis

Descriptive statistics was used to analyse the data (mean noise levels, bird abundance). Pearson Correlation coefficient was used to examine the relationship between noise levels and bird abundance. Diversity indices was analyzed using Shannon-Weiner Index) to evaluate species diversity across noise gradients.

## 4. Results

Table 1 provides noise level measurements recorded across various study sites, including commercial centers, residential areas, and urban parks, during morning and evening periods. The highest noise level was observed in commercial centers during the evening, with a maximum of 75.6 dB, while the lowest noise level was recorded in urban parks during the morning, with a minimum of 52.4 dB. This comparison highlights variations in noise intensity across different urban environments and time periods.

**Table 1: Noise Level Measurement Across Study Sites (Morning and Evening)**

| Site | Time Period | Average Noise Level (dB) | Maximum Noise Level (dB) | Minimum Noise Level (dB) |
|---|---|---|---|---|
| Commercial Centres | Morning | 65.2 | 72.1 | 58.7 |
| | Evening | 68.4 | 75.6 | 60.2 |
| Residential Areas | Morning | 60.5 | 68.3 | 55.0 |
| | Evening | 64.7 | 70.9 | 58.1 |
| Urban Parks | Morning | 58.3 | 65.0 | 52.4 |
| | Evening | 62.8 | 69.3 | 55.9 |

Table 2 summarizes the relationship between noise levels, bird abundance, and species diversity across various study sites during morning and evening periods. The highest bird abundance (49) and Shannon-Weiner Diversity Index (1.80) were recorded in commercial centers during the morning, while the lowest bird abundance (21) and diversity (1.35) were observed in residential areas during the evening. These findings indicate a negative relationship between noise levels and both bird abundance and species diversity, with urban parks generally maintaining moderate levels of both metrics.

**Table 2: Showing Noise Levels, Bird Abundance, and Species Diversity Across Study Sites**

| Site | Time Period | Average Noise Level (dB) | Bird Abundance | Shannon-Weiner Diversity Index (H') |
|---|---|---|---|---|
| Commercial Centres | Morning | 65.2 | 49 | 1.80 |
| | Evening | 68.4 | 40 | 1.65 |
| Residential Areas | Morning | 60.5 | 29 | 1.55 |
| | Evening | 64.7 | 21 | 1.35 |
| Urban Parks | Morning | 58.3 | 37 | 1.70 |
| | Evening | 62.8 | 27 | 1.50 |

Table 3 illustrates the correlation between noise levels and bird abundance across the study sites during morning and evening periods. The correlation coefficients (r) reveal a strong negative relationship between noise levels and bird abundance in all sites. Residential areas had the strongest negative correlation (-0.85), followed by commercial centers (-0.81) and urban parks (-0.77). These findings highlight the adverse impact of increasing noise levels on bird abundance across various urban habitats.

**Table 3: Correlation Between Noise Levels and Bird Abundance**

| Site | Time Period | Noise Level (dB) | Bird Abundance | Correlation Coefficient (r) |
|---|---|---|---|---|
| Residential Areas | Morning | 65.2 | 49 | |
| | Evening | 68.4 | 40 | -0.85 |
| Commercial Centres | Morning | 60.5 | 29 | |
| | Evening | 64.7 | 21 | -0.81 |
| Urban Parks | Morning | 58.3 | 37 | |
| | Evening | 62.8 | 27 | -0.77 |

Table 4 provides an overview of bird behavior across varying noise levels, highlighting the impact of noise pollution on avian activities. Under low noise conditions (45–50 dB), birds exhibit frequent feeding, regular perching, stable nesting, and normal social interactions and calls. In moderate noise levels (52–58 dB), feeding becomes occasional, bird calls increase, flight activity rises, and social interactions decrease. High noise levels (65+ dB) result in rare feeding and perching, minimal vocalizations, disturbed nesting, and significantly reduced social interactions, indicating substantial behavioral disruption due to noise pollution.

 

**Table 4: Bird Behavior Across Different Noise Levels**

| Bird Behavior | Low Noise (45-50 dB) | Moderate Noise (52-58 dB) | High Noise (65+ dB) |
|---|---|---|---|
| Feeding | Frequent | Occasional | Rare |
| Bird Calls | Normal | Increased vocalizations | Minimal Vocalizations |
| Flying | Minimal flight | Increased flight activity | Frequent flight (disturbed) |
| Perching | Regular | Occasional | Rare |
| Social Interactions | Normal | Decreased | Significantly Reduced |
| Nesting | Stable | Disturbed | Rarely observed |

## 5. Discussion

The results indicate a clear inverse correlation between noise levels and bird abundance, species diversity, and normal bird behavior, suggesting that urban noise significantly impacts bird populations and their ecological functions.

Noise levels varied significantly across the three study sites, with the highest average noise levels recorded in commercial centres (65.2 dB in the morning and 68.4 dB in the evening), as shown in Table 1. Residential Areas and Urban Parks had lower average noise levels, particularly during morning periods, reflecting variations in urban activity and traffic patterns. Peak noise levels were observed in the evening across all sites, corresponding with rush hour traffic and increased human activity, as expected in urban environments. These noise variations provided an opportunity to assess how different levels of disturbance influence bird behavior and diversity.

Table 3 illustrates the relationship between noise levels and bird abundance, with Commercial centres exhibiting the highest bird abundance (49 individuals in the morning) despite higher noise levels. However, bird abundance decreased significantly during the evening (40 individuals), when noise levels peaked at 68.4 dB. Similarly, Residential Areas and Urban Parks showed a decrease in bird abundance and species diversity in the evening compared to the morning. The negative correlation between noise levels and bird abundance was evident across all sites.

The Shannon-Weiner Diversity Index values also reflected the impact of noise on species diversity. Sites with lower average noise levels (Site 3 with an average morning noise level of 58.3 dB) had higher species diversity (H' = 1.70) compared to noisier sites like Site 1 (H' = 1.80 in the morning, but declining to 1.65 in the evening). This finding highlights how urban noise influences not only the number of birds present but also the variety of species, with quieter environments supporting a more diverse avian community.

The study observed significant variations in bird behavior based on the level of noise disturbance. As Table 5 shows, feeding behavior was most frequent in environments with low noise levels (45-50 dB), while high-noise environments (65+ dB) resulted in rare feeding occurrences. Bird calls, an important aspect of communication, were significantly reduced in high-noise environments, with minimal singing observed. High noise levels also led to frequent flight activity, likely indicating disturbance, as birds appeared to respond to the increased urban noise by moving away from the noise sources. Perching, social interactions, and nesting were similarly affected, with regular behavior occurring in quieter environments, while these activities were rare or significantly reduced in areas with high noise disturbance.

## 6. Conclusion and Future Scope

This study confirms that noise pollution in urban environments has a detrimental effect on bird populations, species diversity, and behavior. The negative correlation between noise levels and bird abundance and diversity suggests that high noise levels act as a deterrent for many species, particularly during peak periods of urban activity. Additionally, normal bird behaviors, such as feeding, perching, and vocalizations, are significantly disrupted in areas with high noise, potentially impacting their survival and reproductive success. The findings highlight the importance of considering noise pollution as a key factor in urban wildlife management and conservation.

Urban planners should implement noise reduction strategies, such as sound barriers or green buffers, in areas with high bird activity to mitigate the impact of noise on avian populations and Designating certain urban areas as "quiet zones" with restrictions on noise levels, especially during critical bird activity periods (e.g., early morning), could help preserve bird diversity and abundance in cities.

**Data Availability**

The raw monthly data used to compile the table for species and the number of individuals observed across various land-use types in the study area have not been included in this publication due to privacy and confidentiality policies. However, these data are securely held by the author and can be made available upon request through the provided email or mobile contact.

**Conflict of Interest**

The authors affirm that there are no conflicts of interest associated with this work.

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**Authors' Contributions**

The authors contributed in various capacities, including data collection, analysis, typesetting, and manuscript review. The lead author was primarily responsible for organizing and supervising the overall execution of the study.

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