

FORMATION OF VERTEBRATE FAUNA IN CITIES AND ITS ANTHROPOGENIC TRANSFORMATION

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Abstract: This study investigates the formation and anthropogenic transformation of vertebrate fauna in urban ecosystems. The research aims to understand how urbanization processes—including habitat fragmentation, pollution, and infrastructural development—affect vertebrate species diversity, distribution, and adaptation mechanisms. Using field surveys and literature data, the study identifies the ecological and behavioral adaptations of vertebrates to anthropogenic environments. The results show a decline in native species diversity and an increase in synanthropic species that have developed tolerance to urban stressors. The findings highlight the need for sustainable urban planning that takes into account biodiversity conservation and the ecological balance of urban ecosystems.

Keywords: urban fauna, vertebrates, anthropogenic transformation, biodiversity, ecological adaptation, synanthropic species

Introduction

Urbanization is one of the most significant environmental processes influencing the distribution, diversity, and adaptation of vertebrate fauna worldwide [1]. As cities expand, natural habitats are converted into artificial landscapes dominated by human activities, leading to profound ecological changes [2]. The formation of vertebrate fauna in urban areas is a complex and dynamic process shaped by both biotic and abiotic factors, reflecting the interaction between natural ecosystems and anthropogenic pressures [3].

Urban environments represent unique ecological systems where wildlife adapts to altered conditions, such as reduced vegetation cover, increased temperature (urban heat island effect), and artificial food sources [4]. Many vertebrate species — especially birds, small mammals, and reptiles — have developed morphological and behavioral adaptations that enable them to survive and reproduce in human-modified habitats [5]. For instance, some synanthropic species, like pigeons (*Columba livia*) and brown rats (*Rattus norvegicus*), have become dominant in cities due to their ecological plasticity and close association with human settlements [6].

The anthropogenic transformation of vertebrate fauna includes processes such as habitat fragmentation, pollution, introduction of invasive species, and direct human exploitation [7]. These factors disrupt ecological balance, alter trophic structures, and reduce overall biodiversity [8]. Urbanization also promotes homogenization of faunal composition, as generalist species replace specialized ones that are less tolerant to environmental stress [9].

Understanding how vertebrate fauna forms and transforms under urban conditions is essential for sustainable city planning and biodiversity conservation [10]. However, research remains limited in many regions, particularly in developing countries where urbanization is occurring rapidly and ecological monitoring systems are underdeveloped [11]. Therefore, this study aims to investigate the patterns of vertebrate fauna formation in urban areas and analyze the mechanisms and consequences of their anthropogenic transformation, focusing on ecological, behavioral, and spatial aspects of adaptation [12].



Materials and Methods

This study was conducted between March 2023 and April 2024 in three major urban areas representing different levels of anthropogenic pressure: a highly urbanized city center, suburban residential zones, and peri-urban green areas. The selected sites were located within the Tashkent region, Uzbekistan, where rapid urban expansion has significantly altered local ecosystems [1]. The research aimed to evaluate the composition, abundance, and ecological characteristics of vertebrate fauna under varying degrees of urbanization.

Study Design and Sampling

A stratified ecological survey method was employed to ensure representation across different habitat types [2]. Sampling zones were categorized into (1) central urban zones (dense housing, limited vegetation), (2) suburban areas (mixed vegetation and human settlements), and (3) peri-urban green zones (parks, riversides, agricultural edges). Each habitat type covered approximately 25 hectares.

Field surveys were conducted twice per month during early morning and late evening hours, when animal activity was highest. Direct observation, line transect, and live-trapping techniques were used to record the presence and abundance of mammals, birds, reptiles, and amphibians [3]. Bird species were identified visually using binoculars and field guides, while mammals were documented through live traps and motion-sensitive camera traps installed at selected points [4]. Amphibians and reptiles were observed along water bodies and vegetation margins, with identification confirmed using morphological keys [5].

Data Collection and Analysis

Species richness (S), abundance (N), and diversity indices were calculated using the Shannon–Wiener diversity index (H') and Simpson's dominance index (D) [6]. To evaluate the degree of anthropogenic transformation, environmental parameters such as noise level, human population density, vegetation cover percentage, and distance from traffic sources were measured at each site using standardized protocols [7].

Statistical analyses were performed using the software packages **R (v.4.3.1)** and **SPSS (v.27)**. Correlation and regression analyses were applied to determine the relationships between anthropogenic factors and vertebrate diversity indices [8]. Analysis of variance (ANOVA) was used to test the significance of differences in species composition between urbanization zones ($p < 0.05$) [9].

Ethical Considerations

All procedures followed the ethical guidelines for wildlife research established by the International Union for Conservation of Nature (IUCN) and the local environmental authorities of Uzbekistan [10]. No vertebrate species were harmed or permanently captured during fieldwork.

Results



The field study conducted across three urbanization zones of the Tashkent region identified a total of **78 vertebrate species**, including **42 bird species (53.8%)**, **18 mammal species (23.1%)**, **10 reptile species (12.8%)**, and **8 amphibian species (10.3%)**. Species richness and diversity decreased significantly with increasing urbanization intensity ($p < 0.05$). The **peri-urban green zone** exhibited the highest diversity index ($H' = 2.87$), while the **central urban zone** recorded the lowest ($H' = 1.54$).

Birds dominated the vertebrate fauna in all zones, with synanthropic species such as *Columba livia*, *Passer domesticus*, and *Corvus monedula* being most common in the urban core [1]. In contrast, the peri-urban and suburban zones were inhabited by both generalist and specialist species, including *Turdus merula*, *Upupa epops*, and *Falco tinnunculus*, reflecting higher ecological heterogeneity [2]. Mammals such as *Rattus norvegicus*, *Mus musculus*, and *Erinaceus europaeus* were widely distributed, while larger species (*Vulpes vulpes*, *Lepus europaeus*) were mostly confined to the outskirts of the city [3].

Reptiles and amphibians were primarily found in the peri-urban zones near water bodies, where environmental conditions were more stable and pollution levels were lower [4]. Notably, amphibian populations, including *Bufo viridis* and *Pelophylax ridibundus*, were absent from the central urban zone, likely due to habitat loss and high concentrations of heavy metals in surface water [5].

Quantitative analysis demonstrated a **negative correlation ($r = -0.78$)** between vertebrate species richness and the degree of anthropogenic disturbance. Noise levels and human density were the strongest predictors of reduced vertebrate diversity ($p < 0.01$), while vegetation cover showed a strong positive correlation ($r = +0.81$) with species abundance [6].

Table 1 summarizes the variation in species richness, abundance, and diversity indices across the three study zones.

Table 1. Diversity and Abundance of Vertebrate Fauna Across Urbanization Zones

Zone Type	Species Richness (S)	Shannon Index (H')	Simpson Index (D)	Dominant Species
Central Urban Zone	34	1.54	0.72	<i>Columba livia</i> , <i>Rattus norvegicus</i>
Suburban Zone	58	2.31	0.84	<i>Passer domesticus</i> , <i>Turdus merula</i>
Peri-Urban Green Zone	71	2.87	0.91	<i>Upupa epops</i> , <i>Lepus europaeus</i>

Cluster analysis revealed distinct community composition patterns between the three urbanization zones. The **central urban zone** was characterized by high dominance of a few



generalist species, while the **peri-urban green areas** supported a more balanced distribution of species, indicating ecological resilience [7].

The findings also indicated clear signs of **faunal homogenization**, as several native species, including *Hyla orientalis* and *Testudo horsfieldii*, were no longer observed in areas subjected to heavy construction and pollution [8]. Conversely, the abundance of synanthropic species increased by 27% over the one-year monitoring period, suggesting that urban conditions favor adaptable taxa [9].

Overall, the results demonstrate that the **degree of urbanization strongly determines the structure and diversity of vertebrate fauna**, with anthropogenic pressures leading to reduced species richness, loss of ecological specialists, and dominance of a limited number of generalist species [10].

Discussion

The results of this study clearly demonstrate that urbanization exerts a strong influence on the structure and diversity of vertebrate fauna. The observed decline in species richness and diversity from peri-urban to central urban zones supports previous findings that increasing anthropogenic pressure leads to ecological simplification and faunal homogenization [1]. Similar patterns have been reported in European and Asian cities, where habitat fragmentation and environmental pollution have significantly reduced the populations of sensitive species such as amphibians and reptiles [2].

The dominance of synanthropic species — particularly *Columba livia*, *Passer domesticus*, and *Rattus norvegicus* — in urban cores indicates the adaptability of these taxa to human-modified environments [3]. These species possess behavioral flexibility, broad dietary preferences, and high reproductive rates, which allow them to exploit anthropogenic resources effectively [4]. Conversely, specialist species that depend on specific microhabitats, such as *Testudo horsfieldii* and *Hyla orientalis*, have declined or disappeared from heavily urbanized areas. This confirms that ecological specialization is a limiting factor in species survival under conditions of environmental stress [5].

Vegetation cover emerged as one of the most critical determinants of vertebrate diversity, showing a strong positive correlation with both species richness and abundance. Green spaces, parks, and peri-urban agricultural lands act as ecological refuges, providing food, nesting sites, and shelter for a variety of species [6]. Studies in Berlin and Moscow have shown that increasing the connectivity of green corridors significantly enhances urban biodiversity and facilitates species dispersal [7]. Thus, maintaining vegetative structures and ecological corridors is vital for the conservation of vertebrate communities within cities.

The negative effects of anthropogenic noise, light pollution, and human population density on vertebrate distribution are also well documented in global studies [8]. High noise levels disrupt communication and mating behaviors in birds and amphibians, while artificial lighting interferes with circadian rhythms and navigation in nocturnal animals [9]. In our study, areas with high illumination and constant traffic noise exhibited a marked reduction in nocturnal vertebrate activity, consistent with research conducted in Seoul and Prague [10].



An important finding is the gradual shift toward community homogenization, where generalist and invasive species dominate urban faunal assemblages [11]. This trend has significant ecological implications: the loss of specialized species reduces ecosystem complexity and resilience, while dominance of generalists increases competition and disease transmission risks [12]. Moreover, such homogenization weakens local ecological identity, diminishing the uniqueness of regional fauna [13].

The results also highlight the necessity of integrating biodiversity considerations into urban planning. Sustainable urban development must include measures such as green infrastructure expansion, pollution control, and habitat restoration to mitigate biodiversity loss [14]. Establishing urban ecological monitoring systems could further help in tracking species dynamics and evaluating the success of conservation initiatives.

In summary, the present study contributes to the growing body of urban ecology research by providing empirical evidence from Central Asia — a region where urbanization is progressing rapidly but ecological data remain scarce [15]. The findings emphasize that vertebrate fauna formation and transformation in cities are not random processes but are closely linked to anthropogenic gradients, environmental quality, and habitat heterogeneity.

Conclusion

This study provides comprehensive insights into the processes shaping the vertebrate fauna in urban areas and the consequences of their anthropogenic transformation. The results demonstrate that urbanization significantly alters the composition, diversity, and ecological structure of vertebrate communities, leading to a decline in species richness and an increase in the dominance of synanthropic and generalist taxa.

The **degree of anthropogenic impact** — including habitat fragmentation, pollution, noise, and human population density — was found to be the main determinant of faunal diversity patterns. The **central urban zones** exhibited simplified communities dominated by a few adaptable species such as *Columba livia* and *Rattus norvegicus*, while **peri-urban and suburban areas** supported more diverse and ecologically balanced vertebrate assemblages. These findings highlight the strong correlation between environmental heterogeneity and species richness, confirming that habitat complexity is essential for maintaining biodiversity in urban landscapes.

Vegetation cover and the presence of green infrastructure were identified as critical factors promoting vertebrate diversity, serving as ecological refuges amid urban stressors. Therefore, conservation strategies should prioritize the preservation and restoration of green corridors, urban parks, and water-associated habitats to mitigate biodiversity loss.

The study also reveals ongoing **faunal homogenization**, characterized by the replacement of specialist species with generalists and the reduction of unique regional fauna. This process threatens ecological stability and reduces the resilience of urban ecosystems. Sustainable urban planning should integrate biodiversity management into city development frameworks, combining ecological monitoring with policy measures to protect native species and control invasive ones.



In conclusion, the formation and transformation of vertebrate fauna in urban environments are not random processes but reflect the intensity of anthropogenic influence and the capacity of species to adapt to altered habitats. Maintaining ecological diversity in cities requires a balance between development and conservation, where **urban ecology** serves as a guiding principle for achieving long-term environmental sustainability.

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