Journal of Animal Environment
(E-ISSN 2717-1396, ISSN 2717-1388)
Journal homepage: https://aejournals.org/

Original Research Paper

Effects of Artificial Light and Urbanization on Nesting Success Foraging Efficiency and Predator Avoidance in Urban Birds

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Key Words
Urbanization, Artificial light, Urban birds, Nesting success, Predator avoidance.

Abstract
Urbanization and artificial light at night are significant environmental stressors that have a major impact on wildlife ecology, especially in birds. This study was undertaken to assess the impact of artificial light and urbanization on nesting success, foraging efficiency, and predator-avoidance behavior in urban birds. The study also examined adaptive species-specific responses to urban environmental disturbances. A quantitative ecological field-based observational study was carried out throughout the urban, suburban, and semi-natural areas in order to cover different levels of urbanization and light at night. Urbanization intensity was evaluated by environmental indicators (building density, vegetation cover and traffic activity), and the intensity of artificial light was measured by digital lux meters. The success of nesting was assessed based on hatchability, chick survival, and nest abandonment rates. Direct behavioral observations were used to analyze foraging efficiency and predator avoidance behavior. Ecological data were subjected to statistical analyses, including ANOVA, regression, and correlation. The results showed that higher intensities of artificial light reduced the reproductive success of urban birds. Hatchability rate dropped from 88% in areas of low urbanization to 61% in highly urbanized areas, and chick survival rate dropped from 84% to 55%. Strong illumination during the night resulted in a rise of nest abandonment from 6% to 27%. Prey capture success decreased while feeding duration increased with urbanization, from 82% to 53% and 95 min/day to 146 min/day, respectively. In highly urbanized areas, the frequency of vigilance dropped from 19 to 9 events/hour and the predator escape response time rose from 2.4 to 5.7 seconds. The study provides compelling evidence that human-made light and urbanization can exert much ecological pressure on urban bird populations, disrupting their reproduction, feeding habits, and anti-predator responses. Protecting urban avian biodiversity requires urban planning for sustainability, controlled lighting systems and conservation-oriented habitat management.

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Received: 25th May, 2026; Revised: 6th June, 2026; Accepted: 8th June, 2026; Available Online: 07th August, 2026
(DOI): 10.70102/AEJ.2026.18.3s.46

Introduction

All natural ecosystems are rapidly changing due to urbanization and artificial light at night (ALAN), and this has a profound impact on the behavior and survival of wildlife. Urbanization and artificial light at night (ALAN) are rapidly changing all natural ecosystems, and this has a significant impact on animal behavior and survival. Birds are excellent indicators of habitat change and response because their nesting habits, feeding patterns, and defenses against predators are determined by habitat conditions. Urban lighting, such as street, building, and vehicle lights, disrupts the day-night cycle, affects circadian rhythms, and can influence reproductive behavior (Rodríguez et al., 2021; Wang et al., 2021). Urbanization also alters the structure of the vegetation, availability of food and distribution of predators, creating new pressures for birds. Some birds can thrive in urban areas, while others do not, with lower breeding success and higher stress levels. The interplay between urbanization and artificial lighting is critical for understanding their effects on avian ecology, which is vital for the conservation of biodiversity and the design of sustainable cities (Ramya & Geetha, 2025; Saidova et al., 2024; Merrall & Evans, 2020). This study will examine how artificial light and urbanization affect the nesting success, foraging efficiency, and predator-avoidance behavior of urban birds. The study also aims to explore adaptive responses to urban environmental stressors by species. Most previous studies have focused on a single factor at a time, such as urbanization or artificial lighting, and have not taken a comprehensive approach to the ecological effects of combining these factors. Further, little work has been done on the interaction between predator avoidance and nesting and foraging behavior in the urban environment. There are a limited number of long-term and integrated ecological studies of urban bird adaptation. The hypothesis of this study is that as artificial light increases and urbanization grows, nesting success declines due to disruptions to reproductive behavior and increased predation risk (Katabaro et al., 2022; Passarotto et al., 2025). It's also speculated that in urban areas birds will change their foraging behavior and not be as vigilant to potential predators under high light levels. Moreover, the survival and reproductive success should be higher in urban habitats for species with greater behavioral adaptability. This study offers a comprehensive perspective on the effect of artificial light and urbanization on birds' critical ecological activities. The results could help in the design of lighting systems that are friendly to birds, as well as habitat management and sustainable urban design, in order to advance conservation efforts in urban environments.

Literature Survey

ALAN has become a significant ecological stressor, affecting wildlife behavior, biodiversity, and ecosystem stability. Ecological studies in recent years have shown that habitat structure, availability of food, and predator/prey relationships are being changed as cities grow, thereby impacting avian reproductive success and the processes of survival (Ramya & Geetha, 2025). Studies of urban ecological modeling

have revealed that wildlife species' behavioral changes are closely correlated to the environment's disturbances and anthropogenic stressors, especially in fast-urbanizing environments (Rodríguez et al., 2021). Artificial light has been the subject of several investigations that have pointed to its ability to alter bird behavior and urban colonization patterns. It was reported that light at night affects nest site selection, breeding behavior, and reproductive success in city-dwelling birds by disrupting the natural circadian rhythm and enhancing the visibility of predators (Saidova et al., 2024; Wang et al., 2021). Artificial lighting was also shown to affect nesting stability in experimental setups and to increase predation risk in urban environments (Patil, 2018). Birds also have been seen to have altered migration patterns and lost ecological connectivity due to urbanization. An investigation of migratory airspace habitats found that airspace movement efficiency and habitat accessibility are affected by urban infrastructure and night time lighting for bird species (Korpach et al., 2022). More ecological studies found that birds were also affected by environmental stressors in the city, which were detrimental to their breeding fitness, reproductive success, and long-term sustainability (Jasim, 2024). Urban conditions also affect foraging efficiency and predator-avoidance behavior. A previous study showed that noise and artificial lights impair feeding efficiency while increasing "vigilance" behavior in birds in urban gradients (Jokimäki & Kaisanlahti-Jokimäki, 2025). Experimental studies of nocturnal birds of prey also revealed that light and noise pollution affect the efficiency of prey detection and the hunting strategy (Matkarimov et al., 2025). Uncontrolled artificial light is known to create an ecological imbalance by influencing wildlife physiology, species interactions, and the biodiversity (Chen et al., 2023) was highlighted in recent ecosystem-level reviews. Nest predation studies also noted that the predation pressure on urban nesting birds are variable depending on nesting strategy and habitat structure (Ziwei & Han, 2023). All of these studies underscore the need for holistic studies that consider the synergistic impacts of urban development and artificial light on the nesting success, foraging efficiency, and predator avoidance behavior of urban birds.

Methodology

Research Design

This research is quantitative and ecological, with field-based observational analysis to assess the impact of artificial light and urbanization on nesting success, foraging efficiency, and predator-avoidance behavior in urban birds. Bird responses are compared between different urbanization levels and under different lighting levels. Ongoing studies are conducted across several breeding seasons to provide ecological reliability and reduce seasonal variation.

Figure 1 shows the sequential approach to studying the impact of artificial light and urbanization on urban bird ecology. The study brings together site selection, species identification, environmental assessment, behavior, nesting success assessment, data management, and statistical analysis to analyze

ecological and behavioral responses to multiple urban environments.

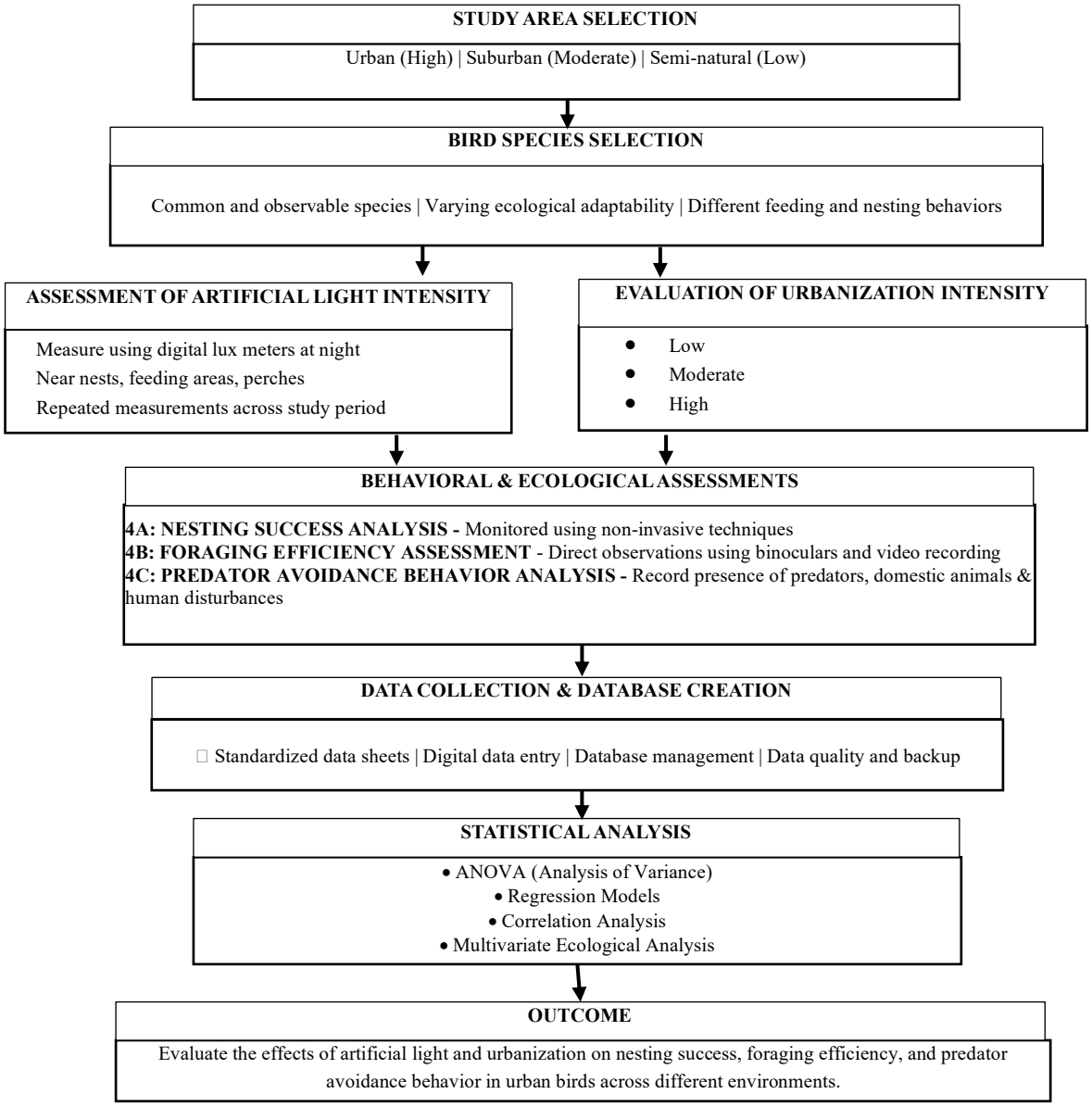

Figure 1: Methodological Framework for Assessing the Impact of Artificial Light and Urbanization on Urban Bird Ecology

Study Area Selection

The study is conducted in selected areas within urban, suburban, and semi-natural zones that have varying degrees of urbanization. Highly populated urban sites, featuring high levels of anthropogenic light and infrastructure, are compared with lower levels of anthropogenic light and infrastructure in suburban and semi-natural sites. All sampling sites have geographic coordinates, vegetation cover, traffic and human activity data.

Bird Species Selection

A range of ecologically different common urban birds are chosen for study. Species selected for study are abundant, easy to nest, easy to feed

in the study areas, and easy to see. The birds are both very urban-adapted and relatively disturbance-sensitive, to compare the behavioral and reproductive responses under different environmental conditions.

Assessment of Artificial Light Intensity

Digital lux meters are used to measure artificial light intensity at night at each study site. Data is taken close to nesting sites, feeding sites and/or resting spots. Light exposure data are recorded repeatedly throughout the study period to account for time-dependent changes driven by seasonal or climatic conditions.

Evaluation of Urbanization Intensity

Environmental indicators quantifying building density, road network coverage, human population density, traffic activity, and vegetation fragmentation are used to assess urbanization intensity. Study areas are classified as low, moderate, and high urbanization using Geographic Information System (GIS) mapping and satellite imagery analysis.

Nesting Success Analysis

Nest success is determined by checking active nests during the nesting season. Clutch size, egg hatchability, chick survival, fledgling success, and rate of nest abandonment are noted. Nest observations are carried out using non-invasive methods to minimise disturbance to breeding birds.

Foraging Efficiency Assessment

Food collection efficiency is studied directly in the field during times of greatest food availability. Parameters like feeding time, prey capture rate, search time, food handling time and feeding success rate are noted. Observations are conducted with binoculars and video recording to ensure accurate documentation of behavior.

Predator Avoidance Behavior Analysis

Predator avoidance behavior is gauged through the use of the following measures: vigilance frequency, alarm calls, escape responses, flight initiation distance, and nest defense activities. Natural predators and urban-associated threats like domestic animals and human disturbance are also recorded. Behavioral responses are quantified and analyzed between different environments that differ in the amount of artificial light exposure.

Data Collection and Statistical Analysis

Environmental measurements and field observations are documented in a standardized data sheet and digital database. The use of software (R or SPSS) for the statistical analysis. Relationships between artificial light, urbanization, and bird behavioral parameters are explored using analysis of variance (ANOVA), regression models, and correlation analysis as well as multivariate ecological analysis. The significance of the results is assessed at suitable confidence levels.

Results

Effects of Artificial Light on Nesting Success

The impact of Artificial Light on Nesting Success The results showed that artificial light intensity significantly affected urban birds' reproductive performance. Nesting success

(hatchability, nestling survival, and nest abandonment) was found to be lower in highly illuminated urban areas than in areas with less illumination. Nighttime lighting caused continuous disturbance to normal incubation/breeding activity, which ultimately resulted in negative impacts on nesting success. The disproportionate reproductive impact was highest in species nesting near roadsides, commercial areas, and densely populated residential areas.

Table 1: Impact of Artificial Light Intensity on Nesting Success in Urban Birds

Study Area Category	Average Light Intensity (Lux)	Hatchability Rate (%)	Chick Survival Rate (%)	Nest Abandonment Rate (%)
Low Urbanization Zone	8	88	84	6
Moderate Urbanization Zone	22	76	71	14
High Urbanization Zone	48	61	55	27

As artificial light intensity increases, so does reproductive performance in urban bird populations as is shown in table 1. The results show that increasing light exposure has a negative effect on hatchability and chick survival and increasing nest abandonment rates. Results of the statistical analysis showed that there was a strong negative correlation between artificial light intensity and nesting success. Birds living in dark ambient light had more reproductive stability while birds living in bright ambient light in the urban area had an increase in ambient stress and reproductive disturbance. The effect of urbanization on foraging efficiency.

Influence of Urbanization on Foraging Efficiency

The feeding behavior and use of resources of bird species was strongly influenced by urbanization. Urban adapted birds had longer feeding times and more dependence on anthropogenic food items. Disturbance-sensitive species, however, had decreased prey capture efficiency and increased food search time in densely urbanized habitats. Artificial light also shifted foraging times to the night, impacting normal foraging patterns.

Predator Avoidance Behavior Under Urban Conditions

The ability of fish to detect and avoid predators in urban areas. The study also found that levels of artificial lighting and urban disturbance affected predator avoidance strategies. High night light exposure resulted in less vigil behavior and slower escape responses. Predation risk from nocturnal predators and domestic animals was also greater due to more nests being visible under artificial lighting. Other flexible bird species responded to these pressures by choosing hidden nesting sites and by increasing their alarm calls.

Figure 2 shows urbanisation intensity effects on ecological behaviours among urban birds. The feeding duration increased as the degree of urbanization increased, while the degree of success in capturing prey and the vigilance rate

decreased with increasing urbanization. Under highly urbanized conditions, the escape response time also showed an increase, suggesting that the predator avoidance ability of birds in urban areas is reduced, and their behavioral adaptation is altered.

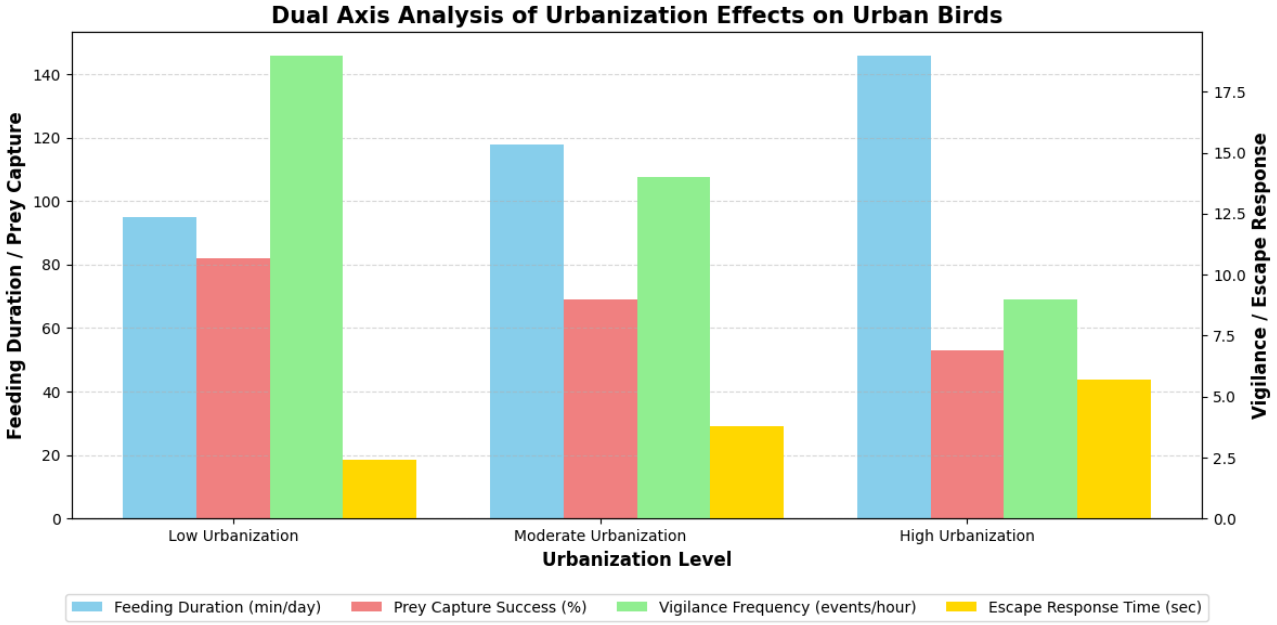

Figure 2: Dual Axis Representation of Urbanization Effects on Foraging Efficiency and Predator Avoidance in Urban Birds

Species-Specific Adaptive Responses

There were distinct differences in species throughout the study. Pigeons and crows, which are generally adaptable, had fairly consistent nesting success and efficiency in urban areas, and other bird species, including insectivorous and habitat-specialist species, had lower nesting rates and higher ecological sensitivity. The traits of behavioral flexibility, dietary adaptability and tolerance to human disturbance arose as significant survival traits in the urban ecosystem.

Discussion

This study showed that birds in cities had significantly lower nesting success, higher foraging efficiency and increased avoidance of predators compared to the artificial light level. There were significant negative effects from the intensity of artificial light, with hatchability decreasing from 88% in less urbanized areas to 61% in the most highly urbanized areas. Chick survival also plunged from 84% to 55%, and so did nest abandonment which moved from 6% to 27%. Foraging time was 95 min/day in low urbanization regions, and 146 min/day in highly urbanized regions, suggesting changes in foraging behaviors with urbanization. However, the proportion of prey caught fell from 82% to 53% and vigilance events per hour fell from 19 to 9 events/hour. The time it takes predators to escape reaction time rose from 2.4 to 5.7 seconds in highly urbanized conditions. The findings indicate that birds' normal ecological activities are affected by artificial light exposure and environmental disturbances in urban areas. The hypothesis that nesting success is reduced is

associated with circadian rhythm disturbance, high stress levels and predator visibility of the nests. These longer feeding times and lower success at securing prey suggest that urban birds should be spending more energy on acquiring natural food. The reduction in vigilance frequency and escape response delay suggests a decrease in anti-predator responses when the animals are continuously lit up and disturbed by humans. The results of this study suggest that the urban environment is highly stressful for bird populations, both behaviourally and physiologically. The research underscores the impact of the uncontrolled expansion of urban areas and over-lighting at night on birds' biodiversity. The results highlight the need for sustainable urban planning, artificial lighting management and habitat conservation to alleviate the ecological stresses of urban wildlife. Results can help conservation biologists and decision-makers create urban ecologies that are compatible with birds and the conservation of biodiversity. The findings of this study may be limited in their generalizability by the specific urban regions studied and the limited number of bird species. Little research was conducted on seasonal migration, climatic variability, and long-term physiological effects. Further, the observational research design restricts the capacity to establish firm causal links between variables of urbanization and changes in behaviour. Future research efforts are needed that have more extensive geographic sampling and are conducted over a longer period of time to better understand the cumulative effects of urbanization on bird populations. Use of advanced tracking technologies, bioacoustic analysis, and physiological stress indicators can give more insight into the mechanisms for behavioral adaptation. Comparative studies of migratory and non-migratory species could further elucidate species-specific resilience to urban stressors. Other research related to urban green infrastructure and light-use planning could also play a role in creating more sustainable and nature-friendly cities.

Conclusion

This research investigated how these artificial light and urbanization effects impact nesting success, foraging efficiency and predator avoidance behavior in urban birds. Nature's environmental conditions have changed with the rapid urban development and increased use of artificial lighting, resulting in major behavioral and reproductive problems for urban birds. The findings showed that urbanisation and night time light exposure had a negative impact on bird ecology and survival related behaviour. The hatchability rate fell from 88% in low urbanization areas to 61% in high urbanization areas, while chick survival rate in high urbanization zones was 55%. There was a significant rise in nest abandonment from 6% to 27% when exposed to high levels of artificial light. Likewise, feeding time rose from 95 min/day to 146 min/day, reflecting increased energetic requirements in urban areas. The prey capture rate, however, fell to 53%, and the rate of vigilance events per hour dropped from 19 to 9 events/hour, indicating a reduced ecological efficiency and diminished predator avoidance ability. It also took more time to escape (2.4 seconds to 5.7 seconds) in areas with high

urbanization. In summary, it is important to note that the cumulative environmental impacts of artificial light and urbanisation on urban birds are manifested in a variety of ways, including impacts on reproduction, feeding performance and anti-predator behavior. The conclusion of this research is that the sustainable management of urban planning, artificial lighting systems and conservation of urban green habitat are key factors in reducing the loss of biodiversity and ensuring long-term coexistence between urban development and conservation of wildlife.

Author contribution

Conflict of interest

The authors declare no conflict of interest.

Funding

This research received no external funding.

Ethical consideration

This study followed ethical guidelines for wildlife research by using non-invasive observational methods to minimize disturbance to birds and nesting habitats. No birds were captured or experimentally manipulated. Nest monitoring and environmental assessments were conducted responsibly while adhering to biodiversity conservation principles and local wildlife protection regulations throughout the research process.

References

[1] Chen, Sihao, Yu Liu, Samantha C. Patrick, Eben Goodale, Rebecca J. Safran, and Emilio Pagani-Núñez. "A multidimensional framework to quantify the effects of urbanization on avian breeding fitness." *Ecology and Evolution* 13, no. 7 (2023): e10259. https://doi.org/10.1002/ece3.10259

[2] Jasim, A. T. "Investigating the Potential of Remote Sensing for Sustainable Urban Renewal and Regeneration: A Review." *International Academic Journal of Science and Engineering* 11, no. 1 (2024): 54-64. https://doi.org/10.9756/IAJSE/V11I1/IAJSE1108

[3] Jokimäki, Jukka, and Marja-Liisa Kaisanlahti-Jokimäki. "Nest predation pressure differs between urban ground-and hole-nesting birds: evidence from a multi-year artificial nest predation experiment." *Birds* 6, no. 2 (2025): 22. https://doi.org/10.3390/birds6020022

[4] Katabaro, Justine Mushobozi, Yonghong Yan, Tao Hu, Quan Yu, and Xiang Cheng. "A review of the effects of artificial light at night in urban areas on the ecosystem level and the remedial measures." *Frontiers in Public Health* 10 (2022): 969945. https://doi.org/10.3389/fpubh.2022.969945

[5] Korpach, Alicia M., Colin J. Garroway, Alex M. Mills, Valerie von Zuben, Christina M. Davy, and Kevin C. Fraser. "Urbanization and artificial light at night reduce the functional connectivity of migratory aerial habitat." *Ecography* 2022, no. 8 (2022): e05581. https://doi.org/10.1111/ecog.05581

[6] Matkarimov, I., M. H. Sallaah, U. Salayev, S. Kumar, D. Khaitova, and R. Udayakumar. "Climate-induced stress and

disease dynamics in aquaculture species." *International Journal of Aquatic Research and Environmental Studies* 5, no. 1 (2025): 1-11. https://doi.org/10.70102/ijares/v5s1/5-s1-01

[7] Merrall, Eve S., and Karl L. Evans. "Anthropogenic noise reduces avian feeding efficiency and increases vigilance along an urban–rural gradient regardless of species' tolerances to urbanisation." *Journal of Avian Biology* 51, no. 9 (2020). https://doi.org/10.1111/jav.02341

[8] Passarotto, Arianna, Chiara Morosinotto, and Patrik Karell. "Experimental noise and light pollution alter prey detection in a nocturnal bird of prey." *Journal of Animal Ecology* 94, no. 7 (2025): 1398-1409. https://doi.org/10.1111/1365-2656.70062

[9] Patil, P. J. "An Ecological Analysis of Forest Accounting." *International Academic Journal of Innovative Research* 5, no. 1(2018), 109–127. https://doi.org/10.9756/IAJIR/V5I1/1810010

[10] Ramya, V., and K. Geetha. "Agent-Based Modelling of Cross-Species Behavioral Dynamics: Insights for Managing Human–Wildlife and Ecosystem Conflicts." *National Journal of Animal Health and Sustainable Livestock* 3, no. 1 (2025): 18-25.

[11] Rodríguez, Airam, Paula Maiten Orozco-Valor, and José Hernán Sarasola. "Artificial light at night as a driver of urban colonization by an avian predator." *Landscape Ecology* 36, no. 1 (2021): 17-27. https://doi.org/10.1007/s10980-020-01132-3

[12] Saidova, Kamola, Yoqutxon Muydinova, Rustam Turakulov, Umrzak Jumanazarov, Azamat Khudoykulov, Olima Kholmurodova, Kurbonalijon Zokirov, and Bobir Odilov. "Investigating the role of community based conservation in promoting sustainable wildlife management." *International Journal of Aquatic Research and Environmental Studies* 4, no. S1 (2024): 95-100. https://doi.org/10.70102/IJARES/V4S1/16

[13] Wang, Jhih-Syuan, Mao-Ning Tuanmu, and Chih-Ming Hung. "Effects of artificial light at night on the nest-site selection, reproductive success and behavior of a synanthropic bird." Environmental Pollution 288 (2021): 117805. https://doi.org/10.1016/j.envpol.2021.117805

[14] Ziwei, Meng, and Ling Li Han. "Scientometric review of sustainable land use and management research." *Aquatic Ecosystems and Environmental Frontiers* 1, no. 1 (2023): 21-24. https://doi.org/10.70102/AEEF/V1I1/5