The Effect of Noise Pollution on Pollinator Biodiversity

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ABSTRACT

Pollinators are a crucial aspect of maintaining our environment and provide virtually all of the food humans consume in order to survive on this planet. However, as the earth becomes increasingly populous, the threats that pollinators and other organisms face today are becoming more vulnerable. Noise pollution, despite having extensive consequences on local wildlife, has remained a subject relatively unstudied. My study aims to provide a greater understanding of the threats pollinators face today by analyzing the relationship between noise and pollinator biodiversity. To do this, in my study I compare a wilderness trail and a large music venue. My research determines whether the presence of noise affects pollinator biodiversity in the surrounding area and measures the significance of these effects. By using scientific observation, data collection, and scientific analysis, my study investigates and evaluates whether or not there is a correlation between exposure to high intensity noise and pollinator biodiversity.

Introduction

Pollinators, such as bees, butterflies, wasps, flies, beetles, hummingbirds, and others, play a crucial role in transferring pollen from the male part of a flower (the anthers) to the female part (the stigma) (Walker, 2020). These remarkable organisms are essential for the production of a significant portion of the world's food. Without their contribution, plants would struggle to grow, thereby jeopardizing a vital component of the human diet. Moreover, research has demonstrated that the diversity of pollinators enhances pollination during climatic disruptions (Burkle and Alarcón, 2011), potentially mitigating pollen limitations.

Furthermore, pollinator diversity has been shown to boost crop yield, aid in environmental pollution control, and assist with pest and disease management (Garibaldi et al., 2014)(Katumo, Daniel Mutavi, et al., 2022). Despite their crucial ecological roles, the existence of pollinators and their diversity is dwindling due to habitat degradation, pesticide exposure, and climate fluctuations (Dicks et al., 2021)((USDA, 2023). For instance, nearly one in four native bee species is at risk of extinction, with 24% facing serious threats (Kopec and Burd, 2017).

While some factors contributing to the decline of pollinators have been extensively studied, other potential threats remain underexplored. Noise pollution is emerging as a significant concern in increasingly urbanized areas. According to the New York City Environmental Protection, human-generated noise disrupts animal communication, mating, foraging behavior, and spatial orientation in both terrestrial and aquatic ecosystems. Some species can adapt to these disturbances, while others cannot (New York City Environmental Protection, 2023).

Research has demonstrated how noise can alter the behavior of various animals. For instance, Dieng et al. (2019) found that dubstep music impairs the prey success of mosquitoes, Kaiser et al. (2001) observed a decrease in frog mating success due to noise pollution, and Senzaki et al. (2016) noted a reduction in owl foraging success caused by traffic noise. Nevertheless, most previous research on noise pollution's impact on

wildlife has concentrated on birds and whales (Duquette et al., 2021; Weilgart, 2007). For example, Research has shown that while noise exposure indirectly increased the rate of pollination among hummingbirds, it negatively impacted animals that prey upon and disperse seeds(Francis, Clinton D., et al., 2012)

Many behaviors exhibited by pollinators involve sound or vibrations, especially in the context of low-frequency cues (Gogla, 2014). Recent research has revealed that nectar-producing plants respond to the sound of pollinators by increasing nectar production to enhance pollination success (Veits et al., 2019). Consequently, it is reasonable to assume that noise exposure could interfere with pollinators' ability to communicate or acquire food(Gogala, M., 2014). In either case, the health and abundance of pollinators may be at risk.

Despite this association, empirical research on the detrimental effects of noise pollution on pollinators is still lacking. This study aims to address this knowledge gap by investigating the relationship between pollinator biodiversity and noise. The hypothesis is that an inverse relationship exists between pollinator biodiversity and noise.

Methods

Data Collection

To investigate the impact of noise pollution on local pollinators and its broader implications for biodiversity, a set of tools was employed, which included a notebook, pencil, GPS device, and a decibel meter. The decibel meter, a scientific instrument designed for quantifying sound levels in specific locations, was particularly essential for its ability to accurately measure even inaudible or faint sounds. This precise measurement capability was pivotal for making informed scientific assessments.

To assess the hypothesis regarding the influence of sound on local biodiversity, two distinct locations were selected, each sharing similar overall environmental characteristics but differing in sound exposure. The first location (referred to as "Location A") lay within close proximity to both a major freeway and The Hollywood Bowl, a prominent music venue. The Hollywood Bowl, on average during a concert has a noise level of 88 dBa(Sound Print, 2023). In contrast, the second location, Deervale Nature Trail, (referred to as "Location B") was situated 9.8 miles away from The Hollywood Bowl and was characterized by a tranquil natural environment. Both locations are within Los Angeles. Data was collected by visiting these locations at noon, measuring the decibel levels at each site, and recording the number of pollinators present in a random 5 by 5 meter area for 15 minutes. This data collection process was conducted through a series of six trials at each location using the described methods. The data collected from these trails can be seen in Table 1.

Table 1. Raw data collected during observation trials.

Location A

Trial	Species	Count of Species
1	bees	32
	white butterfly	3
	yellow jacket	1
	wasp	1
	Total	37
2	bees	102
	yellow jacket	1
	fruit flies	102
	white butterfly	2
	Total	207
3	bees	64
	white butterfly	2
	fruit flies	40
	Total	106
4	bees	70
	white butterfly	3
	wasp	3
	fruit flies	10
	Total	86
5	bees	42
	white butterfly	10
	wasp	4
	fruit flies	20
	Total	76
6	bees	56
	white butterfly	2
	wasp	2
	fruit flies	33
	Total	93

Location B

Trial	Species	Count of Species
1	bees	20
	white butterfly	19
	monarch	2
	unknown	3
	Total	44
2	monarch	3
	white butterfly	21
	bees	16
	yellow jacket	1
	unknown	19
	Total	60
3	monarch	4
	bees	16
	white butterfly	21
	wasps	3
	unknown	12
	Total	56
4	white butterfly	14
	monarch	1
	bees	21
	yellow jacket	2
	wasps	3
	unknown	2
	Total	43
5	monarch	2
	bees	33
	white butterfly	12
	wasp	1
	yellow jacket	1
	bumble bee	1
	unknown	5
	Total	55
6	white butterfly	17
	bees	25
	monarch	3
	wasp	1
	bumble bee	1
	unknown	4
	Total	51

Data Analysis

Subsequent to data collection, a multifaceted approach was employed to analyze the gathered information, utilizing statistical methods such as the Shannon-Weiner Biodiversity Index, Linear Regression, and T-Tests. These methodologies were instrumental in gauging biodiversity and investigating the potential influence of environmental factors on biodiversity levels.

Biodiversity was calculated by using the collected species counts data in the Shannon-Weiner Biodiversity Index formula (Nolan and Callahan, 2006). This index is calculated using the formula:

$$H = -å\,Pi(lnPi).$$

A T-Test, a statistical method employed to assess differences between two groups (Kim 2015), was used in this study to evaluate the comparative biodiversity between Location A and Location B. For instance, a paired samples t-test was employed to determine if there existed a significant difference in biodiversity and sound between the two locations.

Additionally, a linear regression was employed to investigate potential correlations or causations within the collected data. This statistical tool helps discern whether the identified factors truly exhibit a correlation or if their relationship might be coincidental (Montgomery et al. 2021) . Linear regression aids in determining whether a factor genuinely impacts another or whether their apparent relationship is merely happenstance.

Results

Study Sites Characteristics

The paired T-Test sample indicated a statistical difference between pollinator diversity in Location A (Hollywood Bowl) and Location B (Deervale). The mean biodiversity in Deervale (M = 1.242) is significantly different from the mean biodiversity in Hollywood (M = 0.772), with a p-value of approximately 0.0024.

Additionally, the results of the paired T-test indicated a highly significant difference in sound levels between Location A and Location B. The mean sound level in Location A (M = 58.72 dB) is significantly different from the mean sound level in Location B (M = 37.72 dB), with a p-value of approximately 4.62E-06. This suggests that the two study areas have significantly different sound levels. All sound and biodiversity data can be seen in Table 2.

Table 2. Sound and biodiversity measurements for the two study sites.

	Location A		Location B	
Trial	Biodiversity Index (H)	Sound (dBa)	Biodiversity Index (H)	Sound (dBa)
1	0.524448027	60	1.044618786	36.8
2	0.768077497	56.8	1.302068425	38.3
3	0.747307114	58.4	1.401132318	36.2
4	0.651879952	62.3	1.273986176	38.2
5	1.100893895	56.2	1.195749308	37.4
6	0.838222795	58.6	1.236187657	39.4

The Relationship Between Noise and Pollinator Biodiversity

Finally, the linear regression analysis examined the correlation between biodiversity and sound levels. It revealed a strong and negative association between sound levels (dBa) and biodiversity (H), with an R-squared value of 0.7786. The F-statistic ($F_{(1, 10)} = 35.16$) and p-value ($p < 0.001$) both indicated the significance of this relationship (Figure 1.). Sound levels were found to explain 77.86% of the variance in biodiversity.
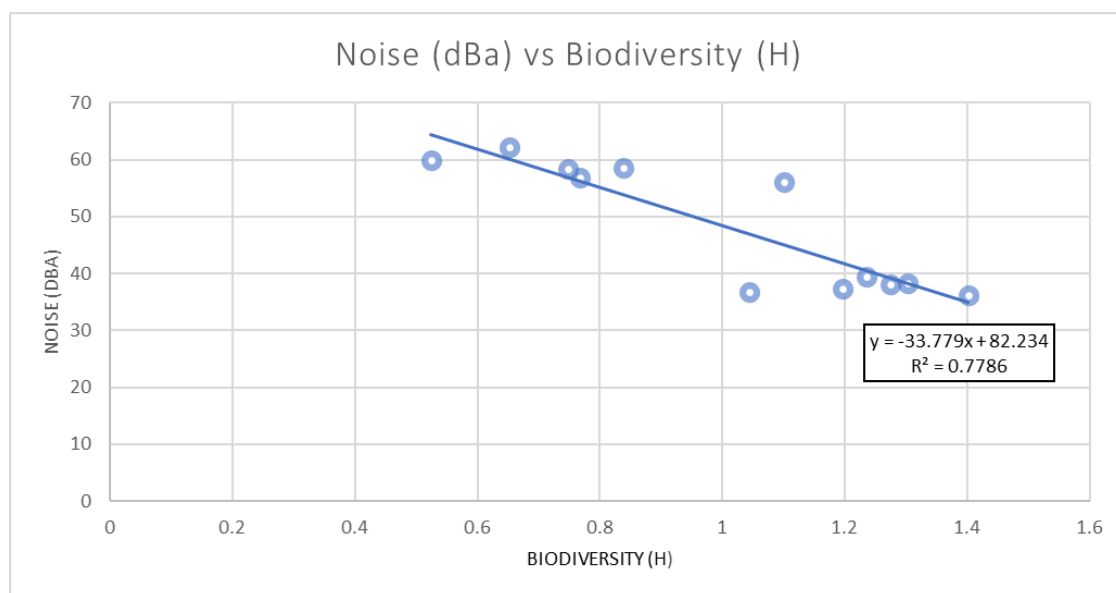

Figure 1. Linear regression in which pollinator diversity, calculated by the Shannon-Wiener Index, is compared to corresponding environmental sound levels.

Discussion

Pollinator diversity within the metropolitan area of Los Angeles showcased a decrease correlated with noise pollution in our data. This confirms our hypothesis that local pollinators, such as bees and butterflies, may either relocate from high-vibration areas or experience a decline in population due to an inability to adapt to heightened sound exposure. This decline in pollinator presence poses a significant threat to the vegetation in local neighborhoods, parks, and gardens, leading to rapid deterioration.

The city's urbanization, escalating at an annual rate of 0.1% since 2000(Atlas of Urban Expansion, 2023), has exacerbated habitat destruction as smaller cities transform into metropolitan zones. As a result, noise pollution is becoming an unavoidable side effect of this growth. Despite being often overlooked, noise pollution significantly impacts the ability of pollinators to communicate, potentially leading to their extinction if left unaddressed. This extinction poses a substantial risk as one-third of the human food supply depends on these pollinators.

My study compared two sites within the Los Angeles metropolitan area: Deervale Park, a serene wilderness trail in a quiet suburb, and the Hollywood Bowl, a large concert venue adjacent to a bustling freeway in Hollywood. The stark difference in sound exposure between the two locations was evident. Deervale Park, shielded by natural foliage, exhibited an average sound exposure of 32.2 dBa, while the Hollywood Bowl registered a significantly higher 58.71 dBa. This disparity was also reflected in the biodiversity, with Hollywood displaying a marked lack of diversity compared to Deervale. These locations underscored the detrimental impact of noise pollution on local wildlife and highlighted the vulnerability of pollinators in metropolitan areas.

Our findings strongly indicate that pollinators are significantly affected by noise pollution, emphasizing the urgency for environmental policy changes. To mitigate the impact of noise pollution on local wildlife, measures such as planting more trees to act as sound barriers, establishing designated quiet zones, reducing aircraft flights, and educating the public on climate conservation are imperative.

In conclusion, this research emphasizes the substantial impact of noise pollution on pollinator biodiversity and the broader implications of habitat destruction in metropolitan cities. The negative correlation observed between sound levels and pollinator biodiversity stresses the critical need to address the adverse effects of noise pollution on the survival and communication abilities of these vital species. As our understanding of humanity's impact on the environment grows, so does the urgency for environmental education and policy reform to protect and preserve our ecosystems.

Acknowledgments

References

Atlas of Urban Expansion. Atlas of Urban Expansion - Los Angeles. (n.d.-a).
http://atlasofurbanexpansion.org/cities/view/Los_Angeles
 The Hollywood Bowl / Los Angeles, CA / Noise Level Information. SoundPrint. (n.d.-a).
https://www.soundprint.co/location/the-hollywood-bowl-los-angeles-ca-5011216
What are pollinators. Pollinator.org. (n.d.-a). http://www.pollinator.org/pollination
Burkle, L. A., & Alarcón, R. (2011). The future of plant–pollinator diversity: understanding interaction
networks across time, space, and global change. *American journal of botany*, *98*(3), 528-538.

Dicks, L. V., Breeze, T. D., Ngo, H. T., Senapathi, D., An, J., Aizen, M. A., ... & Potts, S. G. (2021). A global-scale expert assessment of drivers and risks associated with pollinator decline. Nature Ecology & Evolution, 5(10), 1453-1461.

Dieng, H., The, C. C., Satho, T., Miake, F., Wydiamala, E., Kassim, N. F. A., ... & Morales, N. P. (2019). The electronic song "Scary Monsters and Nice Sprites" reduces host attack and mating success in the dengue vector Aedes aegypti. Acta tropica, 194, 93-99.

Duquette, C. A., Loss, S. R., & Hovick, T. J. (2021). A meta-analysis of the influence of anthropogenic noise on terrestrial wildlife communication strategies. Journal of Applied Ecology, 58(6), 1112-1121.

Francis, Clinton D., et al.(2012) "Noise pollution alters ecological services: Enhanced pollination and disrupted seed dispersal." *Proceedings of the Royal Society B: Biological Sciences*, vol. 279, no. 1739, pp. 2727–2735,

Garibaldi, L. A., Carvalheiro, L. G., Leonhardt, S. D., Aizen, M. A., Blaauw, B. R., Isaacs, R., ... & Winfree, R. (2014). From research to action: enhancing crop yield through wild pollinators2. Frontiers in Ecology and the Environment, 12(8), 439-447.

Gogala, M. (2014), Sound or vibration, an old question of insect communication. In Studying Vibrational Communication (pp. 31-46). Berlin, Heidelberg: Springer Berlin Heidelberg.

Kaiser, K., Scofield, D., Alloush, M., Jones, R., Marczak, S., Martineau, K., ... & Narins, P. M. (2011). When sounds collide: the effect of anthropogenic noise on a breeding assemblage of frogs in Belize, Central America. Behaviour, 148(2), 215-232.

Katumo, & Daniel, M. (2022, February 3). *Pollinator diversity benefits natural and agricultural ecosystems, environmental health, and human welfare*. Plant Diversity. http://www.sciencedirect.com/science/article/pii/S2468265922000166.

Kim, T. K. (2015). T test as a parametric statistic. Korean journal of anesthesiology, 68(6), 540-546.

Kopec, Kelsey, & Burd , L. A. (2023, February). Pollinators in peril: A systematic status review of North American and ... https://www.biologicaldiversity.org/campaigns/native_pollinators/pdfs/Pollinators_in_Peril.pdf?platform=hootsuite

Montgomery, D. C., Peck, E. A., & Vining, G. G. (2021). Introduction to linear regression analysis. John Wiley & Sons.

Nolan, K. A., & Callahan, J. E. (2006, January). Beachcomber biology: The Shannon-Weiner species diversity index. In Proc. workshop able (Vol. 27, pp. 334-338).

Senzaki, M., Yamaura, Y., Francis, C. D., & Nakamura, F. (2016). Traffic noise reduces foraging efficiency in wild owls. Scientific reports, 6(1), 30602.

Veits, M., Khait, I., Obolski, U., Zinger, E., Boonman, A., Goldshtein, A., ... & Hadany, L. (2019). Flowers respond to pollinator sound within minutes by increasing nectar sugar concentration. Ecology letters, 22(9), 1483-1492.

Walker, T. (2020). Pollination: The enduring relationship between plant and pollinator. Princeton University Press.

Weilgart, L. S. (2007). The impacts of anthropogenic ocean noise on cetaceans and implications for management. Canadian journal of zoology, 85(11), 1091-1116.