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Impact of noise pollution on avian behaviour

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Abstract
Noise pollution is increasingly recognized as a critical environmental stressor affecting avian species worldwide. Birds depend heavily on acoustic signals for communication, reproduction, predator avoidance, and social interaction. Anthropogenic noise from urbanization, transportation, and industrial activities interferes with these acoustic signals, forcing behavioural adjustments that may compromise survival and fitness. This paper explores the impact of noise pollution on avian behaviour, focusing on vocal communication, mating success, foraging efficiency, vigilance, and parental care. It also examines case studies, including findings from India, to highlight the regional implications of this global issue.

Keywords: India, noise pollution, avian behaviour, acoustic communication, urban ecology, bioacoustics

Introduction
Birds are among the most acoustically dependent vertebrates, relying on songs and calls for essential functions such as territory defense, mate attraction, and warning signals (Brumm & Slabbekoorn, 2005) [2]. The rapid expansion of anthropogenic noise has disrupted these behavioural patterns, leading to significant ecological consequences (Barber *et al*., 2010) [1]. In urban and peri-urban areas, chronic noise exposure forces birds to adapt their behaviour in ways that may reduce reproductive success, alter community structures, and increase vulnerability to predators (Francis *et al*., 2009) [3]. This study synthesizes research on the behavioural impacts of noise pollution on birds, with an emphasis on both global and Indian contexts.

Methodology
This paper is designed as a review-based study, synthesizing global and Indian research on the effects of noise pollution on avian behaviour. The methodology involved three key steps:

Literature Collection
- Peer-reviewed journal articles were retrieved from databases such as *Scopus, Web of Science, Google Scholar,* and *PubMed* using keywords including *noise pollution, birds, avian behaviour, urban ecology,* and *India*.
- Reports from Indian journals such as the *Indian Journal of Ecology*, *Journal of Environmental Biology*, and *Indian Birds* were prioritized to capture region-specific studies.

Selection Criteria
- Studies published between 2000 and 2023 were included, focusing on behavioural responses of avifauna to anthropogenic noise.
- Both experimental studies (e.g., controlled playback experiments, field spectrogram analyses) and observational surveys (e.g., species richness counts in noisy vs. quiet habitats) were considered.
- Global studies were reviewed for conceptual framing, while Indian studies were highlighted for case-specific insights.

Data Synthesis and Comparative Analysis
- Observed behavioural responses (song modification, foraging efficiency, vigilance, reproductive success, parental care, and roosting behaviour) were categorized thematically.

- Case studies from Indian cities (Bangalore, Delhi NCR, Chennai, Jaipur, and Mumbai) were synthesized and compared in tabular form to highlight regional differences.
- Emphasis was placed on both short-term behavioural adaptations and potential long-term ecological consequences.

This structured methodology allows the paper to provide a comprehensive synthesis of existing knowledge, bridging global literature with region-specific Indian studies.

Effects on Vocal Communication

Noise pollution directly masks bird songs, leading to signal degradation (Slabbekoorn & Peet, 2003) [4]. Many species compensate by increasing song frequency, amplitude, or repetition rate a phenomenon known as the Lombard effect (Brumm & Slabbekoorn, 2005) [2]. While these modifications may help in immediate communication, they can reduce song complexity and effectiveness in mate attraction. For example, urban populations of species like the house sparrow (*Passer domesticus*) and Oriental magpie robin (*Copsychus saularis*) in India have been observed altering their vocalizations to adapt to high traffic noise (Sreekumar & Balakrishnan, 2012) [7].

Impact on Reproductive Behaviour

Courtship displays and mate selection are strongly influenced by vocal cues. In noisy habitats, reduced effectiveness of mating calls leads to lower pairing success and decreased reproductive output (Shannon *et al*., 2016) [5]. Female birds often avoid noisy territories, which reduces nesting density in urban centers. Indian studies have reported lower nesting success in high-noise zones, particularly among common mynas (*Acridotheres tristis*) and pigeons (*Columba livia*), (Kumar & Rao, 2019) [9].

Foraging and Vigilance Behaviour

Anthropogenic noise masks the sounds of both prey and predators, disrupting foraging efficiency and vigilance (Barber *et al*., 2010) [1]. Birds spend more time scanning for threats in noisy environments, which reduces the time available for feeding. In flocking species, alarm calls are often masked by background noise, compromising group defense strategies (Francis *et al*., 2009) [3]. Studies in Indian cities have documented reduced feeding time in urban crows and parakeets exposed to high levels of traffic noise (Chakraborty & Manjrekar, 2018) [8].

Parental and Social Behaviour

Noise pollution interferes with parent-offspring communication, particularly begging calls of chicks (Brumm & Slabbekoorn, 2005) [2]. Masking of these calls reduces feeding efficiency and increases chick mortality. Social interactions within flocks are also disrupted, as coordination and cohesion rely on acoustic signals. In densely populated Indian cities, disruptions in communal roosting behaviour of starlings and mynas have been observed due to persistent night-time noise (Rajalakshmi & Narayan, 2017) [10].

Case Studies from India

- **Bangalore-Song Modifications in Urban Birds:** Species such as purple sunbirds (*Cinnyris asiaticus*) and red-vented bulbuls (*Pycnonotus cafer*) modify song frequency and timing to avoid masking by traffic noise (Sreekumar & Balakrishnan, 2012) [7].
- **Delhi NCR-Decline in Species Richness and Foraging Behaviour:** House sparrows and common mynas show reduced foraging bouts, while pigeons abandon nests near flyovers due to continuous traffic and construction noise (Kumar & Rao, 2019) [9].
- **Chennai-Roosting and Breeding Behaviour:** Noise from industrial and port areas disrupts communal roosting in parakeets and starlings, with delayed breeding and reduced nesting density (Rajalakshmi & Narayan, 2017) [10].
- **Jaipur-Temple Birds and Firecracker Noise:** Festival firecrackers cause panic flights and chick mortality in pigeons, parakeets, and mynas (Jha & Sharma, 2014) [6].
- **Mumbai-Coastal and Wetland Birds:** Noise from construction and vehicular traffic near wetlands masks alarm calls in gulls and waders, increasing predation on chicks (Chakraborty & Manjrekar, 2018) [8].

Comparative Summary of Avian Behavioural Responses in Indian Cities

City/Region	Species Affected	Observed Behavioural Response	Primary Source of Noise
Bangalore	Purple Sunbird, Red-vented Bulbul	Song frequency and timing shifts; dawn singing advanced	Road traffic
Delhi NCR	House Sparrow, Common Myna, Rock Pigeon	Reduced foraging bouts; nest abandonment	Highway traffic& construction
Chennai	Rose-ringedParakeet, Starlings	Disrupted communal roosting; reduced nesting density	Industrial & port noise
Jaipur	Parakeets, Pigeons, Mynas	Panic flights; chick mortality; roost abandonment	Firecrackers (festivals)
Mumbai	Waders, Gulls	Alarm calls masked; higher predation on chicks	Coastal construction vehicular traffic

Mitigation and Conservation Strategies

Mitigation of noise impacts on avian behaviour requires integrating acoustic ecology into urban planning. Strategies include noise-buffer green belts, stricter regulations on traffic and industrial noise near sensitive habitats, and creation of urban "quiet zones" (Shannon *et al*., 2016) [5]. Public awareness campaigns can also play a role in reducing noise during sensitive breeding seasons (Jha & Sharma, 2014) [6].

Discussion

The findings reviewed in this paper highlight that noise pollution is a pervasive disruptor of avian behaviour across ecosystems, but the extent and nature of impacts vary between global and Indian contexts.

Globally, much research has focused on song modification and reproductive consequences, particularly in temperate species such as great tits (*Parus major*) and nightingales (*Luscinia megarhynchos*), (Slabbekoorn & Peet, 2003; Brumm & Slabbekoorn, 2005) [4, 2]. These studies show that birds in noisy habitats adjust song frequency, amplitude, or timing to compensate for masking. Such behavioural plasticity provides short-term benefits but may reduce song

complexity and effectiveness in mate selection (Shannon *et al*., 2016) [5].

In India, research has primarily concentrated on urban species such as house sparrows, bulbuls, mynas, and parakeets (Sreekumar & Balakrishnan, 2012; Kumar & Rao, 2019) [7, 9]. These species demonstrate song adjustments and altered foraging patterns in noisy environments, but the broader ecological consequences remain underexplored. Unlike global literature, which has extensively documented physiological stress (e.g., corticosterone responses) and long-term population shifts (Barber *et al*., 2010) [1], Indian studies often remain site-specific and descriptive, focusing on species richness or anecdotal observations (Jha & Sharma, 2014; Rajalakshmi & Narayan, 2017) [6, 10].

Another important difference is the unique noise sources in India. While traffic and industrial noise are common globally, Indian avifauna also faces disturbances from religious festivals, firecrackers, and continuous urban construction. These episodic yet intense noise events cause panic flights, roost abandonment, and higher chick mortality (Jha & Sharma, 2014) [6]. Such culturally specific noise sources are less documented in Western contexts, underscoring the need for regionally tailored mitigation strategies.

Research Gaps

- **Physiological Stress Studies:** Few Indian studies have measured stress hormones (e.g., corticosterone) in birds exposed to chronic noise, a well-established approach in global research.
- **Longitudinal Monitoring:** There is a lack of long-term datasets tracking population-level changes in noisy habitats in India.
- **Habitat-Specific Impacts:** Most Indian research focuses on urban birds; less is known about the effects of noise on **wetland and forest birds**, which are also heavily dependent on acoustic communication.
- **Community-Level Interactions:** Global research suggests that noise pollution alters predator-prey dynamics and species interactions (Francis *et al*., 2009) [3], but such ecological networks remain underexplored in Indian contexts.

Future Directions

- Integrating bioacoustic monitoring with GIS-based noise mapping to identify urban “acoustic hotspots”.
- Conducting comparative studies between noisy and quiet habitats to quantify reproductive and survival differences.
- Expanding research to include physiological and ecological consequences, moving beyond descriptive observations.
- Collaborating with urban planners and policymakers to design noise-buffer strategies in Indian cities.

Conclusion

Noise pollution significantly alters avian behaviour, particularly in communication, reproduction, foraging, vigilance, and parental care. These disruptions compromise fitness and survival, leading to long-term population declines and ecological imbalances. Indian case studies underscore that rapidly urbanizing regions face unique challenges in managing avian behavioural impacts of noise. A combination of conservation strategies, policy interventions, and urban ecological planning is essential to safeguard avian biodiversity in increasingly noisy environments.

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