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# The value of pocket parks in preserving urban butterfly diversity

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## Abstract

Butterflies, valued for their aesthetic and ecological value, are key subjects in urban biodiversity research. Our study focused on the often-overlooked roles of pocket parks, which are micro-greenspaces and small amusement parks open to the public. Despite their limited size, pocket parks are vital in maintaining the diversity of urban butterflies. We contrasted pocket park diversity with urban parks in Beijing, China. Next, using hierarchical clustering, we classified butterflies into exploiters, adapters, and avoiders based on how well they adapted to urban environments. Finally, we used Logistic regression and Poisson regression to build generalised linear models for all species and each of the three groups separately, allowing us to investigate the differences in the effects of variables from food resources and shelters on various butterfly groups in pocket parks. The results showed that although the primary restrictions differ depending on the group, pocket parks can serve as habitats for most species. Management intensity, pocket park area and nectar plants were significant variables for all species. The tourist intensity and host plants were variables that affected the presence of exploiters. Host plants, nectar plants, and management intensity all affected adapter diversity. Pocket parks' area was only affected avoiders significantly. These

results suggest that pocket parks have roles as source and sink habitats for exploiters and adapters and as stepping stones and corridors for most butterfly species inhabiting cities.

## Introduction

Urbanisation, one of the primary causes of biodiversity reduction (Seto et al., 2012), continues to advance globally. Enhancing the quality of the urban environment, increasing the area of green and blue spaces, and reviving urban plant and animal biodiversity are goals for urban growth (Fuller et al., 2007, Hanson and Olsson, 2023). Recent studies indicated that city expansion negatively affects insect diversity through the increasing percentage of impervious surfaces, pollution, and heat island effect (Fenoglio et al., 2021). However, compared to agricultural landscapes, cities can provide habitats for insects and become refuges for pollinators such as bees and butterflies because of the increased nectar resources (Hall et al., 2017, Daniels et al., 2020, Knapp et al., 2021). Although the relative abundance of butterflies decreased from the natural to the urban areas, the species richness peaked at moderately disturbed sites (Blair and Launer, 1997). Restrepo and Halffter (2013) found higher butterfly richness in built-up than in suburban areas in Mexico. A butterfly survey in Hong Kong also indicated that urban parks play a role in the habitats of locally rare species (Tam and Bonebrake, 2016).

As well as their aesthetic value and pollination function due to their flower-visiting behaviour, butterflies are sensitive to environmental change, making them essential subjects in ecological studies (Oostermeijer and van Swaay, 1998, Warren et al., 2001). However, research has shown that their survival is threatened worldwide (Thomas et al., 2004). Programs have been implemented in Europe (United Kingdom Butterfly Monitoring Scheme, 2023; National Biodiversity Data Center, 2023), Asia (Ma et al., 2018), and North America (North American Butterfly Association, 2023) to monitor the dynamics of butterfly communities in rural areas, protected areas, and forest parks. Citizen science projects are helpful for urban butterfly data collection (Deguines et al., 2020, Pendl et al., 2022, Cheng et al., 2024).

From the landscape scale to the local scale, various indicators related to shelters and food resources can be limited to urban butterfly diversity in adulthood. At the landscape scale, Tzortzakaki et al. (2019) found that land cover was the most influential variable, whereas Kuussaari et al. (2020) found that population density explained butterfly diversity better. At the local scale, nectar plants or flowering plants, the energy source for most adult butterflies, are the main variables that influence butterfly diversity, both in abundance and richness (Han et al., 2021b, Majewska et al., 2018, Tsang and Bonebrake, 2016). Host plant

diversity significantly influences forest butterfly diversity. The number of pedestrians and artificial management activities, including insecticide use, mowing, and weed control, were significantly negative for butterflies (Restrepo and Halffter, 2013, Tam and Bonebrake, 2016, Tsang and Bonebrake, 2016). Aguilera et al. (2019) emphasised that intensive management harms urban butterfly diversity over time. In contrast, the richness of butterfly species has a significant positive correlation with the park area (Soga and Koike, 2013; Horák, 2016; Sing et al., 2016). In addition to adulthood, butterflies go through three life stages: egg, larva, and pupa (Lafontaine et al., 1998). The selection and utilization of habitats vary according to life stage, making the factors that influence butterfly diversity complex. For example, mowing moves eggs laid on leaves and larvae hidden in the leaves (Alcock et al., 2016), moving litter moves larvae and pupae hidden from overwintering (Stefanescu, 2004, Örvössy et al., 2012), and flower resources attract adults to gather and sap (Soga et al., 2015). Furthermore, Dylewski et al. (2019) found that the diversity of pollinators is significantly affected by different types of urban green areas; therefore, it is necessary to analyze butterfly diversity in various habitats. Indeed, studies have indicated that small-scale green spaces such as urban yards and urban rights-of-way are butterfly habitats (Leston and Koper, 2017, Nason and Eason, 2023). However, other green spaces in cities, such as pocket parks and green pieces, which are widely distributed in built areas, have received less attention. Pocket parks, also known as vest-pocket parks (Cohen et al., 2014), are green activity venues in parks that are open to the public. They are small, diverse in shape, and have certain recreational functions, including small amusement parks and micro-green spaces (Nordh et al., 2009).

Many previous studies used biodiversity indices to represent the condition of a butterfly community, ignoring interspecific differences in adaptabilities to the cities (Aguilera et al., 2019, Graffigna et al., 2023, Sing et al., 2019, Tzortzakaki et al., 2019). Callaghan et al. (2021) used a database of butterfly distributions in Europe to perform their analysis. They found a significant correlation between the biological traits of the species and their ability to adapt to urban environments. Bergerot et al. (2010) also found that diet preference combined with other life history traits, such as mobility and flexibility in habitat selection, impacted the distribution pattern of butterflies along an urban-rural gradient. Attention must be paid to the fact that the ability to adapt to urban environments varies among butterflies with different inborn traits. Biodiversity studies, which consider the adaptive differences of species to urban environments, have included bird and butterfly diversity studies. Researchers have adopted multiple classification methods to classify bird communities into urban exploiters, adapters, and avoiders. These three groups reflect a combination of traits such as dietary preference, social structure, and migratory status because of their species-specific adaptability to urban (Blair, 1996, Kark et al., 2007). Nurul et al. (2022) grouped

birds according to their level of urbanisation. Mardiastuti et al. (2020) performed a classification based on encounter probability. Similar studies have also been conducted on butterflies. Callaghan et al. (2021) classified butterflies into three groups by contrasting species distribution frequency in areas with different urbanisations measured by the Visible Infrared Imaging Radiometer Suite nighttime lights and found a correlation between butterfly thermal and diet preferences and their adaptability in urban environments. Soga and Koike (2013) classified butterflies into specialists and generalists according to their food range and voltinism and found that patch isolation affects specialists, while patch area affects both. Konvicka and Kadlec (2011) found that urban-tolerant butterfly species and suburban-adaptable butterflies respond differently to urbanisation after building a generalised linear model for each species.

We suspect that pocket parks can serve as butterfly habitats because of the abundant vegetation there for butterflies as food resources. Habitats can be divided into source and sink. A source habitat supports a positive population growth rate, whereas a sink supports a negative population growth rate (Gilroy and Sutherland, 2007). In this study, considering that butterflies may utilize different habitats during the whole life history, we classified the habitats into three types according to the stage at which they served as habitats for butterflies: when larvae feed in a pocket park, the pocket is a source; when adults feed, the pocket is a sink; and when a butterfly is present in a pocket park using no food resources, the pocket is a stepstone or corridor. In addition, the ability of different species to adapt to urban environments may affect their use of pocket parks as habitats. We conducted a survey of the butterfly communities in Beijing's pocket parks and urban parks. We also attempted to classify butterflies in parks as urban exploiters, adapters, and avoiders and in pocket parks as pocket park exploiters, adapters, and avoiders based on the characteristics of their populations. The three groups of pocket parks will be abbreviated in the text; for example, the ‘pocket park exploiters’ was abbreviated to ‘exploiters’, while the urban parks’ remain the same. After classification, the relationships between butterfly groups and habitat environmental factors were analysed, which helped to better understand how different species with different adaptabilities are affected by environments on a local scale. We hypothesized that (1) pocket parks can provide habitats for urban butterflies, especially for exploiters and adapters; (2) variables limiting butterflies use of pocket parks vary from their different adaptabilities to urban environments; and (3) pocket parks play roles of sink habitats, stepping stones and corridors for urban butterflies.

## Section snippets

## Study area and sampling sites

Our study was conducted in Beijing (39°56′ N, 116°20′ E), the capital of China, located in the northwest of the North China Plain, which is surrounded by mountains on three sides, and the terrain is higher on the northwest and lower in the southeast. It has a predominantly semi-humid and semi-dry monsoon climate in the warm temperate zones. Beijing is divided by six ring roads, within which the city's major built-up areas are considered. The land inside the Fifth Ring Road is Beijing's core…

## Diversity indices in pocket parks contrasted by it in parks

We recorded 1104 butterflies from four families and 16 species from pocket parks, and 2748 from five families and 20 species from parks. Pieridae, Lycaenidae, Nymphalidae, and Papilionidae were recorded in both pocket parks and parks, whereas Hesperiidae were only present in parks. The spatial autocorrelation analysis showed no significant autocorrelation among the sites. The z-value was 0.966 and Moran's index was −0.134 when the input field was the Shannon–Wiener index, whereas the input…

## Pocket parks provide habitats for most of the butterfly species in Beijing

Pocket parks provide habitats for more than 76 % of the butterfly species in Beijing. Within the sixth ring road in Beijing, 31 species were recorded in 10 parks in 2017 (Sing et al., 2019) and 25 in 27 parks in 2021 (Han et al., 2022). In northwestern Beijing, between the 5th and 6th Ring Roads, there are some mountains where inhabited species are rarely seen in metropolitan built-up areas and live only at high altitudes where there is little human disturbance. In the present study, we…

## Conclusion

Our study attempted to understand the significance of pocket parks in providing habitats, including source habitats, sink habitats, stepping stones, and corridors, for the first time by constructing generalised linear models using Logistic regression and Poisson regression. The results showed that pocket parks play a critical role in preserving urban butterfly diversity, both as source and sink habitats for exploiters and adapters and as stepping stones and corridors for most species in urban…

## Declaration of Competing Interest

All authors disclosed no relevant relationships.…

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