LSM3257 Applied Data Analysis in Ecology and Evolution

Project Report

Anthropogenic Noise Potentially Affects Vocalization of Straw-headed Bulbul (Pycnonotus zeylanicus)

Abstract

Introduction

Acoustic space is the resource that different species compete for in nature. Acoustic space can be represented by the range of sound frequency and time available in the environment (Slabbekoorn, 2017). Different species use different partitioned acoustic spaces that enable them to communicate with conspecifics without interfering with other species (Hart et al., 2021). However, increasing human activities have introduced considerable anthropogenic noise into the natural environment, resulting in a reduction in the available acoustic space (Shannon et al., 2016).

The effects of anthropogenic noise pollution on wildlife have been extensively studied (Ismail, 2018). Birds are particularly vulnerable to noise pollution because of their use of acoustic cues for long-distance communication (Vitt & Caldwell, 2009). Noise can affect the propagation of sound between the signal transmitter and receiver through the "masking effect," a process in which the loud sounds dominate the acoustic space and suppress softer sounds (Swanson et al., 2002). Anthropogenic noise is particularly detrimental because it is loud and low frequency, resulting in low attenuation rates and greater impact on the environment (Slabbekoorn, 2017). Masking of communication can limit information from conspecifics, thereby affecting their reproduction and survival rates (DeRuiter et al., 2013).

However, recent studies have shown that birds use mitigation strategies to cope with the negative effects of anthropogenic noise pollution (Brumm & Slabbekoorn, 2005). One such strategy is a shift in the timing of their vocalizations (Fuller et al., 2007; Fig 1a). Birds may reduce their vocalizations during the period when anthropogenic noise is more prevalent to avoid the masking effect (Fuller et al., 2007). This mitigation strategy has been observed repeatedly, and urbanization levels have been reported to cause more than an hour's difference in the timing of the dawn chorus of birds (Sánchez-González et al., 2021).

Another mitigation strategy is to increase the duration of vocalizations (Couter et al., 2020; Fig 1b). This may increase the chance of the acoustic signal reaching the intended recipient. This response is relatively understudied (Couter et al., 2020), as previous studies have mainly focused on the other mitigation strategies, such as changes in amplitude and vocal frequency (Brumm & Zollinger, 2011; Li et al., 2021).

**Diagram

Description automatically generatedFigure 1:** Potential mitigation strategies that birds may use in response to anthropogenic noise pollution. The blue shading shows the anthropogenic noise. (a) shows the increase in vocalization duration, (b) shows the shift in vocalization timing.

Singapore is located at the tip of the Malay Peninsula. The island has lost 95% of its primary forest since British settlement in 1819 (Brook et al., 2003). Regenerated secondary forests are highly fragmented and divided by roads, housing, and industrial facilities (Corlett, 1992). However, despite the degradation of its pristine environment, Singapore hosts a surprisingly diverse avifauna, with 413 species reported (National Parks Board of Singapore, 2022). Many bird species inhabit degraded edge habitats, including the highly sought-after Straw-headed Bulbul (Pycnonotus zeylanicus).

The population of Straw-headed Bulbul is declining globally, and this species has been listed as critically endangered by the International Union for Conservation of Nature (IUCN) Red List of Threatened Species since 2018 (Birdlife International, 2023). Singapore is home to ~500 individuals of this species, representing 20-50% of its global population (Chiok et al., 2021). Their tolerance to degraded habitat and Singapore's relatively limited songbird trade activities have allowed them to thrive in this small island state (Chiok et al., 2021).

Thus, this report aims to investigate the effect of anthropogenic noise pollution on the duration and number of vocalizations of the Straw-headed Bulbul in nature parks adjacent to the Bukit Timah Expressway (BKE), where the Straw-headed Bulbul is known to reside. This study could provide insights into the extent of anthropogenic pollution on this charismatic bird in the conservation field.

Methodology

Data Collection

The data collection was carried out in three nature parks adjacent to the BKE – Chestnut Nature Park (1°22’22”N, 103°46’49”E), Zhenghua Nature Park (1°23’7”N, 103°46’22”E), and Dairy Farm Nature Park (1°21’51”N, 103°46’35”E). Five transects were plotted perpendicularly to the BKE (Fig. 2). The sampling points were chosen along the established trails in nature parks, as permitted by National Parks Board of Singapore. At each sampling point, sound data was collected using the SwiftOne – Terrestrial Passive Acoustic Recording Units (The Cornell Lab of Ornithology; www.birds.cornell.edu). The recording units collected sound data from 0600 to 2000 every day from December 2022 to February 2023.

Diagram

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**Figure 2:** Map of transects and sampling locations perpendicularly plotted along the Bukit Timah Expressway (shown in grey). Sampling points in each transects are at 50 m (filled square), 100 m (filled circle), and 200 m (open square) away from BKE.

The collected data was processed using an acoustic analysis software, Kaleidoscope Pro (Wildlife Acoustics, Inc.; [www.wildlifeacoustics.com](http://www.wildlifeacoustics.com)). This software uses clustering algorithms to sort the sounds in the data and recognize certain bird vocalizations. We used this software to construct a classifier for Straw-headed Bulbul’s vocalizations. The classifier sorts the detected vocalizations depending on the dissimilarity from the ‘model’ vocalization of the Straw-headed Bulbul. To ensure that the detected vocalizations are those of Straw-headed Bulbul, we used a 75% precision cut-off.

Data Analysis

To understand the impact of anthropogenic noise pollution on the bird vocalization, we analysed data using R (R Core Team, 2021; [www.R-project.org](http://www.R-project.org)). The data was tidied using tidyverse package (v.2.0.0; Wickham et al., 2019) and lubraidate package (v 1.9.2; Grolemund & Wickham, 2011). The data was split into ‘off day’ which includes weekends and public holidays, and ‘weekdays’. This was because we observed less noise on off days. For our models, we had duration of the detected vocalization as well as the number of vocalizations during the dawn chorus as response variables, distance from BKE and type of days as predictor variables, and transects as a random effect. The dawn chorus was defined as the period between 06:00 to 10:00 following Gil & Llusia, 2020), and it is the period when we see the most vocal activity for most of the birds.