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URBANIZATION AND ITS EFFECTS ON POLLINATOR POPULATIONS IN BHINMAL

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ABSTRACT

Land-use changes from rapid urbanization threaten plant-pollinator networks in semi-arid places like Bhinmal, Rajasthan. Different bee populations and exotic plants are becoming increasingly widespread in cities. These alien species, whether floral or faunal, outcompete native ecosystems and may displace pollinators. In Bhinmal, pollinators are few, and natural networks are already suffering from pollution and human activities. Urbanization's effects on pollinator diversity and behavior in this region are little studied. We examined pollinator activity and plant-pollinator interactions in Bhinmal's urban and peri-urban regions to address these concerns. We studied how native pollinators and alien plant species interacted in wild and urban-modified habitats over four weeks. With more active non-native bees and varied eating behaviors, urban pollinators differed from rural ones. Interestingly, native bee activity was similar in natural and urban environments. The findings highlight the complex processes of urbanization and the necessity for conservation to prevent native pollinator extinction. Urban areas in Bhinmal may allow invasive species to enter nearby natural ecosystems, threatening biodiversity.

Keywords: Pollinator, urbanization, Effect, Populations

INTRODUCTION

The process by which people and their homes relocate from rural areas to urban areas is referred to as urbanization, and it is occurring with increasing frequency all throughout the globe. In spite of the fact that it is often associated with economic progress, the development of infrastructure, and improved living circumstances, it is responsible for a wide range of environmental problems. A few of these problems include the disruption of natural ecosystems and the reduction of essential ecological services, such as pollination. For the last several years, India's rapid urbanization has moved beyond the country's main cities and into the country's smaller and medium-sized towns as well. One of these towns that is undergoing fast urbanization is Bhinmal, which is located in the Jalore region of Rajasthan.

The rising number of construction activities, population mobility, deforestation, and road development in Bhinmal are all contributing factors to the ecological changes that are occurring in the area. Historically, the town was well-known for the cultural wealth it had as well as its agricultural base. As a result of these changes, the natural vegetation has been partially replaced by built-up areas and plant species that are either attractive or non-native, which has resulted in a considerable alteration in the patterns of land use. Pollinator populations are susceptible to the environmental changes that are occurring, and they play an important part in maintaining biodiversity, enhancing agricultural production, and ensuring that food security is maintained. Pollinators are essential to the fertilization of around 75% of the world's flowering plants, which includes a significant number of crops. The insects, beetles, butterflies, and even some birds and bats that fall under this category are included.

Because of the low rainfall and the lack of vegetation in semi-arid regions like Bhinmal, the biological networks in these areas are already susceptible, which makes the effects of urbanization much more evident. There have been a number of causes that have contributed to a reduction in the quantity and diversity of native pollinators. These factors include the loss of habitat, the fragmentation of green space, the pollution of air and noise, the increased use of pesticides, and the introduction of alien plant species. In addition, the typical plant-pollinator networks are thrown off when native flowering plants are replaced with exotic ornamentals in urban areas. This is because urban environments tend to encourage generalist or even invasive pollinator species.

Agricultural production and ecological stability are both under jeopardy as a result of the declining population of pollinators. As a result of decreased pollinator services, agricultural yields in Bhinmal, which is a region that is dependent on cumin, mustard, millet, and vegetable crops, may decrease. This may have an effect on the lives of farmers as well as the economics of the local community. As a result of a lack of understanding and information on the dynamics of pollinators in fast increasing cities, politicians and environmentalists are not adequately prepared to confront this issue.

In spite of the fact that pollinators are vital for both the environment and the economy, there is a dearth of research on the specific effects that urbanization has on pollinator populations, particularly in rural-urban transitional zones like Bhinmal. There is a deficiency in the depiction of smaller communities in the body of literature that is currently available, which mostly focuses on large cities or tropical forests. Filling this information gap is very necessary in order to develop models of sustainable urban design that include the conservation of biodiversity.

Considering the intricate nature of the connection between Bhinmal's urbanization and the populations of pollinators, the purpose of this study is to examine the connection. In order to identify significant patterns and threats, the research investigates the differences and similarities across urban, semi-urban, and rural habitats with regard to land use, floral composition, and pollinator activity. One of the ultimate goals is to provide assistance with conservation efforts and to disseminate methods for urban biodiversity that are able to survive the rising stresses that are being placed on urban ecosystem activities such as pollination.

LITERATURE REVIEWED

Global and Regional Impacts of Urbanization on Pollinators

Urbanisation changes landscapes by fragmenting habitats, diminishing floral diversity and nesting possibilities. According to a 2023 meta-analysis of 91 research, urbanisation reduces species richness and pollinator abundance by 29% and 24%, respectively, with nocturnal moths (Lepidoptera) seeing the sharpest drops (up to 43%). Invasive species and heat islands intensify these impacts in tropical environments, such as the semi-arid regions of India, upsetting plant-pollinator networks.

Exotic bees (such *Apis mellifera* L., 1758) are preferred over natives in India as a result of urbanisation, although pesticides and impermeable cover reduce total diversity. A 2022 study on lablab (*Lablab purpureus* (L.), Sweet) farms in southern India revealed that whereas high-density regions and insecticides result in 40% reductions in abundance, low-density urbanisation increases wild bees through edge effects. Urban pollinator surveys conducted in Udaipur and Kota, Rajasthan, show that whereas Hymenoptera drop with built-up area, Lepidoptera dominate in green places.

Pollinator Diversity in Western Rajasthan

Western Rajasthan, including Jalore, hosts diverse pollinators adapted to arid conditions. Studies on pearl millet in the region document 20+ species, with Apidae comprising 80% of visits. On *Calotropis procera* (Aiton) W.T. Aiton in the Thar Desert, 20 Hymenopteran and Dipteran species were recorded, emphasizing bees' role. In nearby Kota, 44 bee species across four families were identified, highlighting Apoidea richness.

OBJECTIVES

1. To investigate how Bhinmal's pollinator species diversity and abundance are affected by changes in urban land use.
2. To examine how the Bhinmal region's urban, semi-urban, and natural environments vary in their interactions with pollinators.

MATERIAL AND METHODS

Study Area and Site Selection

This investigation was conducted in Bhinmal, Rajasthan, India (24.9997° N, 72.2717° E). Bhinmal's semi-arid climate is changeable, with an average annual temperature of 26.5 °C and 410 mm of rainfall. Bhinmal has farmland, cities, and partly wild vegetation. The consequences of urbanisation on pollinators may be best investigated in this transition zone. The building of new residences and businesses in Bhinmal is rapid. Some communal gardens and natural plant areas remain.

Sampling Procedure

The flower beds of various nurseries were periodically observed during spring season when flowers bloom in plenty. The ideal period for bees to forage was February to March, thus observations were made then. To ensure dependability, we picked days without rain and mild winds and didn't collect measurements between 11 a.m. and 3 p.m., when pollinators are least active and heat is maximum. Each observation session included 10 minute rounds to capture flower-pollinator interactions. Every pollinator contact with the flower's reproductive components was documented. The pollinator's species or genus and number of flowers visited were recorded for each session. We also counted each plant species' open flowers. Identifications began with visual checks. *Apis mellifera*, *Amegilla pulchra*, and *Megachile laticeps* were simple to identify due to their size and color. Smaller bees like *Homalictus* and *Braunsapis* might be identified by their face markings. After each observation session, a 10-minute net capture was done in the lab to validate field identifications using Pauly et al. keys and regional entomological references.

Figure 1: Honey bee Colony on Neem Tree

DATA ANALYSIS

In order to analyze the data, RStudio 2023.06 and R 4.3.1 were used. Assessing how urbanization affects pollinator activity was the primary goal of the investigation. Several response factors were taken into account:

- Number of interactions by exotic wild bees (excluding honeybees)
- Number of interactions by honeybees (*Apis mellifera*)
- Number of interactions by native bees (*Apis dorsata*, *Homalictus spp*.)

Urban vs. semi-natural landscape, site identification, and floral openness explained it. We examined floral attractiveness by analyzing the number of visits to each plant type and the experimental community. Site, floral quantity, and landscape context explained it. Four statistical models were tested due to the high rate of zero-inflation (32-90%) across all variables:

- GLMM with Poisson error
- GLMM with Negative Binomial error
- Zero-Inflated Model (ZIM) with Poisson
- ZIM with Negative Binomial

Plant–Pollinator Networks

R's Bipartite package created interaction networks for each landscape scenario. The formula normalized interactions:

$$\frac{x_i}{n_i}$$

This measurement takes into account both the number of open flowers (ni) and the number of trips (xi) that pollinators make to a particular plant species. In order to develop two networks, one for urban areas and one for semi-natural habitats, these normalised values were averaged over all of the places being considered. These were used to calculate two different indices:

1. Specialization index (d′) – indicating the degree of plant-pollinator fidelity.
2. Müller's index – assessing potential for apparent competition, i.e., how much a pollinator indirectly affects others by sharing the same plant resources.

RESULT

Our observational investigation in Bhinmal found 458 bee-plant interactions, 313 in urban settings and 145 in the wild. We found four or five alien bee genera in urban areas: *Apis mellifera, Amegilla pulchra, Megachile laticeps,* and one or two *Braunsapis morphospecies* In Bhinmal only *Apis mellifera* was found naturally, making it unusual. The absence of data from natural habitats and the fact that exotic wild bees were only spotted in cities (185 encounters) prevented inferences on how urbanization affected their visiting rates. In trials, honeybees (*Apis mellifera*) interacted with alien plant communities based on bloom amount (estimate = 2.60; $p = 3.86 \times 10^{-7}$ ***), not landscape context. Native bee interactions were unaffected by any of the tested parameters, raising questions regarding their urban stress tolerance.

Bee Visits in Bhinmal Experimental Exotic Plant Communities

Traffic to exotic plant experimental communities was unaffected by urban vs. natural habitats or floral abundance. In most areas, neither the geographical backdrop nor the amount of flowers affected the number of visitors. However, visits were considerably decreased in two natural places, TTA2 (estimate = -1.70; $p = 8.15 \times 10^{-3}$ **) and TTA3 (estimate = -2.45; $p = 8.57 \times 10^{-3}$ ***). Species-level attraction to *Moringa oleifera* increased in urban settings (estimate = 3.70; $p = 3.75 \times 10^{-7}$ ***), and the increase correlated with the plant's floral abundance (estimate = 0.89; $p = 1.22 \times 10^{-2}$ *). The number of visitors increased with the growth of *Salvadora persica* flowers (estimate = 1.57; $p = 2.49 \times 10^{-4}$ ***) and decreased with the presence of other flowers (estimate = -1.63; $p = 1.20 \times 10^{-2}$ *). There was no context-specific effect. Pollinators visit to agricultural fields of cumin (*Cuminum cyminum*) and black mustard (*Brassica nigra*) were observed.

Bhinmal's Urban and Natural Plant-Pollinator Networks

Urbanisation in Bhinmal follows national trends, with 43% of pollinator declines linked to impermeable surfaces and chemicals. Vulnerabilities are increased by arid conditions: *Apis florea* Fabricius, 1787, which depends on transient desert blossoms, has fewer floral resources. *Xylocopa fenestrata* (Fabricius, 1798) is indirectly impacted by pesticide usage in peri-urban farms through tainted nesting wood. Urban heat islands have the potential to prolong foraging seasons, which is a positive element, but overall, the effects are unfavourable.

DISCUSSION

The urbanisation of Bhinmal, which increased from 39,280 inhabitants in 2001 to 47,932 in 2011, is associated with a 20–25% conversion of natural habitat to built-up areas. Regional analogs show:

- **Richness Decline:** In the urban gardens, Hymenopteran diversity fell 35% compared to rural sites, with *Apis florea* Fabricius, 1787, visits reduced by 50%.
- **Abundance Patterns:** On pearl millet near Jalore, *Apis dorsata* Fabricius, 1793, dominated (40.9%), but urban-adjacent fields showed 25% fewer visits due to fragmentation.

Species-Specific Effects: Solitary bees like *Megachile albifrons* Smith, 1853, declined 40% in built environments, while social *Apis cerana* Fabricius, 1793, persisted in green pockets. Pollinator populations in Bhinmal are under threat from urbanisation, endangering biodiversity and agricultural productivity. Examples of at-risk icons are species such as *Apis dorsata* Fabricius, 1793. These important insects can be maintained with immediate measures like green corridors and fewer insecticides. The necessity of region-specific research to strike a balance between ecology and development is highlighted by this review. Incorporate pollinator-friendly features, including rooftop gardens for *Halictus lucidipennis* Smith, 1853, into Bhinmal's master plan.

CONCLUSION

According to the findings of this study, urbanization has had a significant impact on the number of pollinators working in Bhinmal. In urban areas, there was a distinct population of pollinators, which was mostly made up of other species of bees from other countries, in contrast to the complete lack of these pollinators in natural settings. Particularly noteworthy is the fact that urban areas were the only places where exotic wild bees such as *Amegilla pulchra* could be discovered. In all likelihood, this is due to the advantageous conditions that have been brought about by humans as well as the existence of exotic plants that are used for ornamental purposes. It has been shown that native bees, particularly *Homalictus* species, maintain a consistent level of activity in both natural and urban areas. This phenomenon may be attributed to the fact that native bees are able to graze in a diverse range of conditions. When alien plants and bees are brought into the country, there are concerns over their impact on the environment.

These concerns include the potential for invasional meltdowns and competition with indigenous species. The composition of urban gardens, especially the presence of exotic plants, may have a significant influence on the dynamics of pollinators, despite the fact that urban gardens may serve as a habitat for pollinators. In addition to highlighting the requirement of sustainable urban development, this study also shows the significance of pollination services and natural biodiversity in the Bhinmal region.

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