# Passive bioacoustic monitoring as a method to investigate noise pollution in urban parks

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**Abstract**

The acoustic landscape of a place is formed by biophony, anthropophony and geophony. Biophony comprises the sounds produced by living beings, mainly animals during their communications; geophony consists of the sounds of the geophysical environment, like a river, the rain and waterfalls. In this case study, we evaluated the effectiveness of passive bioacoustic monitoring in detecting anthropogenic pollution in an urban park in Belo Horizonte, Brazil. We used the Song Meter recorder model SM2+ from the Wildlife Acoustics, the recorders were configured to receive sounds of up to 20 Hz. Each recorder was fixed in trees 1.5 m above the ground and 2 microphones were used in each of them. The collected data were submitted to the Generalized Linear Model Test (GLMM), which resulted in a strong influence of anthropic noises on the birds' vocalization. Our results demonstrate the effectiveness of the method and point to the need for the development of public policies to mitigate the effects of noise pollution in urban parks.

**Keywords:** biophony, conservation, public policies, urbanism, one-health.

# Monitoramento passivo bioacústico como método para investigar a poluição sonora em parques urbanos

**Resumo**

A paisagem acústica de um local é formada pela biofonia, antropofonia e geofonia. A biofonia compreende os sons produzidos pelos seres vivos, principalmente os animais durante suas comunicações; a geofonia consiste nos sons do ambiente geofísico. Neste estudo de caso, avaliamos a eficácia do monitoramento bioacústico passivo na detecção de poluição antrópica em um parque urbano de Belo Horizonte, Brasil. Utilizamos do gravador Song Meter modelo SM2+ da marca Wildlife Acoustics, os gravadores foram configurados para receber sons de até 20 Hz. Cada gravador foi fixado em árvores a 1,5m do solo e foram usados 2 microfones em cada um deles. Os dados coletados foram submetidos ao teste de Modelo Linear Generalizado (GLMM), onde resultou em forte influência dos ruídos antrópicos na vocalização das aves. Nossos resultados demonstram a eficácia do método, e aponta a necessidade da elaboração de políticas públicas para mitigar os efeitos da poluição sonora em parques urbanos.

**Palavras-chave:** biofonia, conservação, políticas públicas, urbanismo, *one-health*.

## 1. Introduction

The acoustic landscape of a place is formed by biophony, anthropophony and geophony. Biophony comprises the sounds produced by living beings, mainly animals during their communications; geophony consists of the sounds of the geophysical environment (wind, rain, etc.) and finally, anthropophony concerns the sounds produced by man in urban, industrial, road activities, among others (Andrade, 2021).

Anthropogenic actions can impact the fauna of the environment, modifying the habits of the local species. Communication processes between species are also affected by the noise produced by human activities (Pieretti; Farina, 2013). This noise exerts a negative influence on species diversity and abundance (Rheindt, 2003).

Birds can use some strategies to maximize their signal transmission in places with high noise pollution, such as adjusting their temporal or frequency and amplitude parameters (Dias, 2013).
Bioacoustics helps us understand how processes related to changes in environments impact the local fauna. In this report, we analyze an anthropic area and a control area to assess the impact of anthropophony on the local fauna.

## 2. Materials and Methods

### *2.1 Study area*

The study was carried out at Parque das Mangabeiras (Figure 1), located in Belo Horizonte, Minas Gerais State, Brazil. The site is in transition between the *Cerrado* and Atlantic Forest biomes in southeastern Brazil, it is common to find Semideciduous Stationary Formation forests in these regions (Gomes et al., 2004).

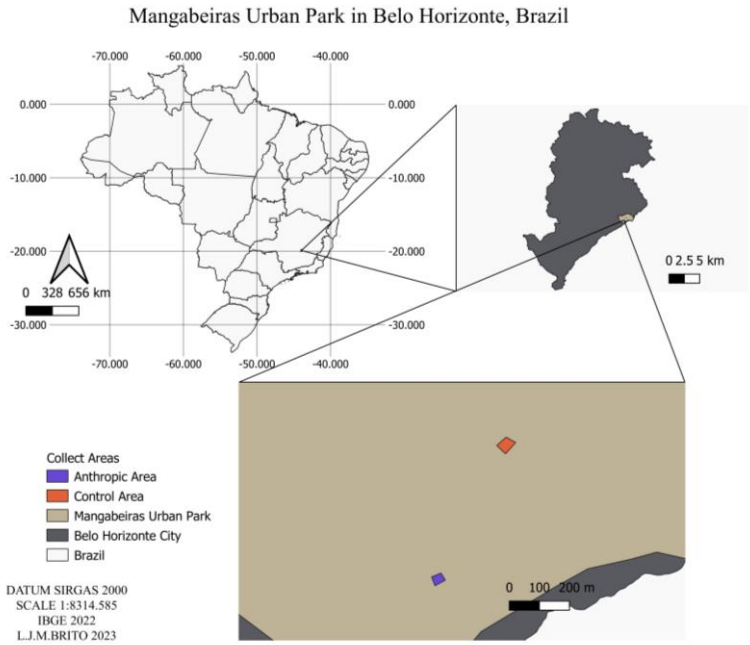


Figure 1. Collecting area in Mangabeiras Urban Park. Data collect.

Recordings were made at two different points in the park, shown in (Figure 1). The first point, close to the entrance road to the park, demonstrates an area with a high rate of anthropic noise and the second point represents the control area, located in an area with less anthropic impact.
The recordings were made using the Song Meter recorder model SM2+ from the Wildlife Acoustics brand, the recorders were configured to receive sounds of up to 20 Hz. Each recorder was fixed in trees 1.5 m above the ground and 2 microphones were used in each of them. Each recorder was turned on for 30 min during the morning period, with the park closed to visitors.

### *2.2 Data analysis*

Data were analyzed using Raven PRO 1.6 software (Yang, 2022). In the program we observed the generated spectrograms, so it was possible to identify several sounds present in the park.
We used Simpson's diversity index (“vegan” package) to estimate the sound diversity of the two points, “n” being the number of sounds in a group and “N” the total number of sounds.
Statistical analyzes were performed using the General Linear Model (GLMM) with each area sampled with a randomization factor.

## 3. Results

The main anthropic noise detected during the analysis of the recordings was from buses and cars arriving at the park (Figure 2).

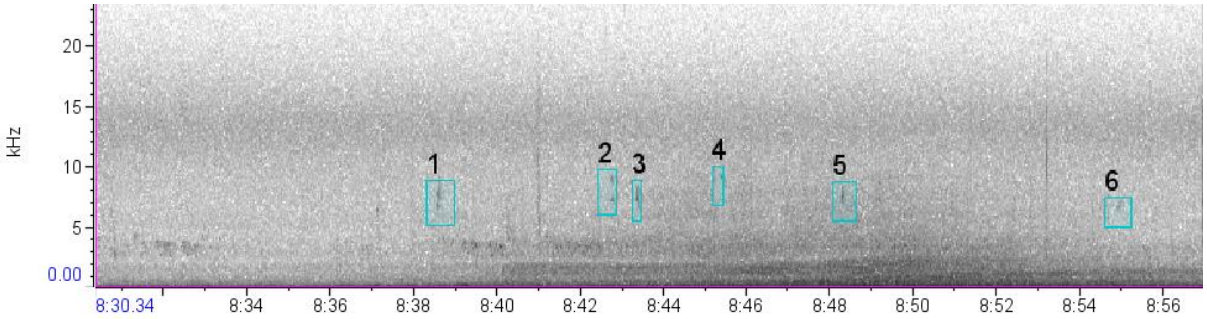


Figure 2. Spectrogram representing car sounds and bird calls highlighted in blue.

In the spectrogram, it is possible to visualize masking of the vocalization of birds in the anthropized area, since the vocalizations sampled in Figure 1 demonstrate notes between 5 and 10 kHz, and the noise of automobiles occupies the entire range between 0 and 10 kHz.

Simpson's index showed 0.11 in sound diversity for the anthropized area, and 0.35 for the control area. To confirm the result, we apply the reduction of "D" (1-D), resulting in D(anthropized area)= 0.88, and D(control area)= 0.64, as the reduction of "D", the closest value of 1 represents greater diversity, it is confirmed that the anthropized area presents greater sound diversity. By applying the GLM, it was possible to analyze whether the anthropized area influences the richness of sounds in the park (Table 1).

Table 1. Final results of the GLMM model to evaluate the effect of the anthropized area on the sound parameters of Mangabeiras Urban Park (BH-MG).

| **Sound** | **Estimate** | **Standart error** | **z value** | **p value ($\alpha < 0.05$)** |
|---|---|---|---|---|
| *Intercept* | 3.7865 | 0.5390 | 7.026 | >0.001 |
| Birds | 1.4854 | 0.3197 | 4.646 | >0.001 |
| Mammals | 24.94 | 42247.17 | 0.001 | 1 |
| Insects | -1.386 | 1.118 | -1.240 | 0.2150 |
| Amphibians | 24.25 | 42247.17 | 0.001 | 1 |
| Anthropic sounds | -0.7419 | 0.3842 | -1.931 | 0.0535 |
| Non-faunistic biophony | 23.4 | 42247.2 | 0.001 | 1 |
| Unidentifiable | 0.6931 | 0.866 | 0.8 | 0.423 |

The influence that anthropic noises have on the richness of sounds is graphically demonstrated in Figure 3, although the statistical analyzes did not demonstrate the influence of anthropic noises on any animal group, except for Birds (Table 1).

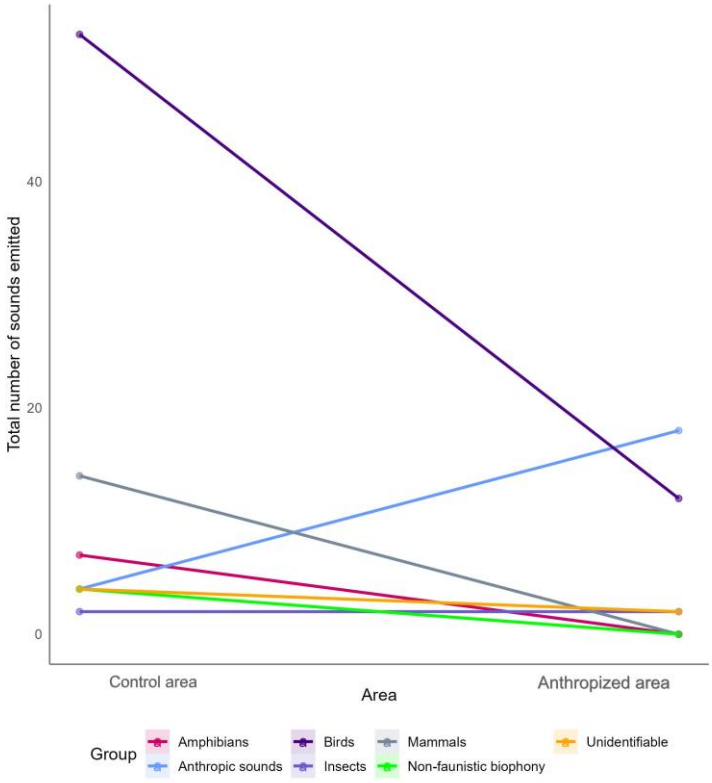


Figure 3. Number of sounds emitted by Amphibians (pink markers), Birds (purple markers), Non-Faunal Biophony (green markers), Insects (violet markers), Mammals (grey markers), Unidentifiable (yellow markers), and Anthropogenic Sounds (blue markers) in the control and anthropized areas.

**4. Discussion**

We detected the effectiveness of passive acoustic monitoring for detecting anthropic sound disturbances and analysis of sound diversity in urban parks, most of the sound categories showed a decrease in the total number of sounds emitted, mainly the group of birds, which had a significantly greater decrease, only the anthropic sounds had an increase in emission, thus being able to prove the effectiveness of the method.

We found, in all, 105 sounds, between natural and anthropogenic, corroborating the hypothesis of the efficiency of passive monitoring for detecting sounds and noise disturbance (Pugliano, 2021). The data found by the analysis through the Simpson's Index, demonstrate a drop in sound diversity from point 1 to point 2, and confirmed by the 1-D test. This decrease in sound diversity is explained by the difference in range of the recorders in relation to the obstacles present in the place where it was planted, not directly reflecting in real numbers of fauna diversity in the two places.

The present work demonstrated a significant reduction in the richness of biophony between the two areas, which can be explained by the anthropic influence. According to Caorsi (2018), several species communicate through acoustic signals, and disturbances from anthropic noise can affect messages transmitted by these animals, which serve to find mates, recognize offspring and compete for resources. Sound stimuli that startle animals can generate self-preservation responses such as fleeing and hiding, noise can also impair sensory capabilities by masking biologically relevant sounds used for communication, threat or prey detection, and spatial navigation (Francis & Barber, 2013).

Some factors had a negative impact on the execution of this work, such as the sampling effort due to the condition in which the researchers were and the weather conditions. It is necessary that in future work there is a greater sampling effort, evaluating not only on different days, but also in different urban parks, at the most different distances from areas with greater traffic of people. The results found in this study serve as a warning to the local population and the government regarding the sound quality to which urban parks are submitted, since these places have a social leisure function, and an environmental function as a genetic bank of several species of animals.

## 5. Conclusions

Passive bioacoustic monitoring was effective in measuring disturbance of biophony by anthropogenic noise, drastically reducing the number of sounds emitted by animal groups, especially birds, which depend on their vocalizations to mark territory, find sexual partners and communicate intra and interspecific.

It is essential that actions are adopted to mitigate the effects of anthropic noise in urban parks in Belo Horizonte. The implementation of urban planning strategies that reduce noise pollution, such as the creation of quiet zones or the implementation of acoustic barriers, can help to preserve the natural biophony of these spaces. In addition, it is important to make the population aware of the impacts of excessive noise on the local fauna and to promote the adoption of more sustainable and less disturbing practices. In this way, it is possible to seek a balance between urban life and the preservation of biodiversity in urban parks.

## 5. Acknowledgments

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## 6. Authors' Contributions

*Luan de Jesus Matos de Brito* & *Paula Vitória Silva*: Both authors has participate in data collecting and writing of this paper. *Luan de Jesus Matos de Brito*: performed the statistical analyzes.

## 7. Conflicts of Interest

No conflicts of interest.

## 8. Ethics Approval

Not applicable. To carry out this study, it was not necessary to issue authorization from a specific public or private institution.

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