Colour preferences in sand dune insects found on ice plant flowers

Simon Hodge[1*] & John Marris[2]

1 - Faculty of Agriculture and Life Sciences, Lincoln University, Canterbury, New Zealand.
2 - Bio-Protection Research Centre, Lincoln University, Canterbury, New Zealand.

*Email: simon.hodge68@gmail.com

Introduction

The ice plant (*Carpobrotus edulis* (L.), family Aizoaceae) is a succulent perennial native to South Africa that has been introduced widely around the world to prevent erosion of sandy or loose soils. At New Brighton sand dunes near Christchurch, dense mats of *C. edulis* now form part of a flora dominated by exotic plants, including marram grass (*Ammophila arenaria* L.), tree lupin (*Lupinus arboreus* Sims) and purple ragwort (*Senecio elegans* L.).

Exotic plants frequently provide acceptable habitats for diverse assemblages of insects and spiders (e.g. Prasad & Hodge 2013). The abundance and diversity of nectar- and pollen-feeding insects can show positive responses to exotic plants that provide extended flowering periods to native plant species (Showler 1989; Stary and Tkalcu 1998; Neinhuis et al. 2009; Vila et al. 2009). Other insects, such as ground beetles, have exhibited negative responses to the presence of exotic plant species in their habitat (e.g. Topp et al. 2008).

Flower-visiting insects frequently exhibit preferences for certain flower characteristics, such as shape, scent and colour, and it is often assumed there is some adaptive role to flower selection in terms of improved insect fitness. Flower colour is one of a range of signals plants use to attract pollinators and insects can learn to associate flower colour with a high quality resource (Raine & Chittka 2007).

At New Brighton, a number of species of arthropods have been observed visiting ice plant flowers, including endemic Coleoptera (*Lagrioida brouni* Pascoe; *Inophloeus rubidus* Broun) and native arachnids (*Cheiracanthium stratioticum* Koch; *Oxyopes gracilipes* (White, 1849)) (Hodge et al. 2017). At least two colour forms of ice plant flowers occur at New Brighton: a common yellow form and a less common pink/purple form (Figure 1). This study compared overall arthropod occupation rates of the two flower colours and assessed whether individual insect species exhibited a preference for either colour form.

Figure 1. Two colour forms of the iceplant, *Carpobrotus edulis*, at New Brighton sand dunes

Methods

A total of 3360 yellow flowers and 240 purple flowers of *Carpobrotus edulis* were inspected for arthropods at New Brighton sand dunes (-43.522, 172.736) between 9 November and 10 December 2014 (Hodge et al. 2017). This highly unbalanced sampling was undesirable, but reflects the unequal abundance of the two colour forms at this site. Insects and spiders were collected from flowers using a battery operated aspirator, with the exception of bumblebees which were identified to species on site.

The native New Zealand ice plant *Disphyma crassifolium*, which has smaller (2–4 cm diameter) white or pink flowers and a more slender (4 mm), cylindrical stem compared to *C. edulis*, also occurs at New Brighton

(Chinnock 1972). *Carpobotus edulis* has flowers of 8–10 cm diameter and much thicker (12 mm) and angular stems than the native species. We are confident that no 'pure' *D. crassifolium* were sampled but cannot rule out that some hybrids with intermediate properties of the two species may have been included in the survey.

Overall occupancy rates and occupancy by the three most commonly encountered insect species, on yellow or purple flowers were compared using Fisher's Exact test.

Results

A total of 478 individual arthropods belonging to 32 species were recorded on *C. edulis* flowers (Hodge et al. 2017: Appendix). The overall occupancy rate of flowers was 10%, but yellow flowers (10.4%) were over twice as likely to have arthropods compared to purple flowers (4.6%) (Fisher's exact test, $P = 0.002$) (Table 1).

The most commonly-occurring species was a pollen beetle in the family Melyridae, close to the genus *Dasytes* sp., which made up 58% of the total invertebrate numbers. The bumble bee *Bombus terrestris* (15% of records) and a long-horned grasshopper, *Conocephalus bilineatus* (8% of records) were also relatively common in the collections.

Dasytes sp. displayed a strong (i.e. fourteen-fold) preference for yellow flowers over purple in terms of presence-absence occupancy (Table 1). Conversely, *Bombus terrestris* exhibited a less-dramatic (≈ 2-fold) but statistically significant preference for purple flowers. The equally substantial colour preference (2-fold) displayed by *C. bilineatus* for yellow flowers was not identified as being statistically significant (Table 1). The ambiguity of this last result reflects the smaller sample size obtained for this species, and more data are required to clarify whether this species exhibits a real colour preference or not.

Table 1. Levels of occupancy (%) of yellow (n = 3360) and purple (n = 240) ice plant flowers at New Brighton sand dunes. P-value obtained from Fisher's Exact Test based on raw count data of occupied and unoccupied flowers of each colour form.

	Total Abundance	Occupation (%)			P
		Total	Yellow	Purple	
Total arthropods	478	10.00	10.39	4.59	0.002
'*Dasytes'* sp.	276	5.22	5.56	0.42	< 0.001
Bombus terrestris	70	1.94	1.82	3.75	0.049
Conocephalus bilineatus	39	1.03	1.07	0.42	0.513

Discussion

The strongest flower colour preference by a single insect species was that of *Dasytes* sp. for yellow ice plant flowers, which is similar to that described for other species of pollen beetles (e.g. *Meligethes* in Doring et al. 2012). The preference for purple flowers by *Bombus terrestris* is also similar to previous studies where a bias towards violet or blue flowers has been described for this species (Raine & Chittka 2007).

Exhibiting a colour preference suggests that visiting flowers of one colour are perceived as more profitable to the insect than visiting flowers of the other. We did not perform any analysis to distinguish whether the purple or yellow flowers contained different amounts of resources such as pollen or nectar. Indeed, as no consistent colour preference was identified across species, these benefits appear to vary among different insect species.

Assemblages of pollinators and other plant-visiting insects are often sampled using pan traps, the colour of which can influence both the abundance and species composition of the animals obtained (Campbell & Hanula 2007; Vrdoljak & Samway 2012). The results of our study suggest that using any one colour of pan trap to study the flower-visiting insects at New Brighton dunes would lead to significant under-collecting of some species, and a range of trap colours is required to obtain satisfactory coverage of all the insect species present.

We focussed on the arthropods visiting one species of flower; there are a number of other species of colourful flowers present at New Brighton dunes and potentially hundreds of species of insects that may choose to visit them (MacFarlane 2005). Further study is required to build a more complete picture of the networks of flower-visiting insects that occur at this site and also to provide more information on the use of exotic plant species by endemic New Zealand insects.

Acknowledgements

The authors wish to thank Jason Roberts and Antony Shadbolt of Christchurch City Council, for permission to carry out the survey at New Brighton and providing a copy of the report by Rod MacFarlane.

References

Campbell JW, Hanula JL (2007) Efficiency of Malaise traps and colored pan traps for collecting flower visiting insects from three forested ecosystems. *J Insect Conserv* 11: 399-408.

Chinnock RJ (1972) Natural hybrids between *Disphyma* and *Carpobrotus* (Aizoaceae) in New Zealand. *New Zeal J Bot* 10: 615-625.

Doring T, Skellern M, Watts N, Cook SM (2012) Colour choice behaviour in the pollen beetle *Meligethes aeneus* (Coleoptera: Nitidulidae). *Physiological Entomology* 37: 360–368.

Hodge S, Curtis N, Vink CJ, Marris J, Brown SDJ (2017) Native arthropods on exotic sand dune flowers: consideration of sample size and number for investigating rare species and sparse communities. *Arthropod-Plant Interactions* 11, 691-701.

Macfarlane RP (2005) New Brighton Sand Dune Invertebrates. A report prepared for Christchurch City Council. Christchurch, New Zealand.

Neinhuis CM, Dietzsch AC, Stout CJ (2009) The impacts of an invasive alien plant and its removal on native bees. *Apidologie* 40: 450-463.

Prasad AV, Hodge S (2013) The diversity of arthropods associated with the exotic creeping daisy *Sphagneticola trilobata* in Suva, Fiji Islands. *Entomol Month Mag* 149: 155- 161.

Raine NW, Chittka L (2007) The Adaptive Significance of Sensory Bias in a Foraging Context: Floral Colour Preferences in the Bumblebee *Bombus terrestris*. *PLoS ONE* 2(6): e556. doi:10.1371/journal.pone.0000556.

Showler K (1989) The Himalayan balsam in Britain - an undervalued source of nectar. *Bee World* 70: 130-131.

Stary P, Tkalcu B (1998) Bumble-bees (Hym. Bombidae) associated with the expansive touch-me-not, *Impatiens glandulifera* in wetland biocorridors. *Anzeiger fur Schadlingskunde Pflanzenschutz Umweltschutz* 71: 85-87.

Topp W, Kappes H, Rogers F (2008) Response of ground-dwelling beetle (Coleoptera) assemblages to giant hogweed (*Reynoutria* spp.) invasion. *Biol Invasions* 10: 381-390.

Vila M, Bartomeus I, Dietzsch AC, Petanidou T, Steffan-Dewenter I, Stout JC, Tscheulin T (2009) Invasive plant integration into native plant-pollinator networks across Europe. *Proc Roy Soc B* 276: 3887-3893.

Vrdoljak SM, Samways MJ (2012) Optimising coloured pan traps to survey flower visiting insects. *J Insect Conserv* 16: 345–354.

APPENDIX

List of arthropod species observed on ice plant flowers at New Brighton (see Hodge et al 2017 for further details).

En – endemic; Na – native; In –introduced.

COLEOPTERA: **Anthicidae** *Lagrioida brouni* Pascoe, 1876 En; **Chrysomelidae** *Bruchidius villosus* (Fabricius, 1792) In; **Coccinellidae** *Coccinella undecimpunctata* (Linnaeus, 1758) In; **Curculionidae** *Inophloeus rubidus* Broun, 1881 En; **Melyridae** '*Dasytes'* sp. En; Scarabaeidae *Pyronota* sp. En. **DIPTERA Agromyzidae** *Cerodontha australis* Malloch, 1925 Na; **Bibionidae** *Dilophus nigrostigma* (Walker, 1848) Na; **Calliphoridae** *Calliphora vicina* Robineau-Desvoidy, 1830 In; **Canacidae** *Tethinosoma fulvifrons* (Hutton, 1901) Na; **Chironomidae** *Chironomus* sp. Meigen, 1803 Na; **Chloropidae** *Apotropina tonnoiri* (Sabrosky, 1955) Na; **Chloropidae** *Aphanotrigonum huttoni* (Malloch, 1931) Na; **Dolichopodidae** *Parentia* sp. Hardy, 1935 Na; **Drosophilidae** *Drosophila pseudoobscura* Frol. & Ast., 1929 In; *Drosophila simulans* Sturtevant, 1919 Na; **Drosophilidae** *Scaptomyza* sp. Hardy, 1950 In; **Empidae** *Thinempis* sp. Bickel, 1996 Na; **Ephydridae** *Psilopa metallica* (Hutton, 1901) Na; *Hecamede granifera* Thompson, 1869 In; Ephydridae *Hydrellia tritici* Coquillett, 1903 Na; **Syrphidae** *Platycheirus* sp. Le Peletier & Serville, 1828 Na; **Teratomyzidae** *Teratomyza neozelandica* Malloch, 1933 En. **HEMIPTERA** Psyllidae. **HYMENOPTERA Apidae** *Bombus terrestris* (Linnaeus, 1758) In; **Braconidae**; **Eulophidae**. **Lepidoptera Tortricidae**. **ORTHOPTERA Tettigoniidae** *Conocephalus bilineatus* (Erichson, 1842) Na. **ARACHNIDA Eutichuridae** *Cheiracanthium stratioticum* Koch, 1873 Na; **Lyniphiidae** *Microctenonyx subitaneus* (Pickard-Cambridge, 1875) In; **Oxyopidae** *Oxyopes gracilipes* (White, 1849) Na.