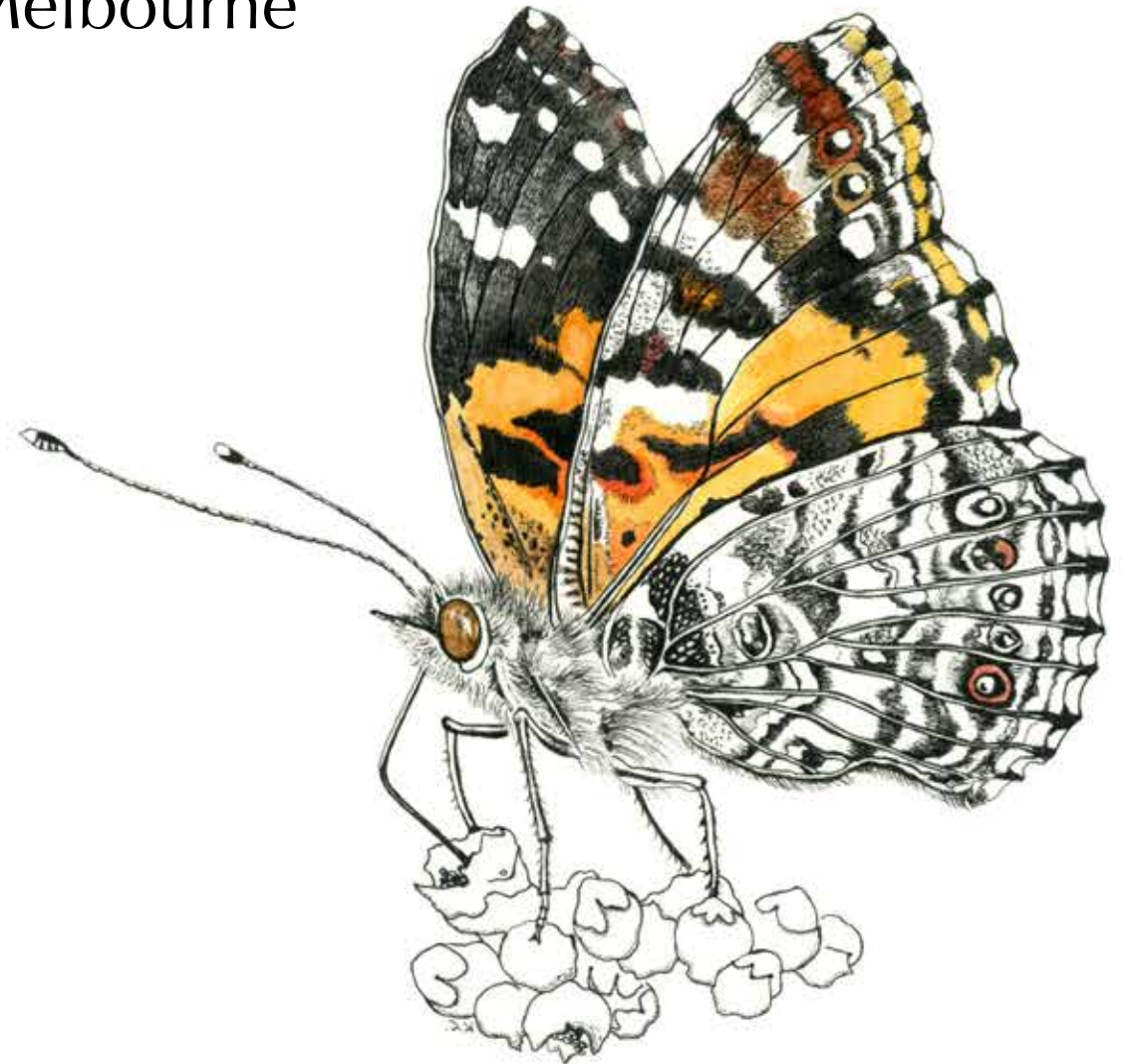


# Our City's Little Gems

Butterfly diversity and flower-butterfly interactions in the City of Melbourne

Holly Kirk  
Tessa Smith  
Anna Backstrom  
Alejandra Morán-Ordóñez  
Georgia E. Garrard  
Ascelin Gordon  
Christopher D. Ives  
Sarah A. Bekessy  
Luis Mata





# **Our City's Little Gems – Butterfly diversity and flower-butterfly interactions in the City of Melbourne**

Report prepared for the City of Melbourne, October 2017

by

Holly Kirk<sup>1</sup>

Tessa Smith<sup>1</sup>

Anna Backstrom<sup>1</sup>

Alejandra Morán-Ordóñez<sup>2</sup>

Georgia E. Garrard<sup>1</sup>

Ascelin Gordon<sup>1</sup>

Christopher D. Ives<sup>3</sup>

Sarah Bekessy<sup>1</sup>

Luis Mata<sup>1</sup>

<sup>1</sup>Interdisciplinary Conservation Science Research Group, Centre for Urban Research, School of Global, Urban and Social Studies, RMIT University, 124 La Trobe Street, Melbourne 3000, Victoria, Australia.

<sup>2</sup>Forest Sciences Centre of Catalonia, Solsona 25280, Catalonia, Spain.

<sup>3</sup>School of Geography, University of Nottingham, University Park, Nottingham NG7 2RD, United Kingdom.

Cover artwork by Kate Cranney **'Australian painted Lady'** (Ink and paper on paper, 2017)

All photographs by Luis Mata unless otherwise stated.

This report was finished in Melbourne (Victoria, Australia) on October 17th, 2017.

**Please cite as:**

Kirk H, Smith T, Backstrom A, Morán-Ordóñez A, Garrard GE, Gordon A, Ives CD, Bekessy SA, Mata L. (2017) Our City's Little Gems – Butterfly diversity and flower-butterfly interactions in the City of Melbourne. Report prepared for the City of Melbourne.

# Acknowledgements

We're very grateful to the City of Melbourne for funding this project. We'd especially like to thank members of the Urban Sustainability Branch for making this exciting research possible

Thanks to John Kirk, Michael Schmid, Kevin Webb and John Wolf for permission to reproduce their images for this report, and to David Cook, Jean and Fred, Michael Jefferies, Dean Morley, Vivek Raj, Sandeep Somasekharan and John Tann for providing photos under the Creative Commons license. Also thanks to CSIRO publishing for allowing us to use their butterfly colour plates.

We'd also like to acknowledge the support of funding from the Australian Research Council - Centre of Excellence for Environmental Decisions (CEED), and the Clean Air and Urban Landscapes (CAUL) and Threatened Species Recovery (TSR) hubs of the Australian Government's National Environmental Science Programme.





# Contents

1 Our City's Little Gems, 1

2 Methods, 9

3 Findings, 15

4 Management recommendations and some concluding remarks, 27

**References, 33**

**Appendix I** Butterfly species profiles, 35

**Appendix II** Plant-butterfly interaction summaries, 57

**Appendix III** List of plants that had no associated butterfly species, 65

**Appendix IV** Summary of not detected butterfly species and species groups, 67





# 1 Our City's Little Gems

## **How did Our City's Little Gems get its name?**

Humans have been fascinated with butterflies for millennia, as evidenced by prehistoric cave paintings found in France (Chauvet Cave, Ardeche). In many different cultures butterflies hold special meaning, be it the symbolism of their metamorphosis, their apparent fragility or their dancing flight from flower to flower. For many people, butterflies are an easily noticeable natural presence in their lives, found in urban and rural habitats across the globe (Ghazanfar et al. 2016, Ramírez-Restrepo & MacGregor-Fors 2016, Wei et al. 2016). Our City's Little Gems acknowledges the eye-catching bright colours and jewel-like patterns of many butterflies, and the precious flashes of colour they bring to Melbourne's green spaces (Figures 1.1 - 1.5).

## **Why are butterflies important?**

Butterflies, like many animals, can play multiple functional roles within an ecosystem. Butterflies

are herbivorous during their caterpillar stage, sometimes establishing themselves as pest species, but can equally be useful as biological control agents of invasive plants (Radchuk et al. 2013). As adults, butterflies rely mainly on flowers for food in the form of nectar, and during their visits may contribute to pollination; a fundamental ecosystem process (Potts et al. 2010, Ghazanfar et al. 2016). Both caterpillar and adult stages are important food sources for insectivorous predators such as birds, and caterpillars can also be used as hosts by parasitoid wasps.

## **Why should we strive to conserve butterflies in urban environments?**

The importance of conserving butterflies in urban environments is twofold: 1) Butterflies are an important part of urban ecosystems as both pollinators and a food source for other species, and 2) Butterflies are charismatic animals, which are valued aesthetically by people, and can play

a key part in engaging community members with urban nature.

### **How does this project relate to *The Little Things that Run the City*?**

This project is a direct extension of *The Little Things that Run the City* project that assessed the insect biodiversity of green spaces in the City of Melbourne (Mata et al. 2015, 2016). Some insect groups, like butterflies, are particularly difficult to identify without capturing them first, and because of time and resource constraints, *The Little Things* project was not able to include them. Because we revisited the same sites, with a focus on butterflies, *Our City's Little Gems* compliments and augments the findings of *The Little Things that Run the City*.

### **What were the project's research questions?**

In this project we asked the following three research questions:

1. How many of the butterfly species that have been historically documented in the City of Melbourne persist within the municipality's boundaries?
2. What is the distribution of butterfly species within the City of Melbourne's public urban green spaces?

3. To which flower species are adult butterflies preferentially attracted?

### **How many butterfly species have been recorded in the City of Melbourne before this study?**

Our search for records of butterfly species occurring within the boundaries of the City of Melbourne indicates that from 1892 to 2016 a total of 45 butterfly species have been recorded in the municipality (Atlas of Living Australia (<http://www.ala.org.au/>)).

### **How will the project's findings inform the City of Melbourne biodiversity management guidelines and policy?**

The findings presented here can be used to inform specific planting palettes in green spaces around Melbourne with a view to restoring butterfly biodiversity. This will be in the form of a suggested plant species list of both native and non-native species, which are known to attract adult butterflies.

### **Will the project's findings also inform other research agendas?**

The study's findings will provide key baseline data

**Figure 1.1 (Opposite page)** The dingy swallowtail *Papilio anactus* in Carlton Gardens.





**Figure 1.2** A lycaenid butterfly species (treated in this study as belonging to the 'little blue butterfly group') visiting a cut-leaved daisy *Brachyscome multifida* in Royal Park.



**Figure 1.3** A skipper butterfly species (treated in this study as belonging to the 'Hesperiidae group') visiting a cut-leafed daisy *Brachyscome multifida* in Royal Park.



**Figure 1.4** The painted lady *Vanessa kershawi* visiting a non-native flower in the Royal Botanic Gardens Melbourne.



**Figure 1.5** The yellow admiral *Vanessa itea* visiting a grasstree (genus *Xanthorrhoea*) in Royal Park.

to *The Shared Urban Habitat*, a research project of the National Environmental Science Programme – Clean Air and Urban Landscapes Hub (<https://www.nespurban.edu.au>) and to the Australian Research Council Linkage Project *Designing green spaces for biodiversity and human well-being* (<https://urbangreenspace.info>).

### **Who funded Our City's Little Gems?**

*Our City's Little Gems* was generously funded by the City of Melbourne. Additional in-kind support was provided by RMIT University, the Forest Sciences Centre of Catalonia, the University of Nottingham, the Centre of Excellence for Environmental Decisions, and the Clean Air and Urban Landscapes and Threatened Species Recovery hubs of the National Environmental Science Programme.



## 2 Methods

### **Where did the study take place?**

In the City of Melbourne (Figure 2.1), a 37.7 km<sup>2</sup> Local Government Area in Victoria, Australia with a current population of approximately 148,000 residents (<http://www.abs.gov.au>).

### **When did the project take place?**

The study took place over 2 months during the Australian summer, from January 11<sup>th</sup> to March 14<sup>th</sup>, 2017.

### **How many study sites were included in the study?**

**15** These comprised: Argyle Square, Canning/Neill Street Reserve, the area of Carlton Gardens south of the Royal Exhibition Building (henceforth Carlton Gardens South), the combined areas of Fitzroy Gardens and Treasury Gardens (henceforth Fitzroy-Treasury Gardens), Gardiner Reserve, Garrard Street Reserve, Lincoln Square, Murchison Square, Pleasance Gardens, Princes Park, Royal

Park, the State Library of Victoria, University Square, Westgate Park and Women's Peace Gardens (Figure 2.1)

### **How many times was each site surveyed?**

**2** Sites were surveyed twice, with the time between one survey period and the next being approximately 30 days.

### **What survey protocol was used?**

Our survey protocol was specifically designed to record flower-butterfly interactions. One to nine survey locations were allocated to each study site, with their geographic location approximately matching the centroids of the tree or mid-storey plots surveyed in Mata et al. (2016). As with *The Little Things that Run the City*, we were interested in developing a protocol in which the survey effort per site varied in proportion to the site's area. We therefore used a logarithmic function closely related to the species-area relationship (see 'How

was the number and size of plots decided?' in Mata et al. 2016 for more details) to determine the number of survey locations per site. At each survey location, the project's field researcher walked along four transects in four different directions (N, S, W, E) radiating away from a central point (this arrangement of survey transects is herein referred to as a 'transect tetrad'). During these timed walks (5 minutes per transect), the surveyor actively searched for plants in flower. If the surveyor encountered a plant in flower, the flower search transect walk was paused and the plant-butterfly interaction observation protocol was implemented. This consisted of at least two five minute periods of actively observing the flower, and noting down the butterfly species that came in touch with the flower's sexual organs. If a new butterfly species landed on the flower during the second observation period this instigated a third five minute period, and so on for a maximum of four periods of observations per flower. After the necessary flower-butterfly interaction observation periods had been completed, the surveyor continued the transect walk (restarting the five minute transect time) until encountering a new plant in flower (flowers of the same plant species were surveyed a maximum of twice per transect, and a maximum of three times per tetrad). A schematic representation and

decision tree of the survey methodology used in this study can be seen in Figure 2.2. Surveys only took place during favourable weather conditions for butterfly activity: no precipitation, wind speed below 5 m/s and temperature above 15 °C.

**How many plant species were surveyed?**

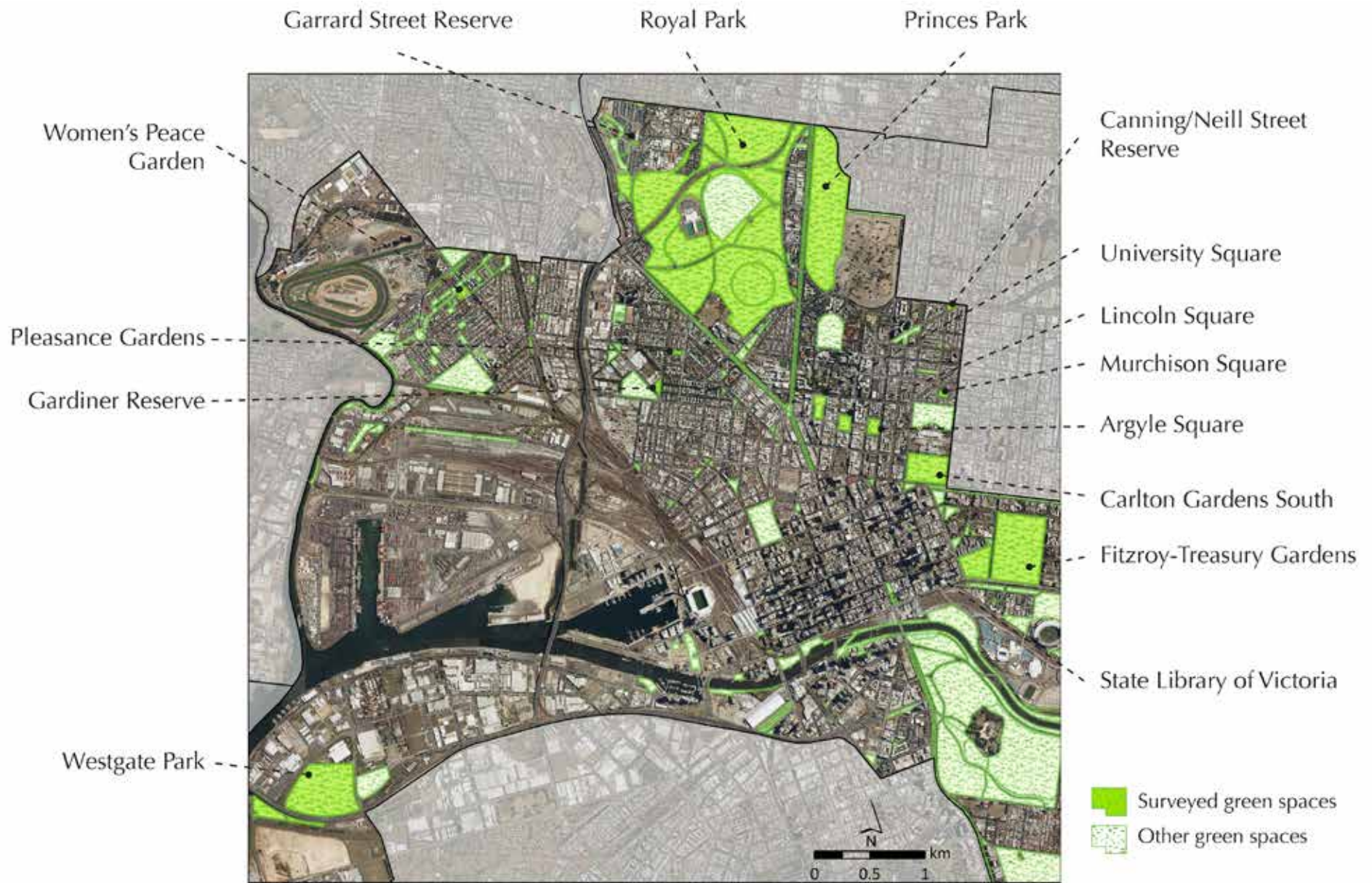
134

**How many flowers were watched to check for visiting butterflies?**

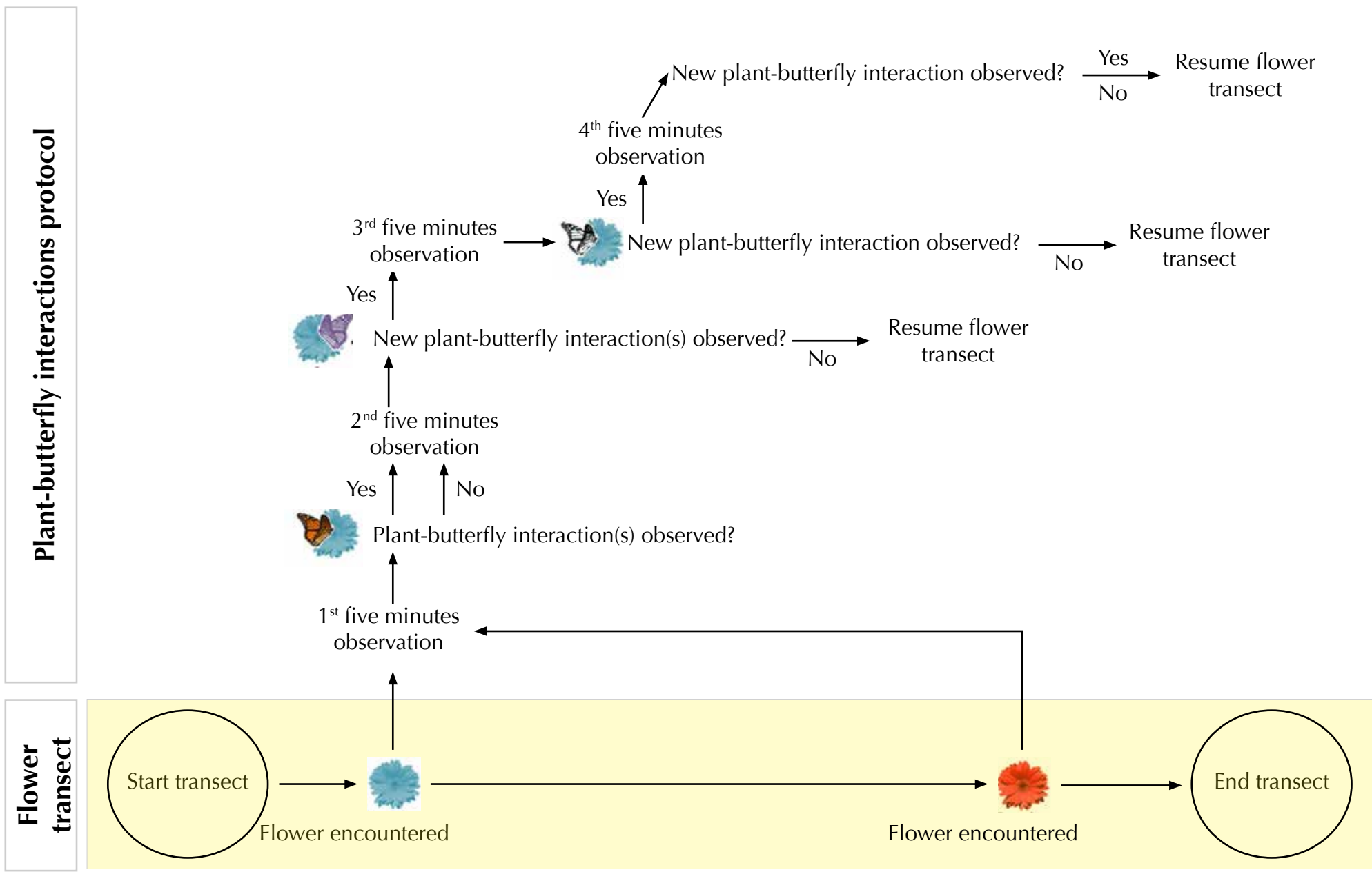
1014

**How many butterfly species and species groups was the field researcher trained to identify?**

21 The field researcher was trained to identify 15 out of the 45 butterfly species that had been previously recorded in the City of Melbourne. These were: Glasswing (*Acraea andromacha*), tailed emperor (*Charaxes sempronius*), lesser wanderer (*Danaus petilia*), monarch (*Danaus plexippus*), small grass-yellow (*Eurema smilax*), ringed xenica (*Geitoneura acantha*), Macleay's swallowtail (*Graphium macleayanum*), Meadow argus (*Junonia villida*) (Figure 3.2), dingy swallowtail (*Papilio anactus*) (Figure 1.1), Chequered swallowtail (*Papilio demoleus*), bright



**Figure 2.1** Map of the City of Melbourne showing the location of the 15 study sites surveyed during this study. Taken from Mata et al. (2016).



**Figure 2.2** A schematic representation and decision tree of the survey methodology. During a given 5 minute flower transect, a surveyor searches for plants in flower. If a flower is encountered, the flower transect walk is paused and the plant-butterfly interactions protocol implemented, which consist of at least two five minute periods of recording the butterfly species that touch the flower. If a new butterfly species lands on the flower during the 2<sup>nd</sup> period this instigates a 3<sup>rd</sup> period, and so on for a maximum of four periods per flower. After the necessary plant-butterfly interactions observation periods are completed, the surveyor continues the transect walk, restarting the five minute transect time.

copper (*Paralucia aurifer*), cabbage white (*Pieris rapae*) (Figure 3.3), varied sword-grass brown (*Tisiphone abeona*), Yellow admiral (*Vanessa itea*) (Figure 1.5) and Australian painted lady (*Vanessa kershawi*) (Figure 1.4). To maximise the accuracy of field identification, the remainder 30 species were combined into the following six species groups: (1) Brown butterfly group (Figure 3.4), comprising *Argynnina cyrila*, *Heteronympha banksia*, *Heteronympha merope*, *Heteronympha paradelpha*, *Heteronympha penelope*, *Oreixenica kershawi* and *Oreixenica lathoniella*; (2) Catopsilia group, comprising *Catopsilia gorgophone* and *Catopsilia pyranthe*; (3) Delias/Belonis group (Figure 4.1), comprising *Belenois java*, *Delias aganippe* and *Delias harpalyce*; (4) Hesperiiidae group (Figure 1.3), comprising *Cephrenes augiades*, *Dispar compacta*, *Hesperilla chrysotricha*, *Mesodina halyzia*, *Ocybadistes flavovittatus*, *Ocybadistes walkeri*, *Taractrocera papyria* and *Trapezites symmomus*; (5) Hypochrysops/Ogyris group, comprising *Hypochrysops delicia*, *Ogyris abrota*, *Ogyris amaryllis* and *Ogyris olane*; and (6) Little blue butterfly group (Figure 1.2), comprising *Candalides acasta*, *Candalides erinus*, *Lampides boeticus*, *Nacaduba biocellata*, *Theclinesthes serpentatus* and *Zizina otis*. Illustrated profiles for these 21 species and species groups are given in

Appendix I.

### **Will the data be available to the public?**

**Yes** The data is available at the City of Melbourne open data platform (<https://data.melbourne.vic.gov.au>). We will publish the project's data via the Open Science Framework (<https://osf.io/>).



# 3 Findings

**How many butterfly species and species groups were sighted in the study?**

**10** These were: the little blue butterfly group (Figure 1.2), the cabbage white (Figure 3.3), the Hesperiiidae group (Figure 1.3), the small grass-yellow, the Australian painted lady (Figure 1.4), the dingy swallowtail (Figure 1.1), the Yellow admiral (Figure 1.5), the brown butterfly group (Figure 3.4), the Macleay's swallowtail and the meadow argus (Figure 3.2).

**Which was the most frequently sighted butterfly?**

The little blue butterfly group. Species belonging in this group were sighted 111 times during the survey, accounting for over 50% of all butterfly sightings (Table 3.1; Figure 3.1; Appendix II).

**How many plant-butterfly interactions were observed during the study?**

**201**

**How many butterfly species were observed only once?**

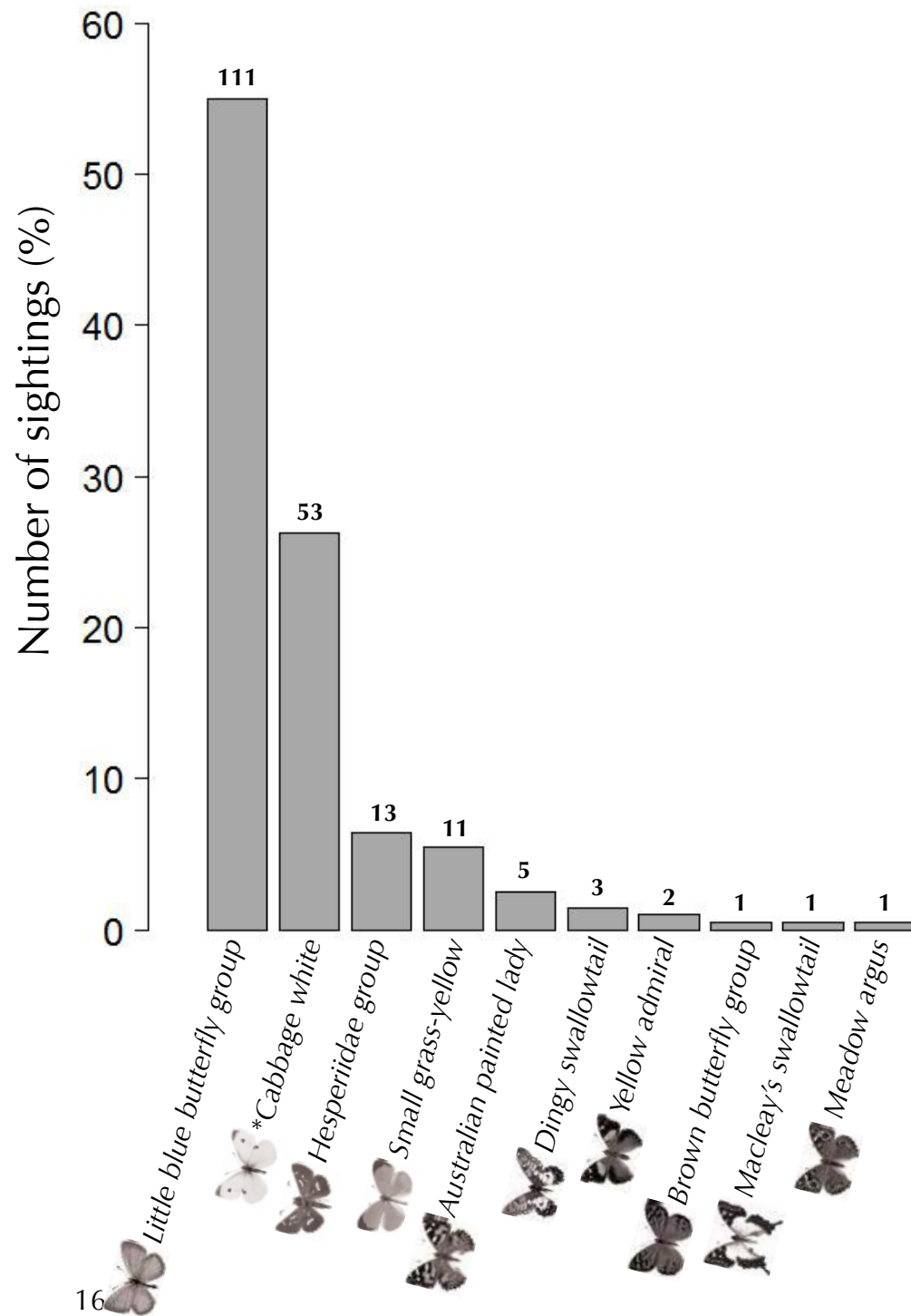
**3** These were: the brown butterfly group (Figure 3.4), the Macleay's swallowtail and the meadow argus (Figure 3.2).

**How many of the observed butterfly species were native to Australia?**

**9** All but one of the observed butterfly species observed were native to Australia. That is 97% of all sighted species in the study.

**Which butterfly species was non-native to Australia?**

The cabbage white (Figure 3.3) was the only non-



**Figure 3.1** Number of sightings of each butterfly species as a percentage of the total number of sightings during the survey. The bold numbers at the top of each bar indicate the total number of sightings of that species. Non-native species are indicated with an \*.

**Figure 3.2 (Opposite page)** The meadow argus *Junonia villida* visiting a species of Goodeniaceae (*Dampiera stricta*). Photo taken at the Royal Botanic Gardens Cranbourne.







**Figure 3.3** The cabbage white *Pieris rapae* visiting the golden everlasting *Xerochrysum bracteatum* in Royal Park.



**Figure 3.4** The common brown butterfly *Heteronympha merope* (treated in this study as belonging to the 'brown butterfly group'). Photo courtesy of John Tann.

native species sighted in the study. This species is found on all continents with the exception of Antarctica. The cabbage white was present at eight out of the 15 green spaces surveyed.

### **Which green space site had the highest number of butterfly species?**

Royal Park. Eight different butterfly species were sighted in Royal Park (Table 3.1), which means that 80% of all recorded species occur in this green space (Figure 3.5). The second and third most species-rich sites for butterflies were Carlton Gardens South and the Women's Peace Gardens, with seven and six butterfly species, respectively (Table 3.1; Figure 3.5). No butterflies were sighted at three of the green spaces surveyed: Canning/Neil Street Reserve, State Library of Victoria and University Square (Figure 3.5). Members of the little blue butterfly group (Figure 1.2) were seen at all sites except for these last three.

### **Which green space had the highest number of plants in flower?**

Royal Park. A total of 64 different plant species in flower were surveyed in this green space. Fitzroy-Treasury Gardens and Carlton Gardens South had respectively the second (42 spp.) and third (30 spp.) highest number of plants in flower. Canning/Neill

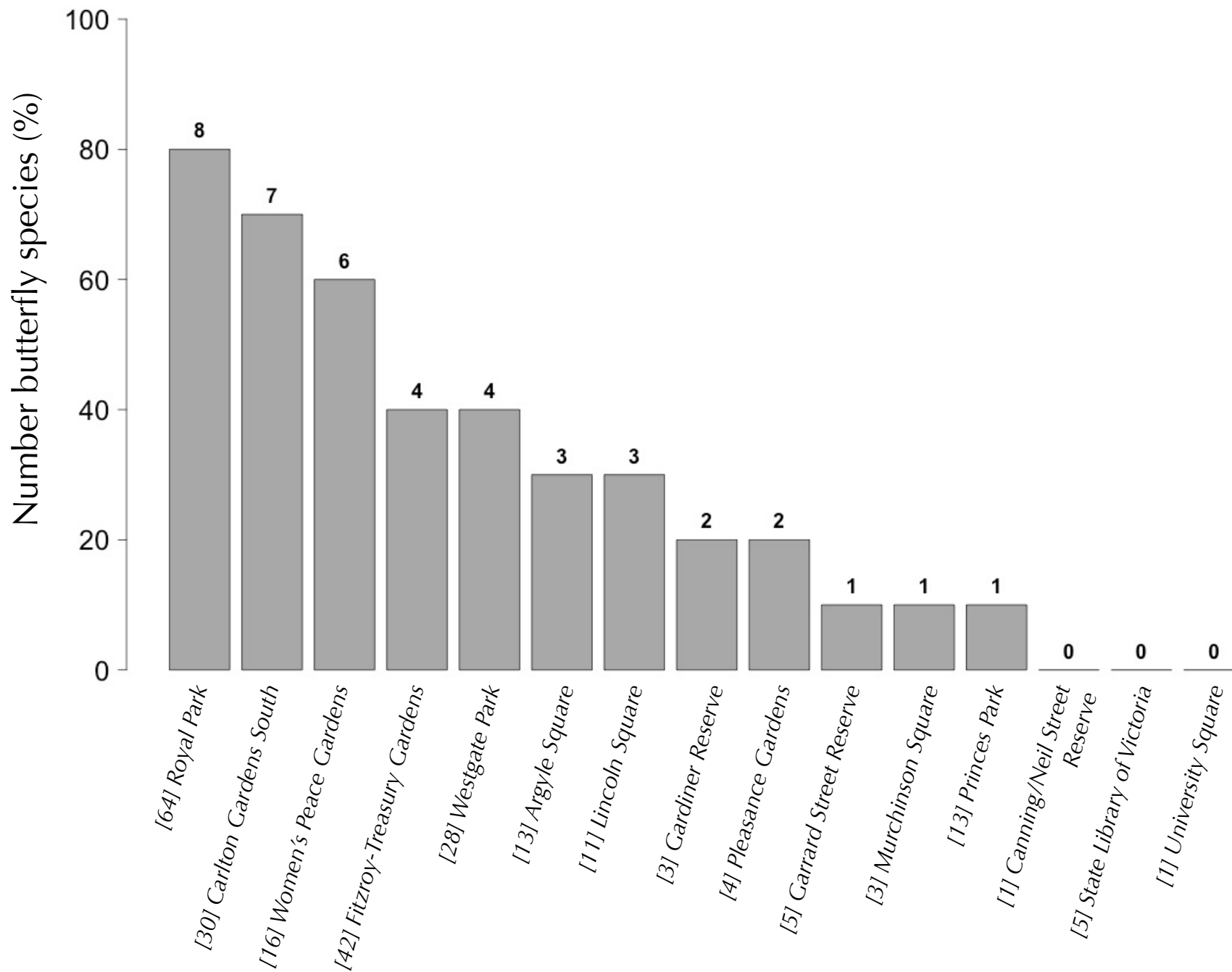
St Reserve and University Square had each only one plant in flower during our study. The number of plants in flower detected/surveyed in each green space is given in Figure 3.5.

### **How many of the surveyed plant species in flower had butterflies associated with them?**

**49** This is about 37% of all plant species surveyed. The scientific names of the 85 plant species on which no butterfly species were observed are given in Appendix III.

### **How many of the surveyed plant species in flower that had butterflies associated with them were native to Australia?**

**14** These were: rough-barked apple *Angophora floribunda*, cut-leafed daisy *Brachyscome multifida*, sweet bursaria *Bursaria spinosa*, river red gum *Eucalyptus camaldulensis*, sugar gum *Eucalyptus cladocalyx*, hop goodenia *Goodenia ovata*, purple loosestrife *Lythrum salicaria*, creeping boobialla *Myoporum parvifolium*, snowy daisy-bush *Olearia lirata*, austral storkbill *Pelargonium australe*, riceflower *Pimelea humilium*, slender pomaderris *Pomaderris racemosa*, bluebell *Wahlenbergia sp.* and golden everlasting *Xerochrysum viscosum*. The butterfly species associated with these native



**Figure 3.5** Number of butterfly species seen in each green space as a percentage of the total number of species observed during the survey. Bold numbers in top of each bar indicate the total number of butterfly species recorded in each site. Numbers between brackets next to the site labels indicate the number of plant species in flower detected/surveyed in each green space site.

plants are given in Appendix II.

### **Which plant species had the highest number of associated butterfly species?**

The non-native cat mint *Nepeta sp.* was associated with the highest number of butterfly species, with six different species recorded on its flowers. The next most popular flowering plant was also a non-native species, the Perez's sea lavender *Limanarium perezii*, which was visited by five different butterfly species. The top native flower for butterfly visits was the cut-leafed daisy, which was associated with four butterfly species. The 21 plant species associated with two or more butterfly species are shown in Figure 3.6. A plant species by butterfly species table indicating the number of times each plant-butterfly interaction was observed across the study is given in Appendix II.

### **Taken together, were there more butterfly species on native or non-native plant species?**











On average, there were 1.2 times more butterfly species associated with non-native than with native plant species.

### **Which butterfly species or species group was associated with the highest number of different plant species?**

The little blue butterfly group (Figure 1.2) interacted with the most diverse range of plant species during this study (32 different plant species; Appendix II). The non-native cabbage white (Figure 3.3) was documented in association with 26 different plant species (Appendix II).

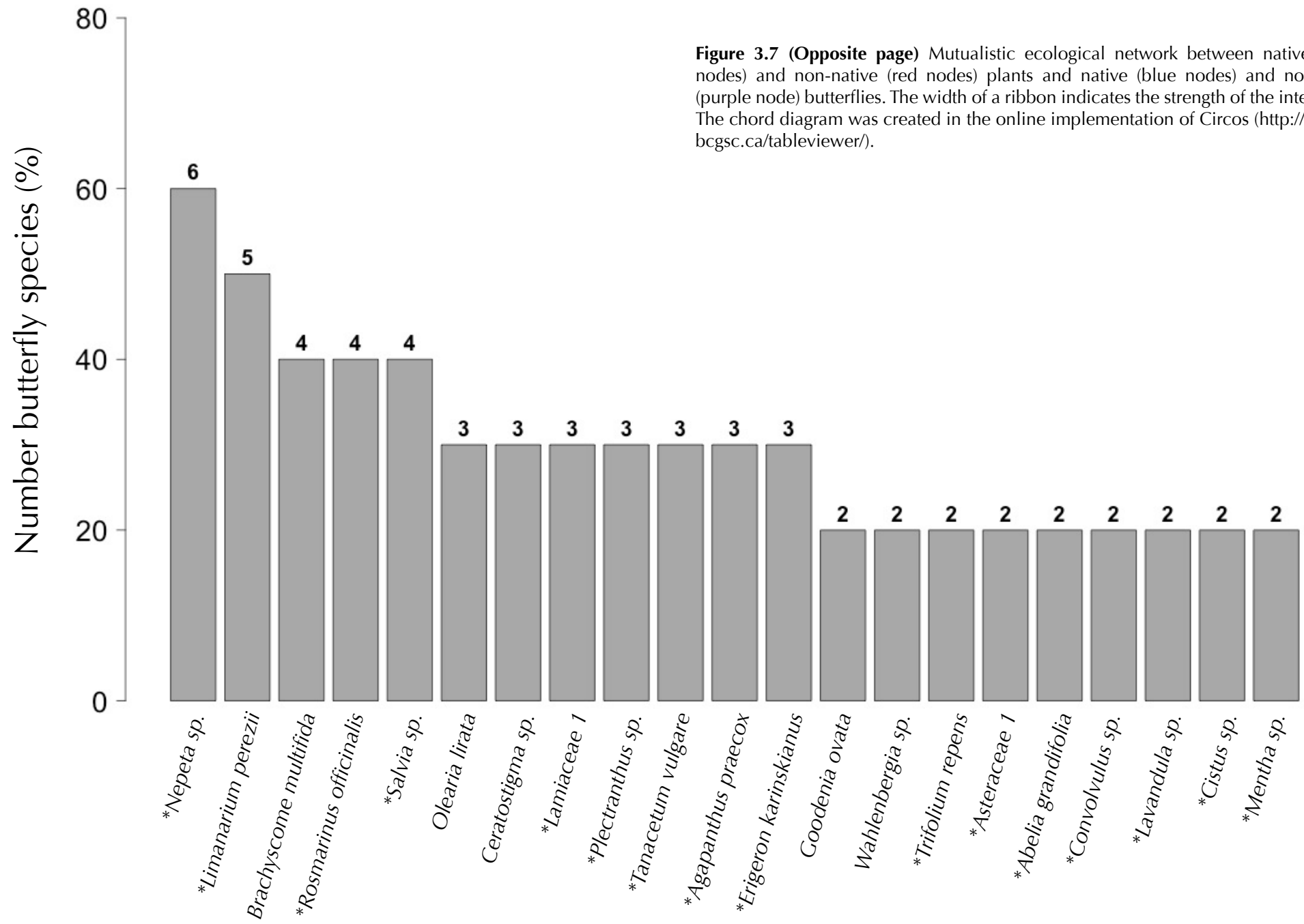
### **Which was the strongest plant-butterfly interaction documented in the study?**

The most common interaction in our study, and the most common interaction between a native butterfly and a non-native plant, occurred between the little blue butterfly group and the white clover *Trifolium repens* (Figure 3.7). Some members of the little blue butterfly group, such as the common grass-blue *Zizania otis*, may lay their eggs on species of clover, which the caterpillars use as a food source (Braby 2000). This may account for the large number of little blue butterfly observations on white clover. There were three equally common interactions between a native butterfly and native plants, these occurred between the little blue butterfly group and the hop goodenia, the snowy daisy-bush and the riceflower (Figure 3.7). The most common interaction of the non-native

		<i>Royal Park</i>	<i>Women's Peace Gardens</i>	<i>Fitzroy-Treasury Gardens</i>	<i>Carlton Gardens South</i>	<i>Westgate Park</i>	<i>Argyle Square</i>	<i>Princes Park</i>	<i>Lincoln Square</i>	<i>Garrard Street Reserve</i>	<i>Murchinson Square</i>	<i>Pleasance Gardens</i>	<i>Gardiner Reserve</i>	<i>Total per butterfly species</i>
Little blue butterfly group		19	21	12	17	5	5	13	7	4	4	3	1	<b>111</b>
Cabbage white		16	8	5	3	12	7	0	1	0	0	0	1	<b>53</b>
Hesperiidae group		1	3	5	1	1	2	0	0	0	0	0	0	<b>13</b>
Small grass-yellow		1	3	5	1	1	0	0	0	0	0	0	0	<b>11</b>
Australian painted lady		1	1	0	0	0	0	0	3	0	0	0	0	<b>5</b>
Dingy swallowtail		1	0	0	1	0	0	0	0	0	0	1	0	<b>3</b>
Yellow admiral		0	1	0	1	0	0	0	0	0	0	0	0	<b>2</b>
Brown butterfly group		1	0	0	0	0	0	0	0	0	0	0	0	<b>1</b>
Macleay's swallowtail		0	0	0	1	0	0	0	0	0	0	0	0	<b>1</b>
Meadow argus		1	0	0	0	0	0	0	0	0	0	0	0	<b>1</b>
Total per study site		<b>41</b>	<b>37</b>	<b>27</b>	<b>25</b>	<b>19</b>	<b>14</b>	<b>13</b>	<b>11</b>	<b>4</b>	<b>4</b>	<b>4</b>	<b>2</b>	<b>201</b>

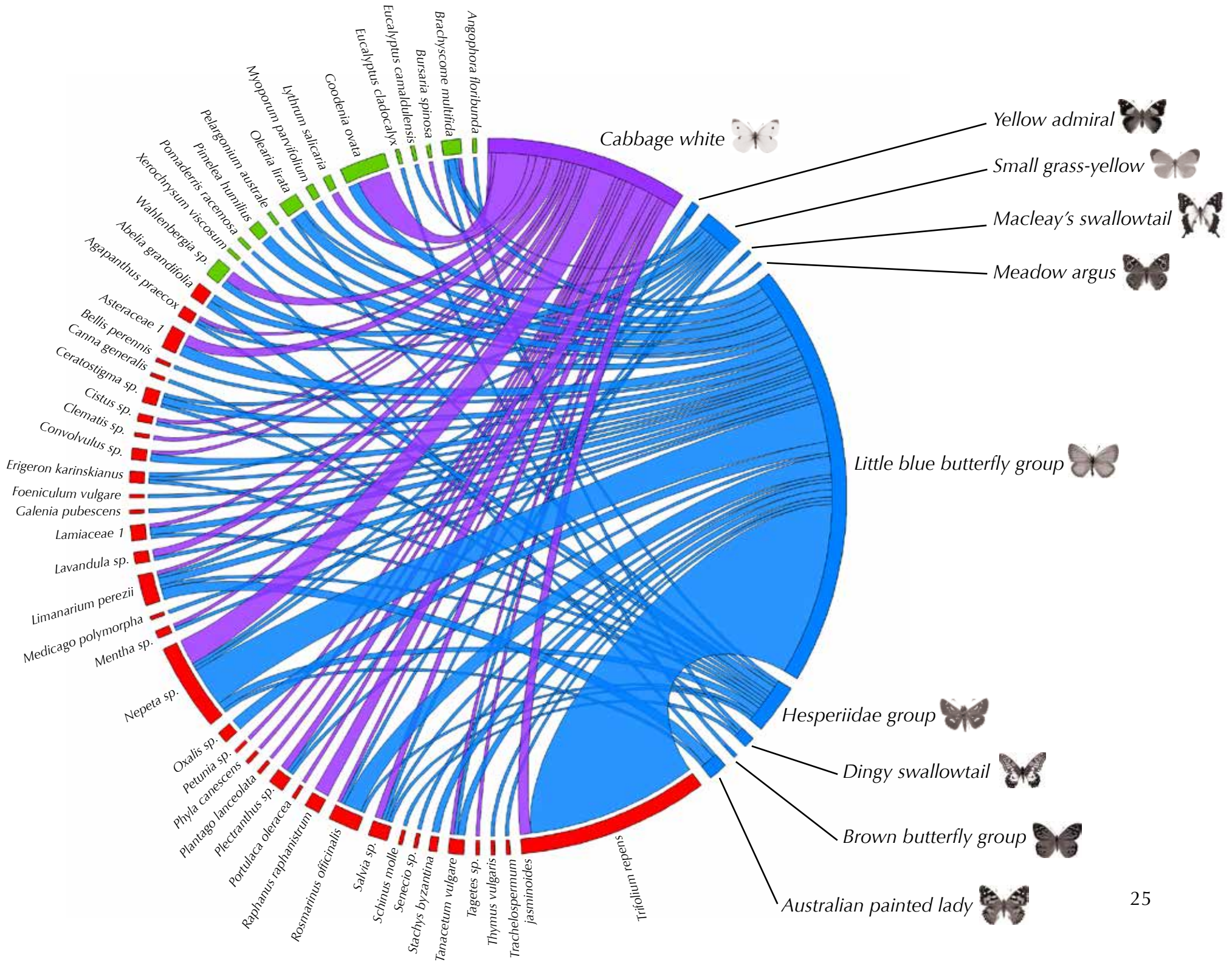
**Table 3.1** Number of plant-butterfly interactions per butterfly species recorded in each study site. Scientific names and species belonging in each group are given in the text.

**Figure 3.7 (Opposite page)** Mutualistic ecological network between native (green nodes) and non-native (red nodes) plants and native (blue nodes) and non-native (purple node) butterflies. The width of a ribbon indicates the strength of the interaction. The chord diagram was created in the online implementation of Circos (<http://mkweb.bcgsc.ca/tableviewer/>).



**Figure 3.6** Number of butterfly species seen in each one of the 21 plant species associated with two or more butterfly species as a percentage of the total number of species observed during the survey. Bold numbers in top of each bar indicate the total number of butterfly species recorded in each plant species. Non-native plant species are indicated with an \*.





cabbage white butterfly with a native plant was with hop goodenia, and with a non-native plant with cat mint (Figure 3.7). Common plant-butterfly interactions can indicate where adult butterflies are relying on a particular plant as a food source (Pocock et al. 2012). Additionally, Figure 3.7 shows that the majority of interactions among native butterflies and plants were with non-native plant species. The number of times each plant-butterfly interaction was observed across the study is given in Appendix II.

# 4 Management recommendations and some concluding remarks

## **What management actions will be of most benefit to butterfly conservation in the City of Melbourne?**

Increase the cover of key flowering plants. Several native flowering plant species were visited by native butterfly species during our study. The native plants that showed the highest number of associated native butterflies were the cut-leafed daisy and the snowy daisy-bush. Likewise, some non-native plant species, for example, the cat mint and the Perez's sea lavender were documented in association with a considerable number of native butterfly species during our study. Adding or maintaining plantings of any of these flowering species may help to keep existing native butterfly species within the city, and potentially attract new species. Caution would be required however when deciding on utilising non-native plants, as very little is known of the quality of the resources (e.g. nutrient content) provided to native butterflies by non-native plants. Furthermore, most butterfly species recorded during this survey rely on different food

plants during their herbivorous caterpillar stage. In order to sustain healthy butterfly populations and communities in the City of Melbourne, it will be important to support them through all stages of their life-cycle (Radchuk et al. 2013).

## **How else can conditions for adult butterflies in the city be improved?**

We provide below four general suggestions that we believe may further contribute to improve butterfly biodiversity in the City of Melbourne:

1. Increase butterfly habitat within public green spaces, including parks and reserves, but also other types of green space around the city, for example, nature-based solutions such as pop-up parks, mobile planting containers, green walls and roofs. This could be achieved through the development of butterfly habitat planting palettes, based for example on the plant-butterfly interaction information provided by this study (Appendix II);



**Figure 4.1** The caper white *Belenois java* (treated in this study as belonging to the 'Delias/Belenois group') visiting a species of Proteaceae (*Grevillea sp.*) in Royal Park.



**Figure 4.2** The red-spotted Jezebel *Delias aganippe* (treated in this study as belonging to the 'Delias/Belenois group') in Westgate Park. Photo courtesy of George Fotheringham.

2. Develop a butterfly biodiversity and conservation program for the private realm to encourage individual and community involvement in butterfly habitat creation through a network of residential and community gardens (e.g. in backyards and schoolyards). This should be synergistically executed along with communication about the detrimental effects of pesticides on butterflies;
3. Maintain, and re-fresh, remnant and native flora communities that strategically provide resources and habitat connectivity for butterflies.

### **Where have the other butterflies gone?**

It's hard to say. Historical data suggests that 45 butterfly species have been recorded in the City of Melbourne, which in this study were treated as 21 targeted butterfly species or species group. Of these, eleven were not detected during our plant-butterfly interactions survey (Appendix IV). Some of the historic records are up to several decades old. During this time, it is very probable that key habitat for these butterfly species has been fragmented, degraded or entirely lost; and these butterflies' ranges may have shifted. It is possible that some species are present in the outer suburbs of greater metropolitan Melbourne, but the urban landscape is forming a barrier to dispersal into the City of Melbourne. This could be ameliorated

by increasing the connectivity between green spaces within the wider city. The restricted survey period (January-March) may have also affected the number of species recorded; for example, the peak flight/migratory season may have passed for some species decreasing the likelihood of detection. That was the case for both the caper white (Figure 4.1) and the red-spotted Jezebel (Figure 4.2), treated here as belonging to the 'Delias/Belenois group', which have been recently recorded in the City of Melbourne outside of the survey period of this study. Finally, while we aimed to achieve a reasonable trade-off between accuracy and effort, it is possible that more effort is required to detect rarer butterfly species than was possible within the time and resource constraints of our study.

### **Would further studies like Our City's Little Gems add to our knowledge of butterfly ecology, biodiversity and conservation in the City of Melbourne?**

**Yes** A key extension to this study would be to survey for a longer period of time, for example, from October to May. This would cover more of the flight season, potentially for a greater range of species, allowing for a more accurate picture of the current butterfly biodiversity in the City of Melbourne. Additionally, a study specifically

aimed at elucidating the trophic network between butterfly caterpillars and their host plants would provide a better understanding of which plants are important for the immature stages of the butterfly life-cycle. More information is vital for understanding the complex effects of future environmental and climate change on our city's little gems (Visser & Both 2005, Radchuk et al. 2013).





# References

- Braby MF. (2016) The complete guide to butterflies of Australia. 2<sup>nd</sup> Edition, CSIRO Publishing, Clayton South, Victoria, Australia.
- Braby MF. (2000) The butterflies of Australia: Their identification, biology and distribution. CSIRO Publishing, Collingwood, Victoria, Australia.
- Ghazanfar M, Malik MF, Hussain M, Iqbal R, Younas M. (2016) Butterflies and their contribution in ecosystem: A review. *Journal of Entomology and Zoology Studies* 115: 115–118.
- Mata L, Ives CD, Garrard GE, Gordon A, Backstrom A, Cranney K, Smith TR, Stark L, Bickel DB, Cunningham S, Hahs AK, Hochuli D, Malipatil M, Moir M, Plein M, Porch N, Semeraro L, Standish R, Walker K, Vesk PA, Parris K, Bekessy SA. (2015) The Little Things that Run the City: How do Melbourne's green spaces support insect biodiversity and ecosystem health? Report prepared for the City of Melbourne.
- Mata L, Ives CD, Morán-Ordóñez A, Garrard GE, Gordon A, Cranney K, Smith TR, Backstrom A, Bickel DJ, Hahs AK, Malipatil M, Moir ML, Plein M, Porch N, Semeraro L, Walker K, Vesk PA, Parris KM, Bekessy SA. (2016) The Little Things that Run the City – Insect ecology, biodiversity and conservation in the City of Melbourne. Report prepared for the City of Melbourne.
- Pocock MJO, Evans DM, Memmott J. (2012) The robustness and restoration of a network of ecological networks. *Science* 335: 973–977.
- Potts SG, Biesmeijer JC, Kremen C, Neumann P, Schweiger O, Kunin WE. (2010) Global pollinator declines: Trends, impacts and drivers. *Trends in Ecology and Evolution* 25: 345–353.
- Radchuk V, Turlure C, Schtickzelle N. (2013) Each life stage matters: The importance of assessing the response to climate change over the complete life cycle in butterflies. *Journal of Animal Ecology* 82: 275–285.

Ramírez-Restrepo L, MacGregor-Fors I. (2017) Butterflies in the city: A review of urban diurnal Lepidoptera. *Urban Ecosystems* 20: 171–182.

Visser ME, Both C. (2005) Shifts in phenology due to global climate change: the need for a yardstick. *Proceedings of the Royal Society B* 272: 2561–2569.

Wei JW, Lee B, Wen LB. (2016) Citizen science and the urban ecology of birds and butterflies - A systematic review. *PLoS ONE* 11: 1–23.

# Appendix I

## Butterfly species profiles

### Notes

All information on butterfly morphology, biology, distribution and caterpillar and adult host associations are based on Braby (2000, 2016).

All these species have been historically detected in the City of Melbourne as reported in the Atlas of Living Australia.

Topside (T) and underside (U) illustrations courtesy of CSIRO publishing.



# Glasswing

*Acraea andromacha* (Fabricius, 1775)

[Lepidoptera: Nymphalidae]



## Characteristics

Almost transparent forewings, while hindwings are creamy with dark spots and a band around the edge.

Has a slow, flapping flight low to the ground.

This butterfly is not often seen in Victoria.

## Caterpillar feeds on

Usually native and non-native species of *Passiflora*. Also found on species of *Adenia* and *Hybanthus*.

## Adults feeds on

No information on the plant species this butterfly feeds on in its adult stage was available in the consulted literature.

This species was not detected in our plant-butterfly interactions survey.



## Brown butterfly group

*Argynnina cyrila*, *Heteronympha banksia*, *H. merope*, *H. paradelpha*, *H. penelope*, *Oreixenica kershawi* and *O. lathoniella*

[Lepidoptera: Nymphalidae]



### Characteristics

A group of butterflies with highly patterned wings in oranges and dark brown. All species have distinctive eye markings in the hindwings, some of them on both the fore and hindwing and both top and underside.

All can be found flying within 1m of the ground and roosting in groups over night between December and May.

### Caterpillar feeds on

The caterpillars of these species are often found feeding on native and non-native grasses and sedges, including species of *Austrodanthonia*, *Brachypodium*, *Bromus*, *Ehrharta*, *Cynodon*, *Microlaena*, *Pennisetum*, *Poa*, *Tetrarrhena* and *Themeda*.

### Adults feeds on

Butterflies from several of these species often seen feeding on daisies and also from eucalypt sap flows.

In this study we recorded the brown butterfly group visiting flowers of the sugar gum *Eucalyptus cladocalyx* (Appendix II).



# Catopsilia group

*Catopsilia gorgophone* and *C. pyranthe*

[Lepidoptera: Pieridae]



## Characteristics

These large pale butterfly species are polymorphic, with colours ranging from white to bright yellow on both wings. Some will also have dark markings around the leading edge of the forewings on the topside.

Both species are migratory, and they are active in Victoria during the late summer into autumn.

## Caterpillar feeds on

Known to feed on both native and non-native species of *Senna* and *Cassia*.

## Adults feeds on

No information on the plant species this butterfly feeds on in its adult stage was available in the consulted literature.

This species was not detected in our plant-butterfly interactions survey.



# Tailed emperor

*Charaxes sempronius* (Fabricius 1793)

[Lepidoptera: Nymphalidae]



## Characteristics

This butterfly has a distinctive cream and black topside, brown, yellow and black markings on the underside and two small tails on each hindwing.

The fast flying adults are often attracted to fruits and sap.

Widespread around eastern Australia.

## Caterpillar feeds on

A wide range of host plants, usually of the legume family (Fabaceae), including native species of *Acacia*.

## Adults feeds on

No information on the plant species this butterfly feeds on in its adult stage was available in the consulted literature.

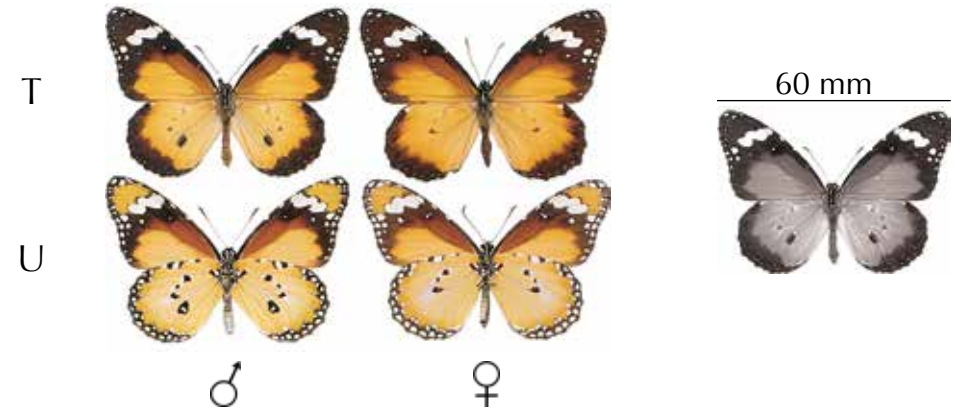
This species was not detected in our plant-butterfly interactions survey.



# Lesser wanderer

*Danaus petilia* (Stoll, 1790)

[Lepidoptera: Nymphalidae]



## Characteristics

A striking orange/yellow butterfly with black and red tips to the wings.

A migratory species that is widespread throughout Australia.

Flight times in Victoria are between October and April.

## Caterpillar feeds on

Caterpillars feed on a wide range of native and non-native host plants in the dogbane family (Apocynaceae), including species of *Asclepias*, *Calotropis* and *Cynanchum*.

## Adults feeds on

No information on the plant species this butterfly feeds on in its adult stage was available in the consulted literature.

This species was not detected in our plant-butterfly interactions survey.

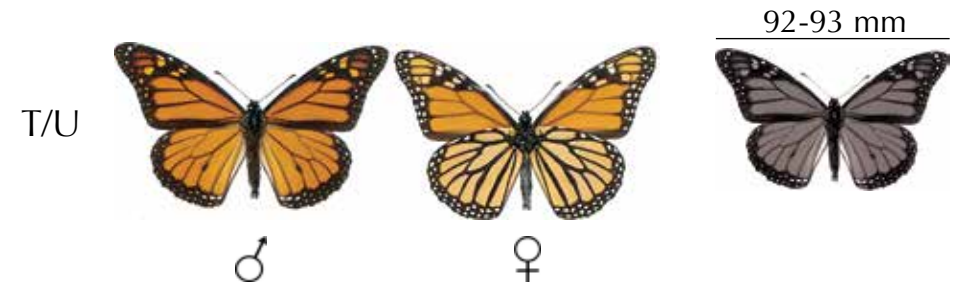




# Monarch

*Danaus plexippus* (Linnaeus, 1758)

[Lepidoptera: Nymphalidae]



## Characteristics

Large orange butterfly with striking black veins across both sets of wings. Paler yellow on the underside.

A migratory species that established in Australia in the 19<sup>th</sup> century.

## Caterpillar feeds on

A range of non-native host plants, including species of *Araujia*, *Asclepias*, *Calotropis*, *Gomphocarpus* and *Stapelia*.

## Adults feeds on

No information on the plant species this butterfly feeds on in its adult stage was available in the consulted literature.

This species was not detected in our plant-butterfly interactions survey.



# Delias/Belenois group

*Delias aganippe*, *D. harpalyce* and *Belenois java*

[Lepidoptera: Pieridae]



## Characteristics

Striking black and white butterflies with colourful black and yellow, or black, red and yellow wing undersides.

Adults can usually be found all year round, with some species showing migratory behaviour.

## Caterpillar feeds on

*Delias agganippe* & *D. harpalyce*:

Host plants include species of mistletoe (*Amyema* spp. & *Muellerina eucalyptoides*).

*Belenois java*:

Host plants include currant bush *Apophyllum anomalum* and species of *Capparis*.

## Adults feeds on

Eucalypt flowers and also the flowers of some caterpillar food plants including *Amyema miquelii*.

This species group was not detected in our plant-butterfly interactions survey. However, *Belenois java* has been recently observed in the City of Melbourne (Royal Park) visiting flowers of a species of *Grevillea* (LM pers. obs.).

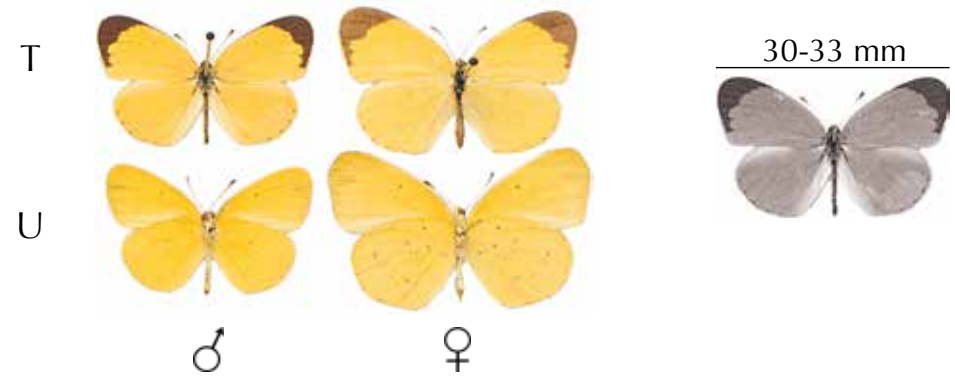
Photo: The caper white *Belenois java* visiting a species of *Grevillea* in Royal Park (Luis Mata).



# Small grass-yellow

*Eurema smilax* (Donovan, 1805)

[Lepidoptera: Pieridae]



## Characteristics

A small yellow butterfly with black tips to the forewings.

Seen flying close to the ground, often slowly.

## Caterpillar feeds on

A range of native and non-native host plants in family Fabaceae, including species of *Cassia*, *Neptunia* and *Senna*.

## Adults feeds on

No information on the plant species this butterfly feeds on in its adult stage was available in the consulted literature.

In this study we recorded *Eurema smilax* visiting flowers of the native cut-leafed daisy *Brachyscome multifida* and the snowy daisy-bush *Olearia lirata*, as well as a wide range of non-native plants (Appendix II).



# Macleay's swallowtail

*Graphium macleayanum* (Leach, 1814)

[Lepidoptera: Papilionidae]



## Characteristics

Large black and white butterfly with greenish colour on wing undersides and brown edges. Distinctive swallowtail shape on hindwings, with a tail.

Usually seen flying fast and high.

Mainly found in Victoria and Tasmania, generally on the wing between November and March.

## Caterpillar feeds on

A wide range of native host plants, including species of *Atherosperma*, *Cinnamomum*, *Cryptocarya*, *Daphnandra*, *Doryphora*, *Endiandra*, *Geijera* and *Tasmannia*

Also feeds on the non-native laurel *Cinnamomum camphora*.

## Adults feeds on

Observed feeding on species of *Buddleja*, *Lantana*, *Leptospermum* and daisies.

In this study we recorded *Graphium macleayanum* visiting flowers of a non-native species of *Plectranthus* (Appendix II).



# Ringed xenica

*Geitoneura acantha* (Donovan, 1805)

[Lepidoptera: Nymphalidae]



## Characteristics

A small butterfly with black, brown and orange markings, and distinctive eye spots on fore and hindwings.

Often found flitting slowly between shady and sun patches.

Victorian flight season is between December and April.

## Caterpillar feeds on

A range of grasses, including *Microlaena stipoides*, *Themeda triandra* and species of *Poa*.

## Adults feeds on

*Bursaria spinosa* and species of *Acacia* and *Eucalyptus*.

This species was not detected in our plant-butterfly interactions survey.



## Hesperiidae group

*Dispar compacta*, *Cephrenes augiades*, *Hesperilla chrysotricha*, *Mesodina halyzia*, *Ocybadistes flavovittatus*, *O. walkeri*, *Taractrocer a papyria* and *Trapezites symmomus*.

[Lepidoptera: Hesperiidae]



### Characteristics

The butterflies in this group are distinct from others, particularly in the way in which they hold their wings, with the forewings often held perpendicular to the hindwings.

All species are dark brown with a variety of orange, yellow or white markings on both wings and often have hairy bodies.

### Caterpillar feeds on

A range of native and non-native host plants, including species of *Axonopus*, *Brachypodium*, *Bromus*, *Carex*, *Cynodon*, *Ehrharta*, *Gahnia*, *Imperata*, *Lolium*, *Megathyrsus*, *Melinis*, *Paspalum*, *Pennisetum*, *Poa* and *Thuarea*.

### Adults feeds on

No information on the plant species this butterfly feeds on in its adult stage was available in the consulted literature.

In this study we recorded the Hesperiidae group on the native plants *Brachyscome multifida* and *Olearia lirata*, as well as a wide range of non-native plants (Appendix II). Also known to visit *Pelargonium australe* (LM pers. obs.).

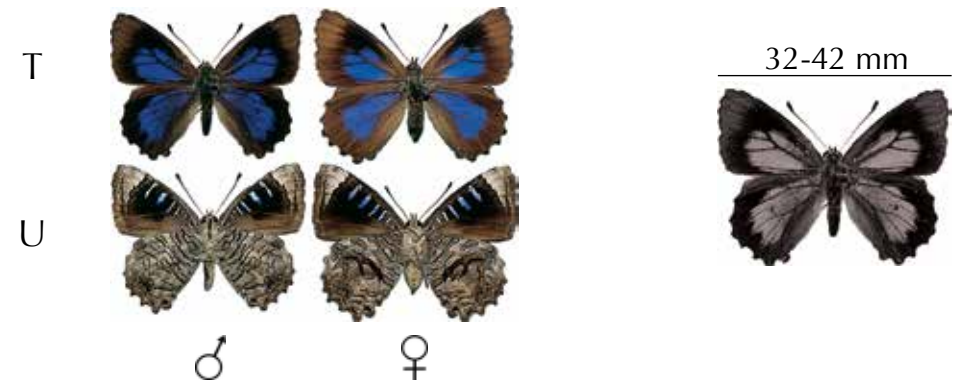
Photo: A species in the Hesperiidae group visiting a flower of the cut-leafed daisy *Brachyscome multifida* in Royal Park (Luis Mata).



# Hypochrysops/Ogyris group

*Hypochrysops delicia*, *Ogyris abrota*, *O. amaryllis* and *O. olane*

[Lepidoptera: Lycaenidae]



## Characteristics

A group of medium sized butterflies all with pale to dark-blue iridescent patches on the forewings. The underside is generally brown with many subtle markings ranging from reddish brown to black and white.

Adults can be seen flying in Victoria between October and April.

## Caterpillar feeds on

Species of *Acacia* and *Amyema*.

## Adults feeds on

Observed feeding on *Amyema miquelii*.

This species was not detected in our plant-butterfly interactions survey.



# Meadow argus

*Junonia villida* (Fabricius, 1787)

[Lepidoptera: Nymphalidae]



## Characteristics

Brown butterfly with orange and blue on wings. Six eye spots on the topside, two on the underside.

Fast flying butterfly that follows a flap-flap-glide flight pattern.

Widely distributed throughout Australia.

## Caterpillar feeds on

Feeds on a wide range of native and non-native host plants, including species of *Plantago*.

## Adults feeds on

No information on the plant species this butterfly feeds on in its adult stage was available in the consulted literature.

In this study we recorded *Junonia villida* visiting the flowers of the river red gum *Eucalyptus camaldulensis* (Appendix II). Also observed visiting the flowers of *Dampiera stricta* (LM pers. obs)





# Dingy swallowtail

*Papilio anactus* (W.S. Macleay, 1892)

[Lepidoptera: Papilionidae]



## Characteristics

Large black and grey butterfly with red and blue dots on the hindwings.

Flight season between November and April when males can be seen patrolling sunny patches between vegetation.

Widespread along the east coast of Australia.

## Caterpillar feeds on

Native and non-native species in the citrus family (Rutaceae). Native citrus species, includes *Citrus australasica*, *C. australis* and *C. glauca*, as well as range of non-native citrus species (e.g. lemon, orange and grapefruit).

## Adults feeds on

No information on the plant species this butterfly feeds on in its adult stage was available in the consulted literature.

In this study we recorded *Papilio anactus* visiting the flowers of native rough-barked apple *Angophora floribunda*, and of the non-native species *Canna generalis* and *Schinus molle* (Appendix II).



# Chequered swallowtail

*Papilio demoleus* (Linnaeus, 1758)

[Lepidoptera: Papilionidae]



## Characteristics

A large black and pale yellow butterfly with numerous dots and markings on both top and underside. Hindwings have red dots on both the top and underside, with a blue eye spot also on the underside.

Very common and widespread throughout Australia.

## Caterpillar feeds on

Native species of *Cullen*, some native and non-native species of *Citrus*, and also on the non-native *Psoralea pinnata*.

## Adults feeds on

No information on the plant species this butterfly feeds on in its adult stage was available in the consulted literature.

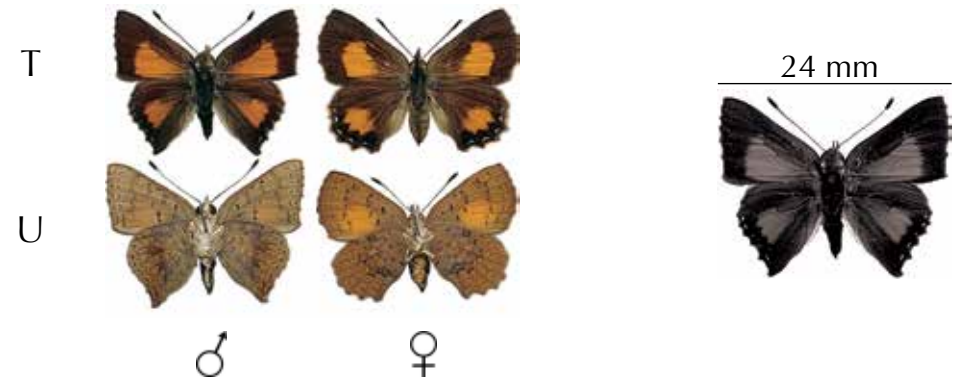
This species was not detected in our plant-butterfly interactions survey.



# Bright copper

*Paralucia aurifer* (Blanchard, 1848)

[Lepidoptera: Lycaenidae]



## Characteristics

Small brown butterfly with orange patches on both set of wings. The underside is a paler brown with delicate speckles.

Seen in flight from April to August.

Restricted to the south-east edge of Australia.

## Caterpillar feeds on

*Bursaria spinosa* and *Pittosporum multiflorum*.

## Adults feeds on

No information on the plant species this butterfly feeds on in its adult stage was available in the consulted literature.

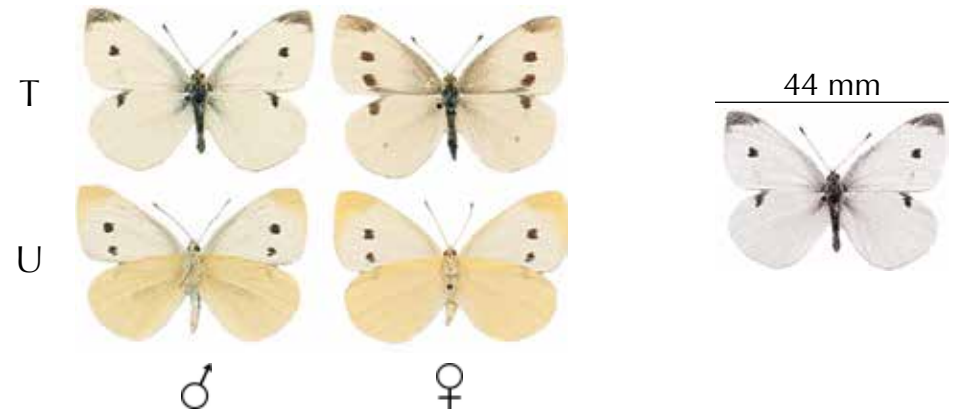
This species was not detected in our plant-butterfly interactions survey.



# Cabbage white

*Pieris rapae* (Linnaeus, 1758)

[Lepidoptera: Pieridae]



## Characteristics

White with paired black dots on both the top and underside.

Non-native to Australia.

Widely distributed across southern Australia.

## Caterpillar feeds on

A range of non-native host plants, including species of *Brassica*, *Cakile*, *Cleome*, *Hirschfeldia*, *Lepidium*, *Reseda*, *Sisymbrium*, and *Tropaeolum*.

## Adults feeds on

No information on the plant species this butterfly feeds on in its adult stage was available in the consulted literature.

In this study we recorded *Pieris rapae* visiting both native (*Brachyscome multifida*, *Bursaria spinosa*, *Goodenia ovata*, *Lythrum salicaria* and *Wahlenbergia sp.*) and non-native plants (Appendix II). Also seen on *Stylidium sp.*, *Olearia lirata*, *Pelargonium australe* and *Xerochrysum bracteatum* (LM pers. obs.).

Also

Photo: *Pieris rapae* visiting the flowers of a species of *Stylidium* during the State Library of Victoria 'Grassland' installation (Luis Mata).



# Varied sword-grass brown

*Tisiphone abeona* (Donovan, 1805)

[Lepidoptera: Nymphalidae]



## Characteristics

Male and female are noticeably different in this species, the female is generally larger and lighter in colour. Both sexes are brown butterflies with orange patches on the forewing and distinctive eye spots on both the top and underside.

Seen flying between September and April.

Restricted to the south east of Australia.

## Caterpillar feeds on

A range of sedge host plants, including species of *Gahnia*.

## Adults feeds on

No information on the plant species this butterfly feeds on in its adult stage was available in the consulted literature.

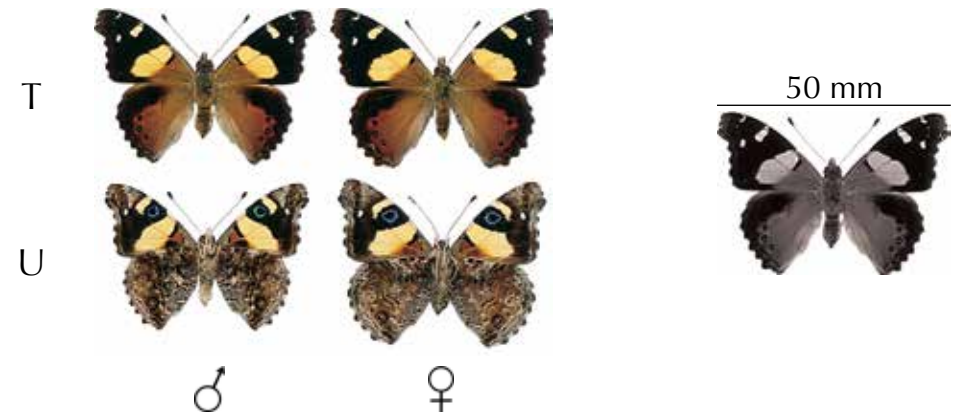
This species was not detected in our plant-butterfly interactions survey.



# Yellow admiral

*Vanessa itea* (Fabricius, 1775)

[Lepidoptera: Nymphalidae]



## Characteristics

Black, yellow and orange butterfly, with scalloped edges to the wings. Underside is highly marked and mottled with pale brown and orange.

Seen in fast flight between August and May.

Widespread throughout southern and eastern Australia.

## Caterpillar feeds on

Native *Parietaria debilis* and *Urtica incisa*, and also on the non-native *Urtica dioica*.

## Adults feeds on

No information on the plant species this butterfly feeds on in its adult stage was available in the consulted literature.

In this study we recorded *Vanessa itea* visiting the flowers of the non-native *Nepeta Sp.* and *Tanacetum vulgare* (Appendix II). Also known to visit *Pimelea rara* and *Xanthorrhoea sp.* (LM pers. obs.).



# Australian painted lady

*Vanessa kershawi* (McCoy, 1868)

[Lepidoptera: Nymphalidae]



## Characteristics

This orange and black butterfly has many delicate markings on both the top and underside, with distinctive white dots and bars on the forewings.

Widespread across Australia.

## Caterpillar feeds on

Native species of *Ammobium* and *Chrysocephalum*, and both native and non-native species in the daisy family (Asteraceae).

## Adults feeds on

No information on the plant species this butterfly feeds on in its adult stage was available in the consulted literature.

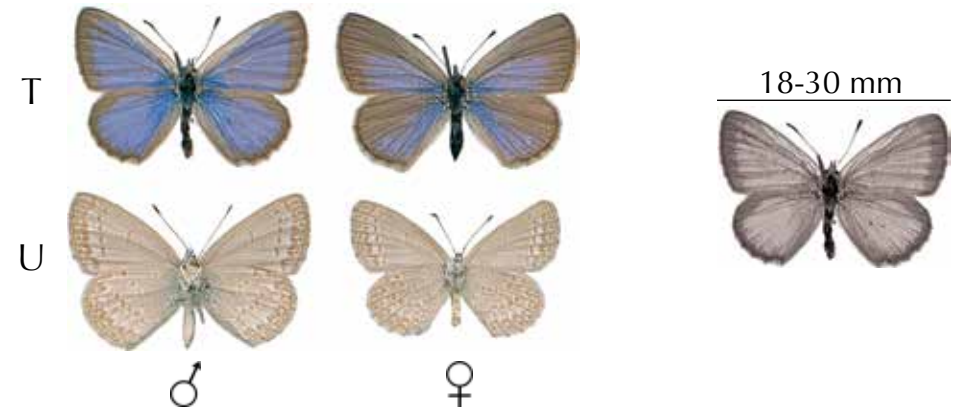
In this study we recorded *Vanessa kershawi* visiting the flowers of native (*Xerochrysum viscosum*) and non-native (*Nepeta sp.* and *Limanarium perezii*) plants (Appendix II). Also known to visit *Arctotheca calendula*, *Chrysocephalum sp.* and *Pimelea rara* (LM pers. obs.).



# Little blue butterfly group

*Candalides acasta*, *C. erinus*, *Lampides boeticus*, *Nacaduba biocellata*, *Theclinesthes serpentatus* and *Zizina otis*.

[Lepidoptera: Lycaenidae]



## Characteristics

Tiny pale butterflies with a blue tinge to the wings, sometimes with an all blue topside bordered by a darker brown. Underside of wings is usually brown with a few speckles. The adult males of many of these species are often more colourful than the female butterflies.

The caterpillar of these species are all parasitic or semi-parasitic in ant's nests.

## Caterpillar feeds on

A wide range of host plants, including species of Chenopodiaceae and Fabaceae.

## Adults feeds on

No information on the plant species this butterfly feeds on in its adult stage was available in the consulted literature.

In this study we recorded the little blue butterfly group on a wide range of native (*Brachyscome multifida*, *Goodenia ovata*, *Myoporum parvifolium*, *Pelargonium australe*, *Pimelea humilium*, *Pomaderris racemosa* and *Wahlenbergia sp.*) and non-native plants (Appendix II). Also seen on *Raphanus raphanistrum* and *Scaveola aemula* (LM pers. obs.).

Photo: A species in the little blue butterfly group visiting the flower of the wild radish *Raphanus raphanistrum* in Westgate Park (Luis Mata).













# **Appendix II**

## Plant-butterfly interaction summaries

Native plant species	Little blue butterfly group	Cabbage white*	Hesperiidae group	Small grass-yellow	Australian painted lady	Dingy swallowtail	Yellow admiral	Brown butterfly group	Macleay's swallowtail	Meadow argus	All butterfly species	N° of associated butterfly species
Hop goodenia	3	9	0	0	0	0	0	0	0	0	12	2
Cut-leafed daisy	2	1	1	1	0	0	0	0	0	0	5	4
Snow daisy-bush	3	0	1	1	0	0	0	0	0	0	5	3
Bluebell	2	3	0	0	0	0	0	0	0	0	5	2
Riceflower	3	0	0	0	0	0	0	0	0	0	3	1
Purple loosestrife	0	2	0	0	0	0	0	0	0	0	2	1
Creeping boobialla	2	0	0	0	0	0	0	0	0	0	2	1
Rough-barked apple	0	0	0	0	0	1	0	0	0	0	1	1
Sweet bursaria	0	1	0	0	0	0	0	0	0	0	1	1
River red gum	0	0	0	0	0	0	0	0	0	1	1	1
Sugar gum	0	0	0	0	0	0	0	1	0	0	1	1
Austral storkbill	1	0	0	0	0	0	0	0	0	0	1	1
Slender pomaderris	1	0	0	0	0	0	0	0	0	0	1	1
Golden everlasting	0	0	0	0	1	0	0	0	0	0	1	1
N° of interactions	17	16	2	2	1	1	0	1	0	1		
N° of associated plant species	8	5	2	2	1	1	0	1	0	1		

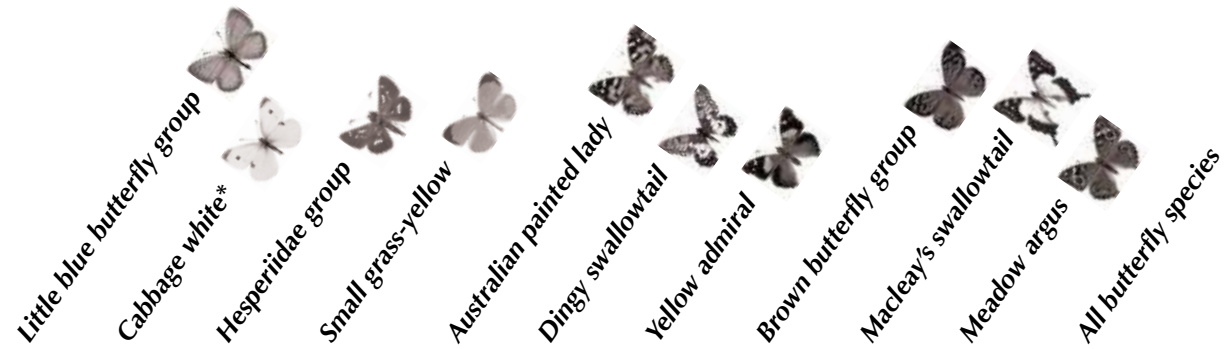
**Table AII.1** Native plant species by butterfly species table summarising the number of observed interactions and the number of associated plant/butterfly species. Non-native butterfly species are indicated with an \*.

<b>Non-native plant species</b>											<b>All butterfly species</b>	<b>N° of associated butterfly species</b>
White clover	47	3	0	0	0	0	0	0	0	0	50	2
Cat mint	11	7	2	1	1	0	1	0	0	0	23	6
Perez'S Sea Lavender	2	1	1	1	3	0	0	0	0	0	8	5
Rosemary	5	1	1	1	0	0	0	0	0	0	8	4
Yellow dandelion group	3	3	0	0	0	0	0	0	0	0	6	2
Sage	1	2	1	1	0	0	0	0	0	0	5	4
Glossy abelia	0	0	2	2	0	0	0	0	0	0	4	2
Leadwort	2	0	1	1	0	0	0	0	0	0	4	3
Deadnettle (unidentified sp.)	2	1	1	0	0	0	0	0	0	0	4	3
Mona lavender	1	2	0	0	0	0	0	0	1	0	4	3
Wild radish	0	4	0	0	0	0	0	0	0	0	4	1
Common tansy	2	1	0	0	0	0	1	0	0	0	4	3
Common agapanthus	0	1	1	1	0	0	0	0	0	0	3	3
Bindweed	2	1	0	0	0	0	0	0	0	0	3	2
Fleabane	1	0	1	1	0	0	0	0	0	0	3	3
Lavender	1	2	0	0	0	0	0	0	0	0	3	2
Wood sorrel	3	0	0	0	0	0	0	0	0	0	3	1
Rockrose	1	1	0	0	0	0	0	0	0	0	2	2
Mint	1	1	0	0	0	0	0	0	0	0	2	2
Lamb's ear	2	0	0	0	0	0	0	0	0	0	2	1
Common daisy	1	0	0	0	0	0	0	0	0	0	1	1

Continued next page.

Non-native plant species	Little blue butterfly group	Cabbage white*	Hesperiidae group	Small grass-yellow	Australian painted lady	Dingy swallowtail	Yellow admiral	Brown butterfly group	Macleay's swallowtail	Meadow argus	N° of interactions	N°of associated butterfly species
Canna lily	0	0	0	0	0	1	0	0	0	0	1	1
Clematis	0	1	0	0	0	0	0	0	0	0	1	1
Fennel	1	0	0	0	0	0	0	0	0	0	1	1
Galenia	1	0	0	0	0	0	0	0	0	0	1	1
Toothed medick	1	0	0	0	0	0	0	0	0	0	1	1
Petunia	0	1	0	0	0	0	0	0	0	0	1	1
Lippia	0	1	0	0	0	0	0	0	0	0	1	1
Narrowleaf plantain	0	1	0	0	0	0	0	0	0	0	1	1
Common purslane	0	1	0	0	0	0	0	0	0	0	1	1
Pepper tree	0	0	0	0	0	1	0	0	0	0	1	1
Ragwort	1	0	0	0	0	0	0	0	0	0	1	1
Marigold	0	1	0	0	0	0	0	0	0	0	1	1
Thyme	1	0	0	0	0	0	0	0	0	0	1	1
Star jasmine	1	0	0	0	0	0	0	0	0	0	1	1
N° of interactions	94	37	11	9	4	2	2	0	1	0		
N° of associated plant species	24	21	9	8	2	2	2	0	1	0		

**Table AII.2** Non-native plant species by butterfly species table summarising the number of observed interactions and the number of associated plant/butterfly species. Non-native butterfly species are indicated with an \*.



Number of interactions with native plants	17	16	2	2	1	1	0	1	0	1	41
Number of interactions with non-native plants	94	37	11	9	4	2	2	0	1	0	160
Total number of interactions	111	53	13	11	5	3	2	1	1	1	<b>201</b>
Number of associated native plant species	8	5	2	2	1	1	0	1	0	1	14
Number of associated non-native plant species	24	21	9	8	2	2	2	0	1	0	35
Total number of associated plant species	32	26	11	10	3	3	2	1	1	1	<b>49</b>

**Table AII.3** Summary of the number of interactions and associated plant species per butterfly. Non-native butterfly species are indicated with an \*.

<b>Common name</b>	<b>Scientific name</b>
Rough-barked apple	<i>Angophora floribunda</i>
Cut-leaved daisy	<i>Brachyscome multifida</i>
Sweet bursaria	<i>Bursaria spinosa</i>
River red gum	<i>Eucalyptus camaldulensis</i>
Sugar gum	<i>Eucalyptus cladocalyx</i>
Hop goodenia	<i>Goodenia ovata</i>
Purple loosestrife	<i>Lythrum salicaria</i>
Creeping boobialla	<i>Myoporum parvifolium</i>
Snow daisy-bush	<i>Olearia lirata</i>
Austral storkbill	<i>Pelargonium australe</i>
Riceflower	<i>Pimelea humilius</i>
Slender pomaderris	<i>Pomaderris racemosa</i>
Bluebell	<i>Wahlenbergia sp.</i>
Golden everlasting	<i>Xerochrysum viscosum</i>

**Table AII.4** Common and scientific names of the native plant species as given in Table A.II1 and the raw data.

Common name	Scientific name
Glossy abelia	<i>Abelia grandifolia</i>
Common agapanthus	<i>Agapanthus praecox</i>
Yellow dandelion group	<i>Asteraceae 1*</i>
Common daisy	<i>Bellis perennis</i>
Canna lily	<i>Canna generalis</i>
Leadwort	<i>Ceratostigma sp.</i>
Rockrose	<i>Cistus sp.</i>
Clematis	<i>Clematis sp.</i>
Bindweed	<i>Convolvulus sp.</i>
Fleabane	<i>Erigeron karinskianus</i>
Fennel	<i>Foeniculum vulgare</i>
Galenia	<i>Galenia pubescens</i>
Deadnettle (unidentified sp.)	<i>Lamiaceae 1</i>
Lavender	<i>Lavandula sp.</i>
Perez'S Sea Lavender	<i>Limanarium perezii</i>
Toothed medick	<i>Medicago polymorpha</i>
Mint	<i>Mentha sp.</i>
Cat mint	<i>Nepeta sp.</i>
Wood sorrel	<i>Oxalis sp.</i>

Common name	Scientific name
Petunia	<i>Petunia sp.</i>
Lippia	<i>Phyla canescens</i>
Narrowleaf plantain	<i>Plantago lanceolata</i>
Mona lavender	<i>Plectranthus sp.</i>
Common purslane	<i>Portulaca oleracea</i>
Wild radish	<i>Raphanus raphanistrum</i>
Rosemary	<i>Rosmarinus officinalis</i>
Sage	<i>Salvia sp.</i>
Pepper tree	<i>Schinus molle</i>
Ragwort	<i>Senecio sp.</i>
Lamb's ear	<i>Stachys byzantina</i>
Marigold	<i>Tagetes sp.</i>
Common tansy	<i>Tanacetum vulgare</i>
Thyme	<i>Thymus vulgaris</i>
Star jasmine	<i>Trachelospermum jasminoides</i>
White clover	<i>Trifolium repens</i>

**Table AII.5** Common and scientific names of the non-native plant species as given in Table A.II2 and the raw data.

\*Asteraceae1 is a morphospecies complex including the following species: *Hypochaeris radicata*, *Lactuca serriola*, *Leontodon taraxacoides*, *Sonchus oleraceus* and *Taraxacum officinale*.





# Appendix III

## Plants in flower that had no associated butterfly species during our survey

### Notes

The number of times that each of these plant species were surveyed is provided in the raw data.

Although no butterflies were observed interacting with these species during the survey period they might be useful food resources at other times of the year.

*Acacia implexa, Acanthus mollis, Ajuga sp., Anagallis arvensis, Angelonia augustifolia, Angiozanthos sp., Anthropodium cirratum, Argyranthemum sp., Atriplex prostrata, Begonia sp., Bougainvillea sp., Brachychitron acerifolius, Brachychitron populneus, Carpobrotus modestus, Cassinia arcuata, Chenopodium nutans, Chenopodium parabolicum, Chlorophytum comosum, Chrysocephalum semipapposum, Clematis tenifolia, Clivia miniata, Coleonema pulchellum, Correa alba, Correa glabra, Corymbia eximia, Cotula coronopifolia, Craspedia sp., Dianella revoluta, Dianthus barbatus, Dietses sp., Echium candicans, Epacris impressa, Epilobium billardierianum, Erythrina cristagalli, Erythrina herbaceae, Eucalyptus eremophila, Euphorbia sp., Grevillea sp., Heleborus sp., Hibiscus sp., Hydrangea sp., Hypericum calycinium, Iris sp., Jacaranda mimosifolia, Kalanchoe sp., Kniphofia uvaria, Lagerstraemia medica, Lagerstraemia sp., Lagunaria sp., Ligustrum sp., Limanium peregrinum, Liriope muscari, Lophostemon confertus, Lotus corniculatus, Malva sp., Medicago lupulina, Melaleuca lanceolata, Melaleuca mesophila, Melaleuca viminalis, Mentha saturioides, Nandina domestica, Nerium oleander, Olearia ramulosa, Ozothamnus ferrugineus, Pelargonium sp., Penstemon sp., Persicaria decipiens, Plumbago auriculata, Polygonum aviculare, Rosa sp., Rubus sp., Santolina chamaecyparissus, Solanum aviculare, Solanum lacantium, Solanum nigrans, Spergularia sp., Strelitzia reginae, Verbena sp., Viburnum sp., Viola tricolor, Vittadinia sp. and Westringia fruticosa.*



## Appendix IV

# Butterfly species and species groups not detected during our survey

Species or species group	Common name	Last recorded	Biology/ecology comment
<i>Acraea andromacha</i>	Glasswing	NA <sup>1</sup>	Vagrant status in Victoria <sup>2</sup> .
Delias/Belenois group		1892 <sup>3</sup> 2014 <sup>4</sup> 2016 <sup>5</sup>	<i>Belonis java</i> is a migratory species, for which host plants do not occur naturally in Victoria - it is blown annually into the state by seasonal warm winds <sup>6</sup> .
Catopsilia group		NA <sup>1</sup>	Both <i>Catopsilia gorgophone</i> and <i>C. pyranthe</i> are migratory species that have been recorded sporadically in Victoria <sup>2</sup> .
<i>Danaus plexippus</i>	Monarch	2016 <sup>7</sup>	<i>Danaus plexippus</i> is a migratory species <sup>2</sup> .
<i>Danaus petilia</i>	Lesser wanderer	1966 <sup>8</sup>	<i>Danaus petilia</i> is a migratory species <sup>2</sup> .
<i>Tisiphone abeona</i>	Varied sword-grass brown	1892	
<i>Charaxes sempronius</i>	Tailed emperor	NA <sup>1</sup>	Not established as breeding in Victoria <sup>2</sup> .
<i>Geitoneura acantha</i>	Ringed xenica	NA <sup>1</sup>	Established as breeding in Victoria <sup>2</sup> .
Hypochrysops/Ogyris group		1977 <sup>9</sup> 2002 <sup>10</sup>	
<i>Papilio demoleus</i>	Chequered swallowtail	2014 <sup>11</sup>	
<i>Paralucia aurifer</i>	Bright copper	NA <sup>1</sup>	Established as breeding in Victoria <sup>2</sup> .

## Notes

1. Only one undated record of this species or species group for the City of Melbourne is documented in the Atlas of Living Australia.
2. Source Braby (2016).
3. The Atlas of Living Australia provides only one record of *Delias harpalyce* dating back to 1892.
4. *Delias aganippe* was last recorded in Westgate Park in May 2014. Source Atlas of Living Australia and BowerBird.
5. *Belenois java* was last recorded in Royal Park in October 2016 (Luis Mata personal observation).
6. Source Museum Victoria (<https://collections.museumvictoria.com.au/species/11414>).
7. The Atlas of Living Australia provides two records of *Danaus plexippus* (March 2015 & March 2016), both from unspecified locations. We are also aware of a 2005 sighting in the Royal Botanic Gardens Melbourne (<https://www.flickr.com/photos/puffinbytes/6273961708/>).
8. The Atlas of Living Australia provides two records of *Danaus petilia*: (i) December 1966, no location specified, and (ii) undated from North Melbourne.
9. The Atlas of Living Australia provides six records of *Ogyris abrota*, including records from 1969 (August & September), 1975 (March) and 1977 (February), as well as an undated record. Records include localities in Royal Park and Parkville, as well as unspecified locations.
10. The Atlas of Living Australia provides one record of *Hypochrysops delicia* from December 2002 (no location specified).
11. *Papilio demoleus* was last recorded in Westgate Park in October 2014. Source Atlas of Living Australia and BowerBird.