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SHORT COMMUNICATION

Survey of insect visitation of ornamental flowers in Southover Grange garden, Lewes, UK

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Abstract Ornamental flowers commonly grown in urban gardens and parks can be of value to flower-visiting insects. However, there is huge variation in the number of insects attracted among plant varieties. In this study, we quantified the insect attractiveness of 79 varieties in full bloom being grown in a public urban garden that is popular due to its beautiful flowers and other attractions. The results showed very clearly that most varieties (77%, $n = 61$) were either poorly attractive or completely unattractive to insect flower visitors. Several varieties (19%, $n = 15$) were moderately attractive, but very few (4%, $n = 3$) were highly attractive. Closer examination of *Dahlia* varieties showed that "open" flowered forms were approximately 20 times more attractive than "closed" flowered forms. These results strongly suggest that there is a great potential for making urban parks and gardens considerably more bee- and insect-friendly by selecting appropriate varieties.

Key words bumble bees; *Dahlia*; double flowers; honey bees; pollinating insects; wildlife friendly gardening

Introduction

Urban gardens and parks are increasingly recognized as of value to wildlife (Goddard *et al.*, 2010; Owen, 2010; Hennig & Ghazoul, 2012). Many garden plants are introduced from other parts of the world (Kendal *et al.*, 2012), and may present different value to native wildlife. For example, butterfly larvae typically have a narrow range of suitable food plants (Dyer *et al.*, 2007). Plants grown outside their original geographic distribution often support fewer herbivores than closely related native species (Perre *et al.*, 2011). However, introduced plants also have generic value to wildlife, such as a bird that can nest in an introduced tree as easily as in a native one. The flowers of introduced plants can be of value to flower-visiting insects. Flowers are generically attractive due to their shape, color and especially their nectar and pollen rewards. Nectar is predominantly a solution of various sugars, mostly sucrose, glucose and fructose, and is an energy source for many insects (Nicolson & Thornburg, 2007). It is common to see native insects foraging on flowers of introduced plants. For example, British butterflies take nectar from *Buddleja davidii*, commonly known as the butterfly bush, which is a plant native to China that is now commonly grown in British gardens (Tallent-Halsell & Watt, 2009), although none use it as a larval food plant (Eeles *et al.*, 2012). However, *B. davidii* is used as a larval food plant by a few highly polyphagous British moths (Owen, 2010).

Many ornamental plants grown in urban gardens and parks are attractive to flower-visiting insects (Comba *et al.*, 1999a,b; Pawelek *et al.*, 2009). Recent research shows that ornamental garden flowers that are readily available for purchase in the United Kingdom at similar prices vary greatly, approximately 100-fold, in their attractiveness to foraging insects, such as bees, hover flies, and butterflies (Garbuzov & Ratnieks, 2014). Thus, there is a great "no cost" potential for gardeners and park managers to help flower-visiting insects by planting varieties attractive to insects. Many gardeners are potentially interested in helping wildlife in their gardens. A survey of UK gardeners showed that 31% deliberately choose plants

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attractive to wildlife (Mew *et al.*, 2003), and the interest and enthusiasm of gardeners appear to be on an increase. Many garden centers now promote certain plant varieties as bee- or butterfly-friendly and the UK's Royal Horticultural Society (RHS) has even started an initiative by labeling some varieties with the "Perfect for Pollinators" trademark logo (Royal Horticultural Society, 2011a). However, the basis on which these recommendations are made is not clear.

The aim of this study was to estimate how useful to insects the plants currently grown in gardens are. We did this by surveying ornamental garden flowers in a local garden which is popular and known for the beauty of its flower displays. We determined the area of each variety and quantified flower visitation by all foraging insects, which were mainly bees and flies. In total there were 79 varieties in full bloom at the time of the survey. Interestingly, our results showed that only 4% were highly attractive, while 30% were not visited by a single insect, and another 47% visited by very few. Our study suggests that gardens have great room for improvement in providing nectar and pollen for bees and other insects.

Materials and methods

Study location

The study was carried out in Southover Grange garden, which is located near the centre of the town of Lewes (area 11 km^2, population 16 000) in the county of East Sussex, United Kingdom. The area surrounding the garden had mostly private residential houses and, due to the small size of the town, was relatively close to agricultural land (<1 km). Southover Grange house and garden is a heritage site of historical significance open to the public and managed by the Lewes District Council (n. d.). It has an area of approximately 1.5 ha and is managed for non-sport recreation, with lawns, ornamental trees and shrubs, annual, and perennial herbaceous flower beds (Fig. 1). No pesticides are used in the garden to control herbivorous insects. The place, with its beautiful surroundings, is a great attraction to local residents, as well as visitors and tourists.

Data collection

The flower beds in Southover Grange garden are managed in such a way as to produce two main blooming periods per year, one in spring and another in late summer. Our survey was conducted over 2 d within the late summer blooming period, when most plant varieties were at or near their flowering peak. Indeed, varieties flowering in late summer have the potential to be more useful to bees and other insects than varieties flowering in spring, as late summer is the time of year when honey bee foraging distances in this part of Sussex (Couvillon *et al.*, 2014), and probably much of Britain (Beekman & Ratnieks, 2000), are greatest, indicating low overall forage availability. We surveyed only those varieties ($n = 79$) that were at or near full bloom during the data collection period.

Fig. 1 Part of Southover Grange garden in Lewes, East Sussex, UK, during the late summer blooming period, August 2012.

We made repeated counts of flower-visiting insects on each patch containing a single variety. These counts were near instantaneous "snapshots" (<10 sec), in which the observer recorded the number of foraging insects at an instant of approaching a patch by scanning it by eye (Garbuzov & Ratnieks, 2014). In total, we took 15 counts from each patch ($n = 117$ patches, some varieties were grown in more than 1 patch) over 2 d (21 and 23 August 2012). The weather conditions on survey days were very good for insects: sunny, calm and warm (peak temp. 21–22 °C).

The insects were identified and grouped to taxa as follows: (i) honey bees (*Apis mellifera*), (ii) 2-banded white tailed bumble bees (*Bombus terrestris*/*lucorum* group, after Fussell & Corbet, 1992), (iii) banded red tailed bumble bees (*Bombus pratorum* group), (iv) brown bumble bees (*Bombus pascuorum* group), (v) other bumble bees, (vi) other bees (non-*Apis* and non-*Bombus*), (vii) hover flies (Diptera: Syrphidae), (viii) other flies (non-Syrphidae), (ix) butterflies & moths (Lepidoptera), and (x) all other insects. Since the number of insects foraging on a patch per unit area is not affected by patch area (Garbuzov M., Madsen A., Ratnieks F.L.W., unpublished data), it is possible to make unbiased comparisons of plant varieties grown in patches of different size. The attractiveness of each variety was, therefore, expressed as the total number of insects

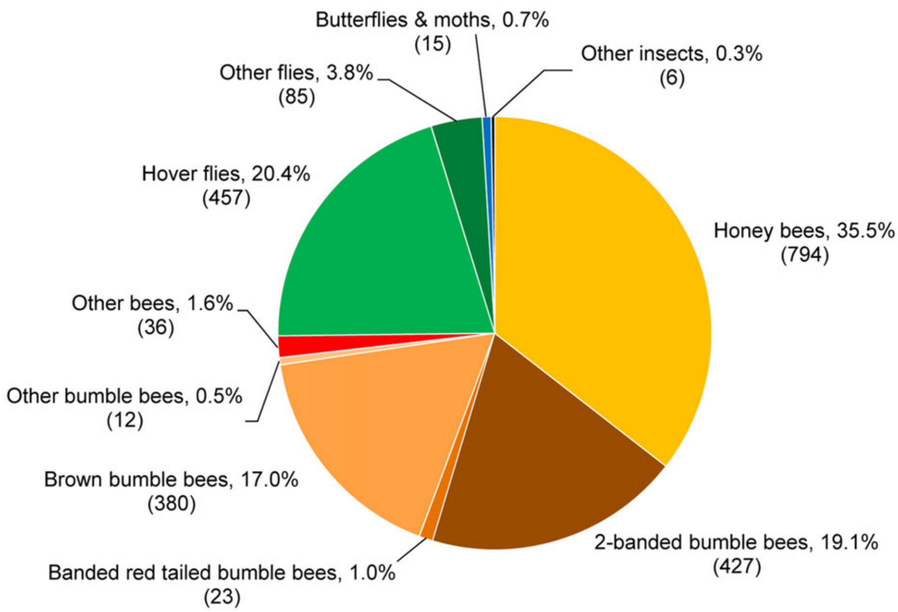

Fig. 2 Relative and absolute numbers of insects in the 10 groups.

per count per square meter. The area of each variety in each patch was measured by approximating it to the nearest geometric shape, for example, a square, a rectangle, a circle, or a combination thereof. Where there were several patches per variety the data were combined (total areas of each variety are listed in Appendix 1).

The list of plant varieties surveyed with some of their characteristics is provided in Appendix 1. The plant varieties were identified with the help of information provided by Richard Eborn of the Lewes District Council. A few varieties could not be fully identified.

Results

Insect flower visitors

In total, 2 235 insects were recorded. The relative and absolute abundance of taxonomic groups are shown in Figure 2. Flower visitors were predominantly bees (74.8%) and flies (24.3%) of which 35.5% were honey bees, 37.7% bumble bees, 1.6% other bee species, 20.4% hover flies, and 3.8% other fly species. Butterflies and moths were 0.7% and other insects 0.3%.

Attractiveness of plant varieties to insect flower visitors

Plant varieties varied enormously in their attractiveness to insect flower visitors, approximately 1 000-fold from the most attractive to the least attractive that had

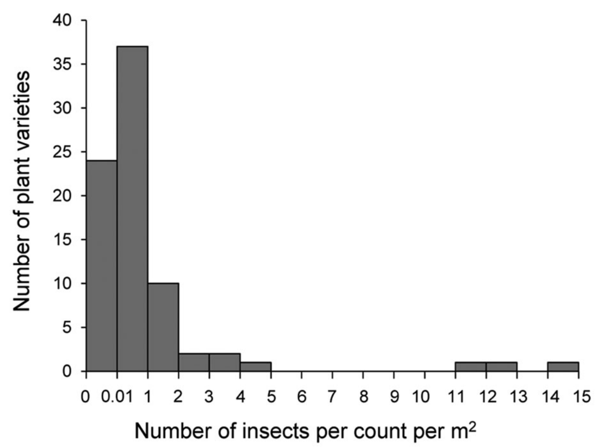

Fig. 3 Frequency distribution of insect-attractiveness of the 79 plant varieties surveyed. Note the first bin (0–0.01) is not to scale with others and includes only those varieties that attracted exactly zero insects.

non-zero insects. Furthermore, the frequency distribution of attractiveness was highly skewed to the right, revealing that most plant varieties were unattractive to insects (Fig. 3). Thirty percent ($n = 24$) of varieties were completely unattractive (0 insects recorded), with a further 47% ($n = 37$) attracting very low numbers (0.01–1/count m^2). Nineteen percent ($n = 15$) were moderately attractive (1–5/count m^2). Very few, 4% ($n = 3$), were highly attractive (>10 /count m^2).

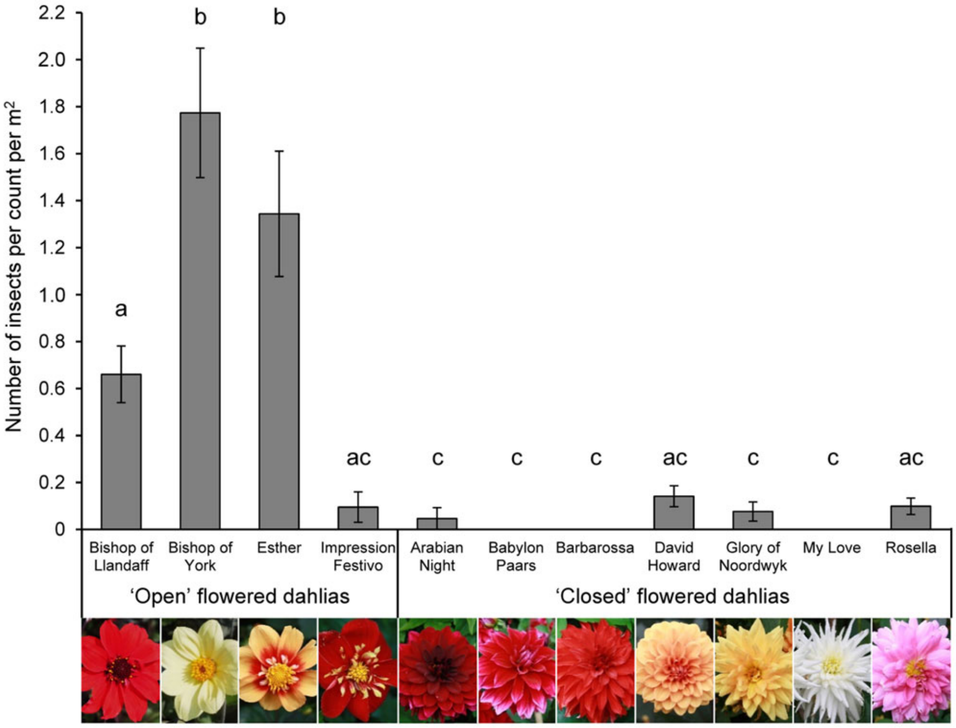

Fig. 4 Mean ± standard error numbers of insects per count per square meter recorded on 11 *Dahlia* varieties. Letters above bars denote significance of Tukey's *post hoc* pairwise comparison test at $\alpha = 0.05$.

Comparison of Dahlia varieties

One of the flower beds in Southover Grange garden was composed exclusively of 11 *Dahlia* varieties. We have, therefore, examined the dahlia results in more detail, and in particular, compared "open" flowered varieties (e.g., single or semi-double) with "closed" flowered varieties (e.g., fully double, decorative, pompon or cactus). GLM confirmed that not all varieties were equally attractive to insects ($F_{10,154} = 24.18$, $P < 0.001$). In addition, flower form (open vs. closed) was a significant factor ($F_{1,163} = 85.23$, $P < 0.001$) that explained 34% of variation ($R^2 = 0.339$), with "open" varieties (mean ± SE = 0.97 ± 0.13 insects/count m^2) approximately 20 times more attractive than "closed" varieties (mean ± SE = 0.05 ± 0.13 insects/count m^2). Of the 4 "open" varieties, 2 were attractive to insects and 2 somewhat attractive (Fig. 4). In contrast, of the 7 "closed" varieties, only 2 were somewhat attractive, while 5 were unattractive.

Discussion

Our results clearly show that most flower varieties being grown in Southover Grange garden were not attractive to insects. Although the overall pattern observed is robust, specific results pertaining to particular varieties should be interpreted with caution, as varieties may be subject to idiosyncratic effects, such as those of patch location with respect to neighboring patches or other factors, or the timing of nectar production. It will also require additional surveys to determine if this is a general pattern in parks and gardens in the United Kingdom and elsewhere. However, given that Southover Grange garden used many widely available and commonly grown plants to provide color, and that color is a goal of many gardeners, we predict that many other gardens will also have low proportions of insect-friendly flowers.

The comparison of the *Dahlia* varieties is interesting as it shows that the breeding of garden flowers to have unusual morphology, such as in the cactus or pompon dahlias, can reduce their value to insects. The open varieties, even those such as "Bishop of Llandaff", which is semi-double (i.e., with an increased number of "petals", actually ray florets in each composite flower or inflorescence), have easily accessible disc florets that provide nectar and pollen (Fig. 5B). Fig. 5C shows two composite flowers of the most attractive of the closed varieties, "David Howard". Only at the end of the blooming period are the disc florets accessible, and their amount is

Fig. 5 *Dahlia* flower varieties: (A) Bishop of York, single, (B) Bishop of Llandaff, semi-double, (C) David Howard, fully double decorative. In David Howard, disc florets providing nectar and pollen are obscured by the ray florets in the newly opened flowers (C, left) and become accessible only towards the end of the flower's life (C, right). In addition, the amount of disc florets in (C) is lower than in (A) or (B).

considerably less than in the open varieties shown for comparison, "Bishop of York" and "Bishop of Llandaff" (Fig. 5A and B).

These results strongly suggest that there is a great potential to make urban parks and gardens considerably more bee- and insect-friendly by appropriate plant selection. Southover Grange garden is beautiful, and the varieties chosen lead to a spectacular display of many colors. But with many thousands of garden flower varieties available (e.g., over 70 000 in the RHS Plant Finder alone [Cubey & Merrick, 2011]) we are certain that having insect friendly plants need not lead to a reduction in the overall attractiveness.

Selecting insect-friendly plant varieties requires information on insect-attractiveness. Some of this information may be available in the numerous recommended plant lists, produced by both amateurs (e.g., Creeser, 2004; Lavelle & Lavelle, 2007) and professional organizations (e.g., International Bee Research Association, 2008; Royal Horticultural Society, 2011b; Xerces Society, 2011; Kirk & Howes, 2012). These recommendations appear to be based mainly on personal observations and opinions, rather than empirical data. However, the best plants from this survey (*Sedum* and *Origanum*, Appendix 1) tend to be often recommended in lists, both being featured in 14 of 15 lists in one sample (Garbuzov & Ratnieks, in press), implying that well-informed opinion, perhaps backed by extensive observation, can be nearly as good as rigorously collected empirical data.

Our study presents a short survey with useful, but necessarily limited results. Furthermore, the methodology used in our survey could be used to assess the insect-attractiveness of flower patches that are already being grown, by gardeners themselves or by the general public as "citizen science." Such surveys require relatively little effort. For example, our survey took 3 d of fieldwork, of which 2 d were spent counting insects and 1 d was used to measure flower patch areas. In addition, the methods, including insect identification, are simple to learn. Alternatively, given more time and resources, more detailed and standardized trials could be performed, which would provide a more accurate and complete picture (e.g., Garbuzov & Ratnieks, 2014).

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Disclosure

The authors declare no conflict of interest.

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Appendix 1 Seventy-nine plant varieties surveyed in the Southover Grange garden.