EFFECTS OF URBAN DEVELOPMENT ON VOCALIZATIONS AND BEHAVIOUR OF RED-VENTED BULBUL (*Pycnonotus cafer*)

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This study investigates the effects of urban development on the vocalizations and behavior of the Red-vented Bulbul *(Pycnonotus cafer*), focusing on responses to different land use systems and encounters with different predators; particularly, how urban development influences their behavior and vocalizations in response to different land use systems and encounters with predators. Objectives include identifying the vocal repertoire of Red-vented Bulbuls, examining the effect of predators and land use systems on vocalization responses, and monitoring aggressive behavior towards predators across different habitats. The study was conducted over duration of 6 months in three distinct sites: urban, semi-urban and natural habitats. A total of 18 individual birds were observed across these sites, selected randomly to ensure a representative sample. Recordings were conducted using a Marantz PDM661 solid state recorder and Senheiser MKH 20 microphone. Bird behavior was observed during vocal recordings and Raven 1.2.1. Software was used for acoustic analyses. Predator exposure experiments involved the presentation of actual size owl and cat models, representing avian and terrestrial predators respectively. Trials were conducted near the birds' nests. Each trial lasted for 5 minutes after the Bulbul's first call and then the Bulbuls' aggressive behavior and alarm calls were recorded. Vocalizations were analyzed revealing three distinct call types: Comfort calls, Gathering calls, and Alarm calls. This study reveals significant variations in vocal call characteristics among Red-vented Bulbuls in different habitat types. Urban habitats showed higher mean number of notes, number of notes in first 20 seconds, fundamental frequency, most expressed frequency and inter-note duration. ($p<0.05$) This explains heightened environmental stressors in urban areas due to human development anthropogenic disturbances. Notably, urban habitats elicited the highest response rates to predator models compared to semi-urban and natural habitats. The differential response of Red-vented Bulbuls to predator models across habitat types, with higher response rates observed in urban habitats, emphasizes the heightened vigilance and adaptive behavior of these birds in urban environments. This highlights the urgency for sustainable urban planning and habitat management practices to mitigate the effects of urbanization. This study provides valuable insights for future urban planning initiatives aimed at minimizing negative effects on wildlife.

Keywords: Behaviour, Predators, *Pycnonotus cafer,* Red-vented Bulbul,

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1. INTRODUCTION

The increasing human population has led to converting natural habitats into urban areas, resulting in a transition from natural to semi-urban and urban habitats. Urban development significantly impacts the environment, causing habitat loss, fragmentation, and pollution. This has long-term consequences for humans and wildlife, affecting air and water quality, climate patterns, and ecological balance. Habitat loss is a significant issue, as animals are forced to adapt to urban environments or migrate to new areas. Some organisms may migrate out of the area, some species go extinct, or some may adapt to survive in an urbanized environment. Urban development produces some of the greatest local extinction rates and frequently eliminates the large majority of native species (Vale &Vale, 1976) Birds, are one of nature's most beautiful creatures and are highly threatened by environmental pollution and urbanization. Deforestation, land alteration, and the application of chemicals to crops and residential areas have led to various repercussions for birds' survival in human-altered landscapes. Birds have adapted their lifestyles to cope with urbanization. Key modifications in their lifestyle due to urbanization include changes in diet and foraging patterns, and many urban birds have adapted to include human-generated food sources. They have learned to scavenge from garbage bins, feed on discarded food etc. Loud noises cause physical damage to sensory hair cells, causing irreversible hearing loss in animals. Noise pollution can also lead to behavioral changes. Urbanization can lead to changes in birds' social behaviour, such as forming larger flocks to increase their chances of finding food and protecting themselves from predators. However, few studies have been conducted in Sri Lanka on the vocalization of animals with urbanization. *Pycnonotus cafer* (Red-vented Bulbul) is a common species found in various parts of Asia. These monogamous birds form long-lasting pair bonds and breed between June and September, with a typical clutch of 2 or 3 eggs (Vijayan, 1980). As omnivores, they can be affected by pollutants in their environment through their food, which can be transferred to the birds when they eat contaminated foods. Therefore, the Red-vented Bulbul is a suitable model organism to investigate how they have survived when a natural habitat has been transformed into urban environments.

Research Question

Do Red-vented bulbuls use different alarm calls and display different behaviour when they are in different land use systems and encounters with different predators?

Aim

The aim of this study was to understand how urban development influences the behaviour and vocalizations of Red-vented Bulbuls, particularly in response to encounters with predators in location with different land use patterns.

Specific Objectives

1. To identify the vocal repertoire of Red-vented Bulbuls.
2. To investigate the effect of predators and land use systems (urban, semi-urban and forest) on the vocalization response of Red-vented Bulbul
3. To monitor the aggressive behavior of Red-vented Bulbul in response to different predators and land use systems. (urban, semi-urban and forest).

2. METHODOLOGY

The research was conducted in three study sites: The Open University of Sri Lanka, Nawala premises, (Latitude: 6.9094° N Longitude: 79.8988° E) Jaela residential area, (Latitude: 7.0655° N Longitude: 79.9307° E) and Muthurajawela Sanctuary. (Latitude: 7.0578° N Longitude: 79.9442° E) The study spanned a duration of 6 months. A total of 6 individual birds were sampled at each site, with sampling conducted in 3 different locations within each study area. Individuals were selected randomly to minimize bias. The calls of bulbuls were recorded using a Marantz PDM661 solid-state recorder and Sennheiser MKH 20 microphone fitted with a Telinga parabolic reflector. Previously recorded calls were played back to attract birds and induce a response. Once an individual started responding in the recordable zone and started responding, their calls were recorded for 5-10 minutes. During these recordings, the bird behaviour accompanying the calls was observed and noted with the different patterns of vocal types were categorized first. The program Raven 1.2.1 (Bioacoustics Program, Cornell Lab of Ornithology, New York) was used for acoustic analyses and measurements.

Predator Exposure Experiments

Cats and owls are common predators in many urban environments, and they are relatively easier to study compared to some other predators. Cat is a terrestrial animal, and the owl is an avian animal. Therefore, these two predator models were chosen to observe how Red-vented Bulbul face terrestrial predators and avian predators. The experiment was conducted during daytime and three trials were conducted in each habitat type by presenting a handmade owl and cat model. The owl and cat were introduced to Red-vented Bulbuls about 1 meter away from their nest, positioned on a tree branch within 2 meters above ground level. Each trial lasted for 5 minutes following Bulbul's initial call, during which the aggressive behaviour of the Bulbuls was monitored, and alarm calls were recorded.

Level of Aggression towards Predator Models

Aggression scores, were recorded based on the degree of aggression of the actual bird towards the predator models.

0 = bird flew ignoring the model, no aggression
1 = bird landed within a ~2 m radius of model
2 = bird landed next to the model on the same branch/trunk
3 = bird landed closer to the model and had eye-to-eye contact on the model
4 = physically attacked the model with no vocal interaction
5 = called and physically attacked the model.

A score of 0-1 was considered as no response and a score of 2-5 was considered as a response for aggression.

The recorded data were analyzed, and the quantified data were presented statistically through tables and graphs using IBM SPSS version 20.

3. RESULTS

The study analyzed the vocal repertoires consisting of three (03) distinct types of vocal calls in the Red-vented Bulbul in Sri Lanka. Vocal call types were named Comfort calls, Gathering calls and Alarm calls. Comfort calls are melodious and sweet, used to maintain communication and social bonds within a group. It was observed that the inter-note duration was notably longer compared to other call types with a consistent occurrence of single notes following each other at uniform intervals. Unlike the comfort calls, the gathering calls exhibited shorter intervals between notes. A notable feature observed in the sonogram was the altering sequence of two closely spaced notes followed by a longer pause, and then another sequence of two closely spaced notes. It was observed when bulbuls sensed danger or threats; they emitted sharp and loud alarm calls. Alarm calls were typically sharp and piercing, meant

to grab attention and warn others of potential danger. Unlike comfort and gathering calls, alarm calls exhibited significantly shorter intervals between the notes. A notable feature observed in the sonogram was the consistent occurrence of single notes closely following each other in rapid succession. Each individual note in the alarm calls was tightly packed, with minimal intervals between them, emphasizing the urgency and intensity of the vocalization.

Comparison of call differences of Red-Vented Bulbul in different habitat

The findings presented in the Table 3.1 reveal that the mean number of notes in each column, number of notes in the first 20 seconds, fundamental frequency, most expressed frequency, and inter-note duration are significantly higher in urban habitats than the semi-urban habitats and natural habitats. ($p<0.05$) The difference between urban habitat, semi-urban habitat and natural habitat is significant. ($p<0.05$, one-way ANOVA with Tukey's family error post hoc test).

Table 3.1: Comparison of call differences of Red-vented Bulbul responses to the cat and owl model in different habitats (Mean ± SEM). The range is given in parenthesis.

Parameters	**Urban Habitat**		**Semi-urban Habitat**		**Natural Habitat**	
	Cat model n=6	***Owl model n=6***	***Cat model n=10***	***Owl model n=10***	***Cat model n=6***	***Owl model n=6***
Total duration (s)	2.08± 0.66 (0.77-3.52)	2.09±0.73 (0.89-3.52)	2.04 ± 0.10 (1.35-2.93)	1.98 ± 0.20 (1.30-3.20)	2.30± 0.50 (1.73-2.97)	2.32 ± 0.02 (1.93- 2.30)
Number of notes column	5.16 ± 1.83 (3-7)	3.50±2.42 (1-7)	7.86 ± 0.63 (3-7)	8.50±2.10 (2-7)	6.83 ± 2.00 (4 - 7)	6.33 ± 0.52 (4 - 9)
Number of notes in each column	8.88 ± 2.49 (4-13)	8.14 ± 3.20 (2-12)	8.62 ± 1.35 (5-12)	7.98 ± 0.35 (6-12)	6.98 ± 1.35 (5-12)	8.10 ± 2.35 (7-14)
Number of notes in the first 20 seconds	9.0 ± 2.21 (6-11)	7.66 ± 2.73 (3-11)	6.32 ± 1.73 (4-10)	8.10 ± 1.73 (3-11)	8.60 ± 2.50 (4-10)	8.10 ± 2.40 (5-12)
Number of notes in the second 20 seconds	8.75 ± 2.96 (4-13)	9.00 ± 4.12 (2-12)	7.80 ± 2.20 (2-12)	8.10± 2.12 (3-12)	9.10 ± 2.40 (3-12)	8.90 ± 2.50 (4-12)
Fundamental frequency (F0) (Hz)	2495 ± 50.71 (1110-3430)	2596 ±48.80 (1110-3550)	1364 ±26.50 (1180-1537)	1412 ±38.30 (1157-1710)	1411 ±28.60 (1230-1610)	1378.6 ± 27 (1200-1500)
Most expressed frequency (FH) (Hz)	5610 ± 11.06 (3340-9180)	4513 ±56.81 (3110-5510)	3106 ±49.30 (2844-3414)	3058±28.10 (2843-3168)	3029 ±60.90 (2620-3345)	3013 ±44.80 (2825-3332)
Inter-note duration (s)	0.15 ± 0.13 (0.01-1.02)	0.18 ± 0.07 (0.05-0.29)	0.05 ±0.00 (0.03-0.07)	0.04 ±0.00 (0.03-0.07)	0.05 ± 0.00 (0.03-0.07)	0.06 ±0.00 (0.03-0.14)

Behavioural Response

Findings show that, 100% of bulbuls responded to the cat model and 67% of bulbuls responded to the owl model in urban habitat. (n=6)(Figure 3.1) In semi-urban habitats, 100% of bulbuls responded to the owl model compared to only 50% responding to the cat model. (n=10). In natural habitats, 80% of bulbuls responded to the cat model and 60% of bulbuls responded to the owl model (n=6) the statistical analysis further underscores the significance of these findings, with a p-value of 0.05 indicating a highly significant difference in response rates among habitat types. (X^2 test, $p < 0.05$).

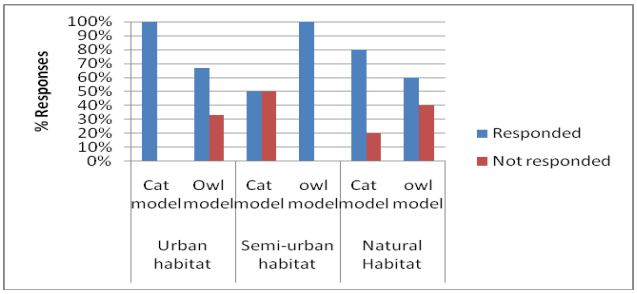

Figure 3.1: Percentage of Red-vented Bulbul responded to the cat model and owl model in urban habitat (n= 6), Semi-urban habitat (n= 10) and Natural habitat (n= 6). Score 0-1 consider as no response and 2-5 consider as the response for aggression.

4. DISCUSSION AND CONCLUSION

The higher fundamental frequency and total duration observed in gathering calls suggest their role in attracting attention and facilitating social interactions within the group. The higher mean number of node columns, mean number of notes in the first 20 seconds and mean number of most expressed frequency, in Alarm calls underscore their function as rapid and effective signals of danger. Alarm calling is a fast and effective means of signalling danger, and some animals not only respond to conspecific alarm calls but can also identify the alarm calls of other species. (Fallow et al., 2013) One of the key findings of the study is the significant variation in vocal call characteristics among different habitat types. The mean number of notes in each column, number of notes in first 20 seconds, fundamental frequency, most expressed frequency and inter-note duration is significantly higher in the urban habitat than the semi-urban habitat and natural habitat. This explains that in urban habitats, Red-vented Bulbuls experienced heightened environmental stressors and disturbances. Urban noise pollution prompts Red-vented Bulbuls to amplify their vocal signals through heightened amplitude modulation. In the face of loud ambient noise, necessitating louder vocalization for effective transmission, these birds exhibit increased intensity variations in their calls. The characteristics of anthropogenic noise include high amplitude and low-frequency sounds (typically <4 kHz) that overlap with bird signals, reducing the effective space for communication (Gill et al., 2015). Noise in bird songs disrupts their transmission and reception, leading to adaptive strategies. Birds adjust their singing frequency, pitch, complexity, intensity, and duration to cope with human-made noise. Red-vented Bulbuls in urban environments amplify their vocal signals to avoid background noise, shift their singing frequency to higher ranges, and increase the minimum or dominant frequency to increase audibility and transmission effectiveness.

The 100% response rate of bulbuls to the cat model in urban areas underscores the heightened vigilance and sensitivity of these birds to feline predators, which are common in urban environments. Conversely, the lower response rate of bulbuls to the owl model in urban habitats may be attributed to the relatively lower frequency of encounters with avian predators such as owls in urban landscapes. While owls may still pose a threat to bulbuls, their nocturnal habits and less visible presence in urban areas may result in fewer direct interactions with bulbuls. Predator densities frequently vary among sites with different levels of urbanization. For example, domestic and feral predators (e.g. cats and dogs) may attain very high densities in urban areas (Sorace, 2002). In semi-urban habitat, characterized by a mix of urban and rural elements, the response pattern reversed compared to the urban setting. Here, 100% of bulbuls reacted to the owl model, suggests a heightened awareness and vigilance towards avian predators, which may be more prevalent or pose a greater threat in semi-urban landscapes compared to domestic cats. The lower response rate to the cat model in semi-urban areas may be influenced by factors such as reduced cat populations, alternative predator pressures, or differences in habitat structure and vegetation cover that affect predator-prey interactions. In natural habitats, where human disturbance is minimal and ecosystems remain relatively intact, the observed response rates to predator models exhibit intermediary values, reflecting a balanced adaptation to the predator landscape. The 80%

response rate of bulbuls to the cat model and 60% response rate to the owl model in natural habitats suggest a moderate level of vigilance towards both feline and avian predators.

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