Journal of Tropical Biology and Conservation 21: 88–95, 2024 *ISSN 1823-3902*
E-ISSN 2550-1909

Research Article

Non-Native Plants Provide Nectar and Host Plant Resources to Native Butterflies

Sze Huei YEK[1,2]*, Zhi Hoong WONG[3] and Pei Wen HON[4]

[1]*Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah, Jalan UMS, 88400 Kota Kinabalu, Malaysia.*
[2]*School of Science, Monash University Malaysia, Bandar Sunway 47500, Malaysia.*
[3]*School of Pathways & Immersion, Monash University Malaysia, Bandar Sunway 47500, Malaysia.*
[4]*Department of Biological Sciences, Sunway University, Bandar Sunway 47500, Malaysia.*

*Corresponding author email address: szehuei@ums.edu.my

Received 06 May 2024| Accepted 15 October 2024| Published 14 November 2024
DOI: https://doi.org/10.51200/jtbc.v21i.5590

ABSTRACT

Urban restoration projects often aim to completely remove non-native plant species from the restored landscape and replace them with native plant species. However, this is unrealistic as early successional plants in urban settings comprise predominantly of non-native plant species. In this study, we investigate whether native butterfly species showed a preference on using native versus non-native plant species in their nectar sourcing and caterpillar host plant choice in two urban gardens at Monash University Malaysia. Native butterflies significantly preferred non-native plant species as nectar food plants, suggesting butterflies are generalists in nectar sourcing. Native butterflies showed no preference towards non-native plants as caterpillar host plants. However, six native butterfly species in our study (*Zizula hylax*, *Hypolycaena erylus*, *Chliaria othona*, *Junonia orithya*, *Yppthima* spp., and *Eurema hecabe*) can use non-native plants as their caterpillar host plants. This demonstrates the usefulness of these non-native plant species in an urban garden by maintaining native butterfly biodiversity. This study indicates a paradigm shift is required among urban ecologists to recognize that not all non-native plants have negative impacts on biodiversity. For more effective urban restoration planning and management, further research emphasising how native insects use non-native plant species is required to maximise biodiversity and ecosystem services restoration.

Keywords: non-native species; nectar food plants; caterpillar host plants; *Zizula hylax*; *Lantana camara*; *Acraea terpsicore*.

INTRODUCTION

In developing countries, urbanisation is a major threat to biodiversity, disrupting the balance and ecological interaction between species (McDonald et al., 2008). By 2050, 68% of the world's population will inhabit urban areas (Simkin et al., 2022). Most of this urban expansion occurs in areas of high biodiversity, putting tremendous pressure on global biodiversity (Simkin et al., 2022). Thus, it is crucial to emphasise the preservation of biodiversity in urban areas as much as possible, to minimise the impact of urbanisation through restoration projects guided by scientific principles (Lepczyk et al., 2017).

Cities are natural laboratories for testing ecological theories and uncovering new community patterns (Rivkin et al., 2019). This is because newly cleared pockets of areas in the urban landscape undergo different stages of succession, colonisation, and community assembly sorting between species, all within a significantly altered ecosystem (Rebele, 1994). As most existing community ecological theories were derived from research conducted in natural, non-urban systems (Wainwright et al., 2018), the direct application of these theories in the context of urban community and biodiversity planning may not be a matter of direct translation (Aronso et al., 2017).

In most contexts, urban restoration projects aim to restore the biotic communities of profoundly altered landscapes to their pre-urbanised state (Gobster, 2007). These restoration processes are often achieved through re-vegetation using a diverse assemblage of native plant species (Miyawaki, 2004). However, native plant species obtained from relatively undisturbed habitats (i.e., climax species) are often better adapted to habitats at later ecological succession stages (Chazdon et al., 2007). They are, therefore, unsuitable for newly disturbed or substantially altered urban landscapes. For instance, native plant species from pristine environments will most likely have the characteristics of slow growth, low intrinsic rate of population increase, and production of few offspring with long generation intervals (Guariguata & Ostertag, 2001). On the other hand, cleared or highly disturbed landscapes in the urban environment may be more suited for colonisers or generalists with characteristics of rapid development, high intrinsic rate of population increases, and the production of numerous offspring with short generation intervals (Guariguata & Ostertag, 2001).

Urban plant communities are composed of a few anthropogenically selected plant species, such as herbs, edible plants, and aesthetically pleasing bushes that have been introduced globally, the majority of which are non-native species (Jasmani et al., 2017). Despite the loss of genetic diversity, many of these non-native plants are thriving in urbanised conditions. These plants can influence local plant composition and diversity, e.g., through competition, underscoring the need to comprehend how communities and biodiversity can be sustained in the presence of non-native species in novel environments (Kowarik, 2011).

Consequently, the choice of plant species in urban biodiversity projects should not be based on their origin (native or non-native) but on suitable life history characteristics (Faeth et al., 2011). For urban green spaces, depending on the disturbance level (i.e., temperature, light intensity, soil integrity, etc.), plant species with the characteristics and life history of pioneers and generalist species can be gradually introduced to facilitate succession stages (Sullivan et al., 2019).

This study investigates how native butterflies utilise native and non-native plant species in two garden plots at Monash University Malaysia. We surveyed the plants used by butterflies at the garden plots. Butterflies visit plants for two resources: nectar source (nectar food plants) and to lay their eggs for butterfly larval development (caterpillar host plants). Butterflies are generalists when it comes to nectar feeding. Hence, we expect butterflies will not show preference regarding plant origin in food plant visitations. However, butterfly development on host plants is derived from evolutionary-ecological processes (Janz et al., 2001). As such, we can expect butterflies to visit native host plants.

METHODOLOGY

We set up two study plots to investigate the interactions between pollinators (we used butterflies as our pollinator species) and urban plant communities. Both plots were located at Monash University Malaysia (N3°3’47.52”, E101°36’1.26”). The first plot was a garden patch (15.77 m^2), designated to be set up as a butterfly garden for a campus biodiversity initiative (Fig. 1A). This patch was wholly cleared of its original landscaping vegetation (*Leucophyllum frutescens*) and replaced with a mixture of native and non-native plant species in April 2018. In the first garden plot, some of the plants, such as *Arundina graminifolia*, *Spathoglottis plicata*, *Bidens pilosa*, *Passiflora foetida*, *Passiflora suberosa*, and *Stachytarpheta indica*, were harvested directly from a nearby location. Other non-native plants (*Lantana camara* and *Ixora* cultivar) commonly used in landscaping projects and public parks in the state of Selangor were obtained from nurseries in Sunway City. Other species (i.e., *Orthosiphon stamineus*, *Antigonon leptopus*, *Torenia* sp., *Angelonia* sp., and a *Citrus* cultivar), commonly found in private gardens, were donated. The remaining plant species (i.e., *Mimosa pudica*, *Tridax procumbens*, *Ageratum conyzoides*, *Emilia sonchifolia*, and *Desmodium triflorum*) were primarily weeds.

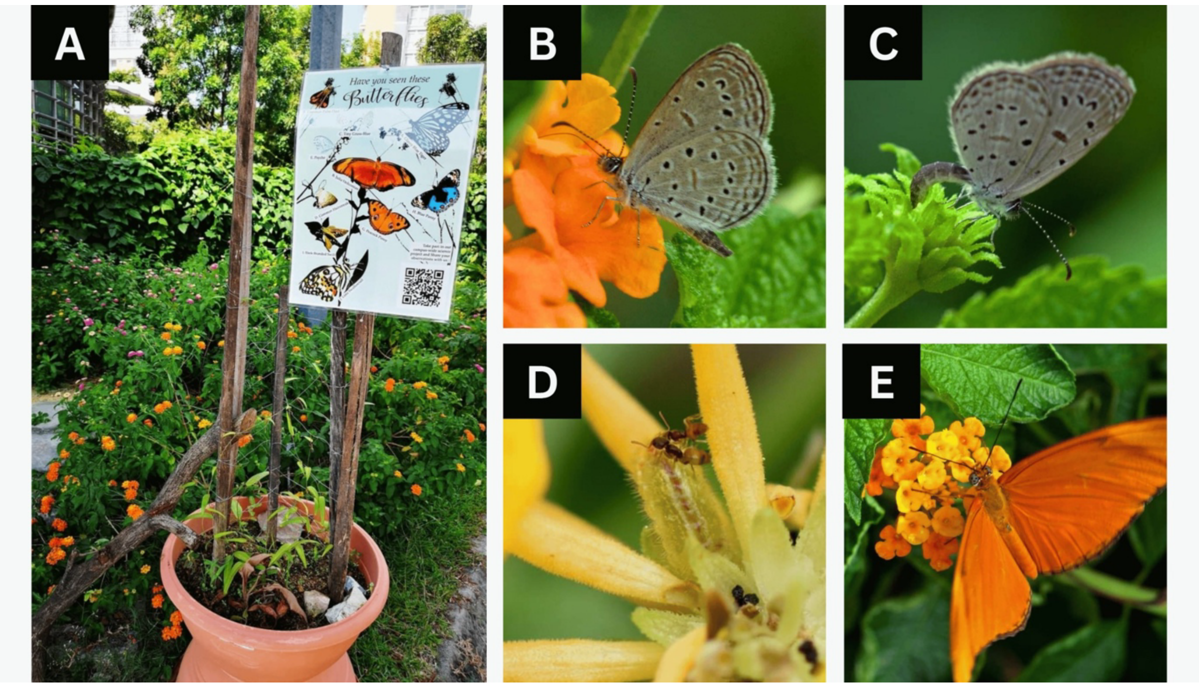

Figure 1: (A) Monash University Butterfly Garden. (B) *Zizula hylax* adult taking nectar from *Lantana camara* flowers. (C) *Zizula hylax* adult ovipositing on *Lantana camara* flower buds. (D) *Zizula hylax* larva feeding on *Lantana camara* flowers while tended to by ants. (E) *Dryas iulia* adult taking nectar from *Lantana camara* flowers.

Plants were identified with the help of the pl@ntNet plant identification website (Affouard et al., 2023). The second plot (129.49 m^2) is an established garden that consists of a mixture of native and non-native herbs, maintained by a campus gardener, and serves as an additional data point for our butterfly plant visitation observation. Hence, we did not identify the plant species at this garden plot. These two gardens had minimal maintenance to allow natural succession and pollinator-plant interactions.

We conducted butterfly observations for two time periods: (1) 11:00 to 11:30 hr and (ii) 15:00 to 15:30 hr for 29 days in April 2019, one year after the garden plots were established. These two time periods correspond to the peaks of butterfly activity. Butterfly species visiting plants inside the garden plots were photographed during observation. These were subsequently identified to species levels using the identification guide 'The Butterflies of the Malay Peninsula (5th Edition)' (Corbet & Pendlebury, 2020). The interaction between butterflies, potential food, and host plants was also recorded. The plant species where the butterfly was observed feeding nectar from the flowers was classified as a nectar food plant. In comparison, the plant where the butterfly was seen laying eggs or caterpillars feeding on the leaves was classified as a caterpillar host plant.

To assess the native butterflies' preference for native versus non-native nectar food plants, we compared the number of native butterfly species visiting native nectar food plants, to the number of native butterfly species visiting non-native nectar food plants. Similarly, to assess the native butterflies' preference for native versus non-native caterpillar host plants, we compared the number of native butterfly species utilising native caterpillar host plants, to the number of native butterfly species utilising non-native caterpillar host plants. Due to the uneven number of native and non-native nectar food- and caterpillar host plants, our data points do not meet assumptions required for parametric testing. Hence, we decided to conduct two independent non-parametric comparison tests (Wilcoxon Signed Rank), one on native butterfly preference on nectar food plants, and the second test on native butterfly preference on caterpillar host plants. These statistical analyses were carried out in JASP (2022) statistical software.

RESULTS AND DISCUSSION

Nineteen butterfly species visited the two garden plots over 29 days of observation, with two non-native species (*Acraea terpsicore* and *Dryas iulia*) recorded (Table 1). The 17 native butterfly species significantly preferred non-native plants for nectar sources (Wilcoxon Signed Rank Test; $Z = 2.953$, $p < 0.05$). Butterflies are generalists in nectar sourcing, responding to the composition of flowers with nectar sources in that landscape (Jain et al., 2016).

Table 1: Butterfly species and their food and host plant visitations over 29 days at garden plots at Monash University Malaysia. Nineteen butterfly species were recorded, with two non-native species (*Acraea terpsicore* and *Dryas iulia*).

Butterfly species	Status	Native food plant	Non-native food plant	Native host plant	Non-native host plant
Zizula hylax	Native	*Emilia sonchifolia, Desmodium triflorum*	*Lantana camara, Ageratum conyzoides, Tridax procumbens,*	*Mimosa pudica*	*Lantana camara*

			Antigonon leptopus		
Acytolepis puspa	Native	*Emilia sonchifolia, Ixora javanica, Desmodium triflorum*	*Lantana camara, Ageratum conyzoides, Tridax procumbens, Antigonon leptopus*		
Hypolycaena erylus	Native	*Ixora javanica, Desmodium triflorum*	*Tridax procumbens, Caesalpinia pulcherrima, Antigonon leptopus*	*Ixora javanica*	*Khaya senegalensis*
Arhopala centaurus	Native		*Bidens pilosa, Antigonon leptopus*	*Syzygium grande*	
Chliaria othona	Native	*Ixora javanica*		*Dendrobium crumenatum*	*Phalaenopsis hybrid*
Ideopsis vulgaris	Native	*Vitex negundo*	*Lantana camara, Tridax procumbens, Bidens pilosa, Caesalpinia pulcherrima, Antigonon leptopus*		
Danaus chrysippus	Native	*Ixora javanica, Vitex negundo*	*Lantana camara, Tridax procumbens, Bidens pilosa, Caesalpinia pulcherrima, Antigonon leptopus*		
Junonia iphita	Native		*Lantana camara, Bidens pilosa*	*Ruellia repens*	
Junonia almana	Native	*Ixora javanica*	*Lantana camara, Tridax procumbens, Bidens Pilosa*	*Ruellia repens*	
Junonia orithya	Native		*Tridax procumbens*	*Asystasia gangetica*	*Angelonia spp.*
Acraea terpsicore	Non-native	*Ixora javanica, Vitex negundo*	*Lantana camara, Tridax procumbens, Bidens pilosa*		*Passiflora foetida, Passiflora suberosa*
Hypolimnas bollina	Native	*Vitex negundo*	*Lantana camara, Bidens pilosa*	*Aystasia gangetica*	
Yppthima spp.	Native	*Emilia sonchifolia*	*Tridax procumbens*	*Tylophora flexuosa*	*Axonopus compressus*
Dryas iulia	Non-native				
Papillio demoleus	Native	*Ixora javanica, Vitex negundo*	*Lantana camara,*	*Calamondin cultivar*	

			Caesalpinia pulcherrima		
Papillio polytes	Native	*Ixora javanica, Vitex negundo*	*Caesalpinia pulcherrima*	*Calamondin cultivar, Murraya koenigii*	
Appias libythea	Native	*Emilia sonchifolia*	*Lantana camara, Ageratum conyzoides, Tridax procumbens, Bidens Pilosa*	*Cleome rutidosperma*	
Eurema hecabe	Native	*Vitex negundo*	*Ageratum conyzoides, Tridax procumbens, Caesalpinia pulcherrima*		*Caesalpinia pulcherrima*
Leptosia nina	Native		*Ageratum conyzoides*	*Cleome rutidosperma*	

The native butterfly species showed no preference for whether the caterpillar host plants were native or non-native (Wilcoxon Signed Rank Test; $Z = 2.132$, $p = 0.025$). Caterpillar host plant choice depends on a narrower set of parameters, especially their co-evolutionary history (Janz et al., 2001). As expected, caterpillar host plant choices were restricted to one or two species, unlike the nectar food plant preferences. Six native butterflies (*Zizula hylax*, *Hypolycaena erylus*, *Chliaria othona*, *Junonia orithya*, *Yppthima* spp., and *Eurema hecabe*) were able to lay eggs on non-native host plants, demonstrating these non-native caterpillar host plants (*Lantana camara*, *Khaya senegalensis*, *Phalaenopsis* hybrid, *Angelonia* spp., *Axonopus compressus*, and *Caesalpinia pulcherrima*) serve a beneficial role in the local butterfly community (Table 1, Fig. 1B-D).

Unsurprisingly, we detected a significant preference for butterfly visitations on non-native flowers in heavily altered urban landscapes with higher proportions of non-native vegetation. The non-native butterfly *Acraea terpsicore* visited flowers of both native and non-native plants for nectar sources. *Dryas iulia*, the second non-native butterfly, was actively flying and interfering with other butterflies but not alighting on any flowers during our survey period (personal observation, Fig. 1E). In addition, the non-native butterfly *Acraea terpsicore* lays eggs on non-native host plants (*Passiflora foetida* and *P. suberosa*), suggesting that this non-native butterfly species was likely introduced with their host plants (Abang et al., 2016). *Acraea terpsicore* introduction is believed to be a result of the invasive population extending to Peninsular Malaysia from Southern Thailand (Burg, 2018).

CONCLUSION

Ultimately, the insistence on using native floral species exclusively in urban rehabilitation is misguided and the common perception that all non-native species are damaging is not always true (Richardson & Ricciardi, 2013) but rather, context-dependent (Boltovskoy et al., 2018). Instead of directing limited resources to remove established exotics, it is more important to first evaluate the role of these non-native plant species play in maintaining or interfering with local diversity and providing ecosystem services. Additionally, studies on the "merits" of non-native species are few and far between (e.g., the potential emergence of new ecosystem services). Still, they must be conducted to better understand their roles in urban ecosystems (Schlaepfer, 2018). This study showed that most non-native plant species in urban gardens can serve as nectar sources for native butterflies and some even as caterpillar host plants for the native butterfly species. We believe that urban biodiversity management can be improved if we carry out more studies such as this one, incorporating other insect-plant interactions such as native insect herbivores, and plant parasites to understand what roles non-native plant species play in an urban community.

ACKNOWLEDGEMENTS

This work was supported in part by funding from the Education Excellence Monash University Malaysia Learning and Teaching Research Grants (E/EE/LTG_08/2018/01) to SHY and ZHW.

REFERENCES

Abang F, Noor S, Hazali R, Dieng H (2016) First record and occurrence of *Acraea terpsicore* (Linnaeus, 1758) (Lepidoptera: Nymphalidae) in Malaysian Borneo. Serangga 21: 21–31.

Affouard A, Joly A, Lombardo J, Champ J, Goeau H, Chouet M, Gresse H, Botella C, Bonnet P (2023) Pl@ntNet automatically identified occurrences. V1.8. Pl@ntNet https://ipt.plantnet.org/resource?r=queries (accessed 1 May 2018).

Boltovskoy D, Sylvester F, Paolucci EM (2018) Invasive species denialism: sorting out facts, beliefs, and definitions. Ecology and Evolution 8: 11190–11198. https://doi.org/10.1002/ece3.4588.

Burg NA (2018) Using molecular markers to trace the population history of volant organisms at differing temporal scales. City University of New York. 103 pp.

Chazdon RL, Letcher SG, van Breugel M, Martinez-Ramos M, Bongers F, Finegan B (2007) Rates of change in tree communities of secondary Neotropical forests following major disturbances. Philosophical Transactions of the Royal Society B: Biological Sciences 362: 273–289. https://doi.org/10.1098/rstb.2006.1990.

Corbet AS, Pendlebury HM (2020) The butterflies of the Malay Peninsula (5th Edition). Malaysia: Kuala Lumpur: Malayan Nature Society. 506 pp.

Faeth SH, Bang C, Saari S (2011) Urban biodiversity: patterns and mechanisms. Annals of the New York Academy of Sciences 1223: 69–81. https://doi.org/10.1111/j.1749-6632.2010.05925.x.

Guariguata MR, Ostertag R (2001) Neotropical secondary forest succession: changes in structural and functional characteristics. Forest Ecology and Management 148: 185–206. https://doi.org/10.1016/S0378-1127(00)00535-1.

Gobster PH (2007) Urban park restoration and the "museumification" of nature. Nature and Culture 2: 95–114. https://doi.org/10.3167/nc.2007.020201.

Jain A, Kunte K, Webb EL (2016) Flower specialization of butterflies and impacts of non-native flower use in a transformed tropical landscape. Biological Conservation 201: 184–191. https://doi.org/10.1016/j.biocon.2016.06.034.

Janz N, Nyblom K, Nylin S (2001) Evolutionary dynamics of host-plant specialization: a case study of the tribe Nymphalini. Evolution 55: 783–796. https://doi.org/10.1111/j.0014-3820.2001.tb00814.x.

Jasmani Z, Ravn HP, van den Bosch CCK (2017) The influence of small urban parks characteristics on bird diversity: a case study of Petaling Jaya, Malaysia. Urban Ecosystems 20: 227–243. https://doi.org/10.1007/s11252-016-0584-7.

JASP Team (2022) JASP Version 0.16.4 [Computer Software].

Kowarik I (2011) Novel urban ecosystems, biodiversity, and conservation. Environmental Pollution 159: 1974–1983. https://doi.org/10.1016/j.envpol.2011.02.022.

Lepczyk CA, Aronson MFJ, Evans KL, Goddard MA, Lerman SB, MacIvor JS (2017) Biodiversity in the city: fundamental questions for understanding the ecology of urban green spaces for biodiversity conservation. BioScience 67: 799–807. https://doi.org/10.1093/biosci/bix079.

McDonald RI, Kareiva P, Forman RTT (2008) The implications of current and future urbanization for global protected areas and biodiversity conservation. Biological Conservation 141: 1695–1703. https://doi.org/10.1016/j.biocon.2008.04.025.

Miyawaki A (2004) Restoration of living environment based on vegetation ecology: theory and practice. Ecological Research 19: 83–90. https://doi.org/10.1111/j.1440-1703.2003.00606.x.

Rebele F (1994) Urban ecology and special features of urban ecosystems. Global Ecology and Biogeography Letters 4: 173–187. https://doi.org/10.2307/2997649.

Richardson DM, Ricciardi A (2013) Misleading criticisms of invasion science: a field guide. Diversity and Distribution 19: 1461–1467. https://doi.org/10.1111/ddi.12150.

Rivkin LR, Santangelo JS, Alberti M, Aronson MFJ, de Keyzer CW, Diamond SE, Fortin M-J, Frazee LJ, Gorton AJ, Hendry AP, Liu Y, Losos JB, MacIvor JS, Martin RA, McDonnell MJ, Miles LS, Munshi-South J, Ness RW, Newman AEM, Stothart MR, Theodorou P, Thompson KA, Verrelli BC, Whitehead A, Winchell KM, Johnson MTJ (2019) A roadmap for urban evolutionary ecology. Evolutionary Applications 12: 384–398. https://doi.org/10.1111/eva.12734.

Schlaepfer MA (2018) Do non-native species contribute to biodiversity? PLoS Biology 16: e2005568. https://doi.org/10.1371/journal.pbio.2005568.

Simkin RD, Seto KC, McDonald RI, Jetz W (2022) Biodiversity impacts and conservation implications of urban land expansion projected to 2050. Proceedings of the National Academy of Sciences 119: e2117297119. https://doi.org/10.1073/pnas.2117297119.

Sullivan BW, Nifong RL, Nasto MK, Alvarez-Clare S, Dencker CM, Soper FM, Shoemaker KT, Ishida FY, Zaragoza-Castells J, Davidson EA, Cleveland CC (2019) Biogeochemical recuperation of lowland tropical forest during succession. Ecology 100: e02641. https://doi.org/10.1002/ecy.2641.

Wainwright CE, Staples TL, Charles LS, Flanagan TC, Lai HR, Loy X, Reynolds VA, Mayfield MM (2018) Links between community ecology theory and ecological restoration are on the rise. Journal of Applied Ecology 55: 570–581. https://doi.org/10.1111/1365-2664.12975.