Butterfly Feeding Preferences for Four Zinnia Cultivars[1]

Kenneth V. Yeargan[2] and Sarah M. Colvin[3]
Department of Entomology, University of Kentucky, Lexington, KY 40546

Abstract

Zinnias are recommended frequently for inclusion in butterfly gardens as nectar sources for adult butterflies, but little is known about butterfly preferences for different zinnia cultivars. We compared numbers and species of butterflies that visited four widely available zinnia cultivars: *Zinnia violacea* Cav. (formerly *Zinnia elegans* Jacq.) 'Lilliput', 'Oklahoma', 'State Fair', and *Zinnia marylandica* Spooner, Stimart, and Boyle 'Pinwheel'. Mixed colors were used for all cultivars. Based on a total count of 2355 butterflies, representing 30 species, more than twice as many total butterflies visited 'Lilliput' than visited any of the other cultivars. Also, a greater number of butterfly species visited 'Lilliput' than visited any of the other cultivars. More than half of the counted butterflies belonged to the family Nymphalidae, with members of the families Pieridae and Hesperiidae being the second and third most frequent visitors, respectively.

Index words: Lepidoptera, flower visitation, butterfly gardens.

Species used in this study: *Zinnia violacea* Cav. 'Lilliput', 'Oklahoma', 'State Fair', and *Zinnia marylandica* Spooner, Stimart, and Boyle 'Pinwheel'.

Significance to the Nursery Industry

The popularity of butterfly gardening is reflected in the large number of popular press articles, internet sites, and university extension recommendations devoted to this topic. Recommendations of specific plants for butterfly gardens typically include plants that can serve as food for caterpillars and plants that serve as nectar sources, and hence attractants, for adult butterflies. Zinnias often are included in the latter group of recommended plants, but without further guidance regarding particular zinnia cultivars. Based on the research performed in this study, the zinnia cultivar 'Lilliput' was much more effective at attracting butterflies than were three other widely available zinnia cultivars. This research provides guidance to those who make recommendations about plants for use in butterfly gardens.

Introduction

Zinnias are among the most popular annuals grown in North America (9). Many factors likely contribute to this popularity, including the fact that zinnias exhibit considerable diversity of plant growth habit and in the color, shape, and size of the flowers. Thus they can be used many ways in garden settings. Also, zinnias are relatively easy to grow, begin flowering as young plants, continue to produce flowers throughout the growing season, and are excellent cut flowers. An additional factor that may contribute to their popularity is the fact that zinnias often are promoted (e.g., in seed catalogs) as good plants for attracting butterflies to a garden.

Most commercial zinnia cultivars belong to the species *Zinnia violacea* Cav. (formerly *Zinnia elegans* Jacq.), including 'Lilliput', 'Oklahoma', and 'State Fair' (three cultivars used in our study). *Zinnia angustifolia* H.B.K. (narrow leaf zinnia) also is cultivated extensively. Interspecific crosses of *Z. violacea* and *Z. angustifolia* produced allotetraploid hybrids that have been collectively named *Zinnia marylandica* Spooner, Stimart, and Boyle (9). *Zinnia marylandica* cultivars include the commercially successful 'Pinwheel' (used in our study) and 'Profusion' series, both of which exhibit disease resistance.

Previous research showed significant differences in butterfly feeding preferences among cultivars of *Buddleja* and *Lantana* species (4, 5). Over the past several years, one of us (KVY) had observed that 'Lilliput' zinnias appeared to be especially attractive to butterflies but experimental comparisons of butterfly feeding preferences among zinnia cultivars have not been reported. Our objective in the present study was to determine in a field experiment whether butterfly feeding preferences differed among four commonly available zinnia cultivars.

Materials and Methods

We used mixed-color plantings of four cultivars: *Zinnia violacea* 'Lilliput', 'Oklahoma', 'State Fair', and *Zinnia marylandica* 'Pinwheel'. The colors for each cultivar were 'Lilliput': red, purple, rose, white, orange; 'Oklahoma': scarlet, cherry, white, yellow; 'Pinwheel': cherry, rose, white, orange, salmon; 'State Fair': red, purple, pink, white, yellow, orange. The study was conducted at the University of Kentucky's Spindletop Research Farm near Lexington, KY. A randomized complete block design was used to establish 16 plots (4 blocks × 4 cultivars). Each plot contained 15 plants of a particular cultivar (3 rows with 5 plants per row) and measured 2.7 × 3.7 m (9 × 12 ft). Plants were spaced 0.6 m (2 ft) apart within rows, and rows were 0.8 m (2.5 ft) apart. Plots were separated from one another in all directions by alleys of bare soil that were 10 m (33 ft) wide and a similar space of bare soil surrounded the entire set of plots. These spans of bare soil served to isolate each plot from other zinnia plots and from other types of vegetation in the surrounding area.

We purchased seeds of three of the cultivars from a mail-order vendor and we purchased 'Lilliput' seeds from a local retail store. Plants were grown from seed in a greenhouse and transplanted to the field before they began to flower; hence, we did not know the flower color of individual plants at the time of transplanting. Seeds were planted in trays in a greenhouse on May 16, 2007. On June 6, each zinnia plot

[1]Received for publication July 7, 2008; in revised form October 29, 2008. We thank S. Kristine Braman and Joseph D. Culin for reviewing an earlier version of the manuscript and Kimberly Decker for technical assistance. This study (Paper 08-08-083) was conducted in connection with a project of the Kentucky Agricultural Experiment Station.

[2]Professor, to whom reprint requests should be addressed. kyeargan@uky.edu

[3]Graduate research assistant.

was treated with Treflan (trifluralin) herbicide, which was immediately incorporated into the soil with a rotary tiller. On the same day, following the incorporation of the Treflan, a plastic sheet was placed over each plot and the alleyways were treated with Bicep II Magnum (S-metolachlor + atrazine) herbicide; the plastic sheets prevented drift of this herbicide from landing on the zinnia plots. Herbicide rates were 1.1 kg a.i.·ha^{-1} (1 lb·A^{-1}) for Treflan and 1.3 kg a.i.·ha^{-1} (1.2 lb·A^{-1}) S-metalochlor + 1.8 kg a.i.·ha^{-1} (1.6 lb·A^{-1}) atrazine for Bicep II Magnum. The plastic sheets were removed from the plots on June 13 and discarded. Zinnias were then transplanted into bare soil and watered at that time; no subsequent irrigation, mulch, or fertilizer was used. Supplemental weeding of the plots was done by hand as needed and alleyways were mechanically tilled as needed to maintain weed control for the remainder of the growing season.

Beginning August 16, butterfly visitation to the zinnia plots was monitored at weekly intervals for seven weeks. Butterfly counts were done twice on each date, starting at 10 a.m. and again at 2 p.m., to provide data for morning and afternoon butterfly visitation to the plots. All butterflies present in each plot were identified and their numbers were recorded. The observer took care when approaching each plot not to disturb the butterflies. Counts were completed for all four zinnia cultivars in the first block before moving to the second block; this was repeated for each of the four blocks. Total time required for counting butterflies in the 16 plots on a given morning or afternoon varied with butterfly abundance, but usually ranged from about 0.5 h to about 1.5 h. Butterflies were identified to species in all cases except *Colias eurytheme* and *Colias philodice*, which were combined in the data as *Colias* spp. because it was not possible to distinguish their white color morphs in the field. We did, however, confirm that both of those *Colias* species were present during the study. Repeated measures analyses of variance were used to compare butterfly visitation among the four zinnia cultivars. Tukey's multiple comparisons test was used to compare mean numbers of butterflies that visited each cultivar. Separate analyses were done for total butterflies and for each of the four most abundant butterfly taxa. Statistix 8 software (Analytical Software, Tallahassee, FL) was used for all statistical analyses.

Results and Discussion

More than twice as many total butterflies (i.e., all species combined) visited 'Lilliput' than visited any of the other three cultivars tested (Fig. 1). Significant differences occurred among cultivars for total butterflies in both morning ($F = 78.3$; d.f. = 3, 12; $P < 0.001$) and afternoon ($F = 21$; d.f. = 3, 12; $P < 0.001$). Means comparison tests (Tukey's HSD with $\alpha = 0.05$) showed that 'Lilliput' attracted more total butterflies than any of the other cultivars in morning and afternoon, while there were no differences among 'Oklahoma,' 'Pinwheel,' and 'State Fair.' The same types of statistical analyses were performed separately for the morning and afternoon counts of the four most abundant taxa, which accounted for 85.2% of the total butterflies recorded: *Euptoieta claudia*, *Colias* spp., *Pieris rapae*, and *Atalopedes campestris* (analyses not presented). Each of those analyses produced results similar to the analyses for total butterflies. There were significantly more members of each of those four taxa observed visiting 'Lilliput' than any other cultivar. Also, for three of those butterfly taxa there were no significant differences among the other cultivars. The exception was *E. claudia*, which was significantly more abundant on 'Oklahoma' than on 'State Fair.' This exception does not appear to be a sampling artifact because *E. claudia* was the most abundant species in the study and the same statistically significant pattern ('Oklahoma' > 'State Fair') was seen for both the morning and afternoon counts of this species.

Numbers of butterflies visiting the zinnias differed significantly among dates over the seven-week sampling period for both morning ($F = 46.9$; d.f. = 6, 72; $P < 0.001$) and afternoon ($F = 17.4$; d.f. = 6, 72; $P < 0.001$). Mean numbers of butterflies (all species combined) were relatively low for all cultivars on the first sampling date, but were generally higher for 'Lillput' zinnias on subsequent dates (Fig. 2). The exception occurred on the morning of the fifth sampling date (September 11). This was the coolest of the seven sampling

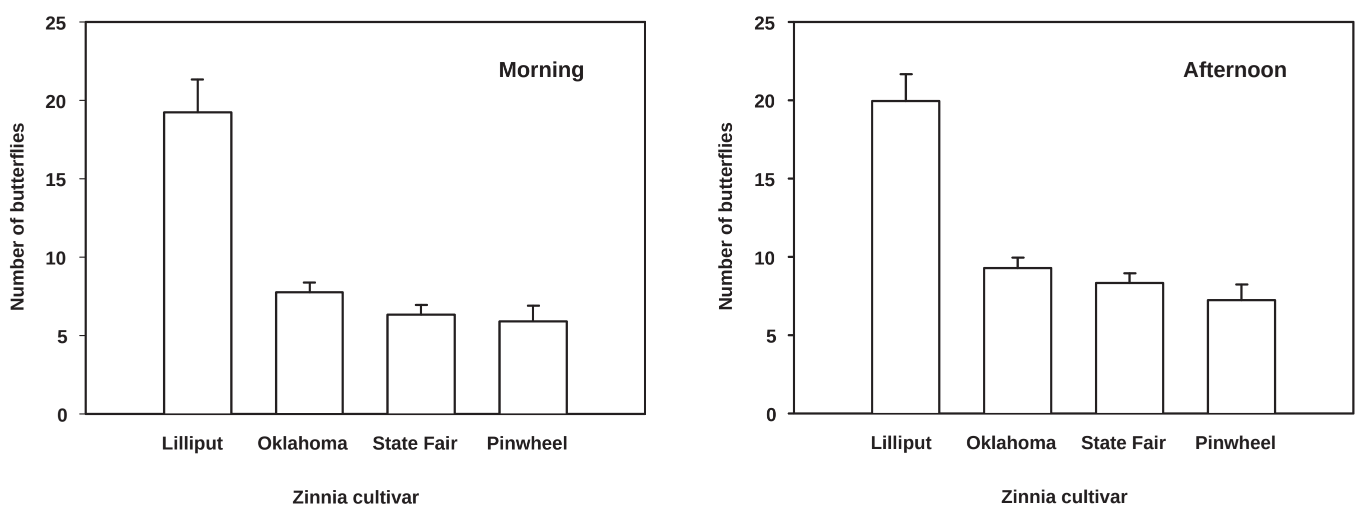

Fig. 1. **Mean number of butterflies per plot, all species combined, averaged across seven sampling dates; lines above bars represent one standard error. In both morning and afternoon, butterflies were significantly more abundant on 'Lilliput' than on any other cultivar, with no significant differences among the other cultivars (Tukey's HSD test with $\alpha = 0.05$).**

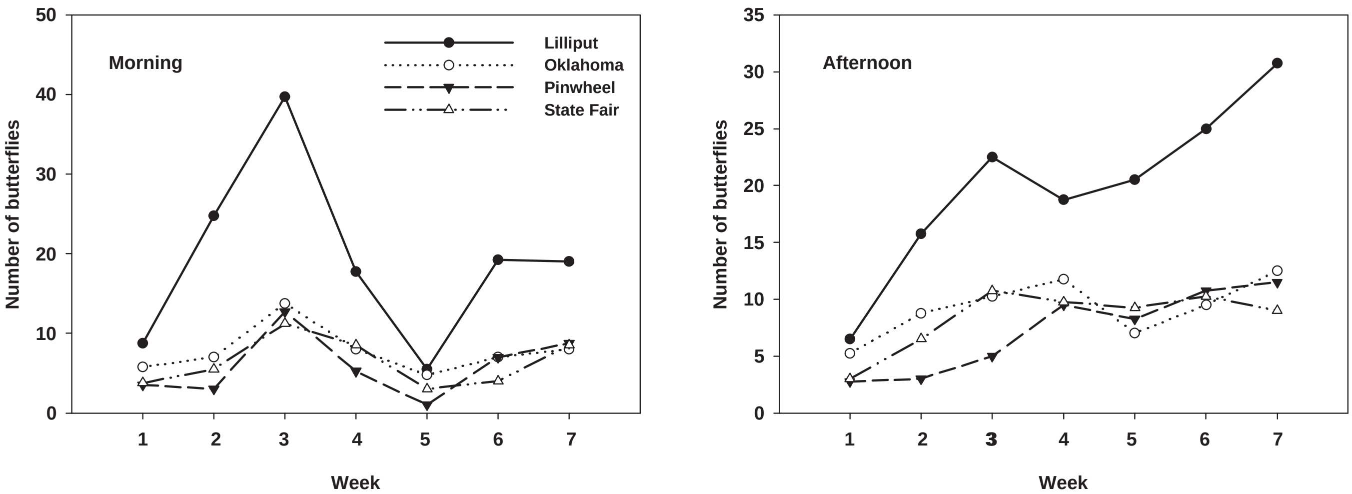

Fig. 2. Mean number of butterflies per plot, all species combined, on each of seven weekly sampling dates between August 16 and September 25. Means represent the average of four plots for each cultivar; repeated measures analysis of variance showed that butterfly abundance varied significantly among sampling dates in both morning (F = 46.9; d.f. = 6, 72; P < 0.001) and afternoon (F = 17.4; d.f. = 6, 72; P < 0.001).

dates, and low temperatures may have suppressed butterfly activity that morning; butterfly numbers were not similarly depressed in the afternoon on that date. Variation in numbers and activity of adult butterflies through time is to be expected, due to many factors. Such factors may include plant size and flower abundance. Our plants were relatively small at the start of the seven-week sampling period but they continued to grow and produce more flowers as the season progressed. Seasonal timing of butterfly life cycles can affect the numbers of adults present at any point in time because butterfly species vary in the number of generations per year and when those generations occur as eggs, larvae, pupae, and adults. Weather conditions, particularly temperature, precipitation, and wind speed, can directly affect adult butterfly activity. Weather conditions also may indirectly affect butterfly visitation to flowers by altering the condition of the plant (e.g., nectar flow). Despite the expected variation among sampling dates, 'Lilliput' zinnias attracted more butterflies than did any of the other zinnia cultivars on most sampling dates (Fig. 2).

Butterflies in the family Nymphalidae (brush-footed butterflies) accounted for 60% of the 2355 individuals recorded during this study, with Pieridae and Hesperiidae representing 23.6 and 16.1% of the total butterflies, respectively. Members of other families (Lycaenidae and Papilionidae) accounted for less than 1% of the total.

The variegated fritillary, *E. claudia*, was the most abundant butterfly species visiting zinnias, representing slightly more than 50% of the total butterflies counted in both the morning and the afternoon (Table 1). Eight additional species of Nymphalidae were observed. Two species of *Colias* (*C. eurytheme* and *C. philodice*) and *P. rapae* accounted for most of the Pieridae observed. Thus, while Nymphalidae and Pieridae were the most prevalent butterfly families in terms of abundance, their numbers were dominated by just four species. The family Hesperiidae (skippers) was represented by the greatest number of species. Hesperiidae accounted for half of the 30 butterfly species observed, but represented only about 16% of the total individuals. Among the 15 species of Hesperiidae, *A. campestris* was the most abundant, representing 7.3% of the total butterflies.

The primary role of nectar-producing plants in a butterfly garden is to attract and retain large numbers of butterflies, but high species diversity among those visitors also is desirable. 'Lilliput' not only had the largest number of butterfly visitors, but it also had the greatest number of species. Because we combined the two *Colias* species in our field data, we recorded 29 separate taxa, even though 30 species were present during the study. 'Lilliput' was visited by 27 of those 29 butterfly taxa, while fewer taxa visited each of the other cultivars ('State Fair' – 22; 'Oklahoma' – 20; 'Pinwheel' – 17). The two species not observed on 'Lilliput', *T. lineola* and *E. comyntas*, were represented in our study by only 2 and 5 individuals, respectively, among 2355 total butterflies.

The purpose of our study was to determine whether butterfly feeding preferences differed among selected zinnia cultivars and, if so, to identify a good zinnia cultivar for use in butterfly gardens. We did not attempt to determine the reason why more butterflies fed on 'Lilliput' than the other tested cultivars but that would be an interesting topic for further study. We used mixed color plantings in an effort to minimize effects that flower color might have on attraction of butterflies, although the role of color is not clear. In a study of *Z. violacea* 'Peter Pan', butterfly visitation differed among flower colors, but apparent color preferences were not consistent among butterfly species (7). In two studies of butterfly feeding preferences for *Buddleja*, the role of color was equivocal; one study found an effect of color, while the other did not (3, 5). The cultivars we used varied in plant size and flower size. 'Lilliput' was intermediate in plant size among the four cultivars and had the smallest flowers of the three double flowered cultivars tested ('Pinwheel' is single flowered). Hence, nothing obvious about the general appearance of 'Lilliput' plants or flowers seems to explain the butterflies' strong preference for that cultivar. Perhaps the preference is related to undetermined differences among zinnia cultivars in the quantity and/or quality of nectar they produce. Previous studies have shown that quantity and sugar composition of nectar differs among cultivars of *Lantana* and *Buddleja* species (4, 5). Butterflies are known to have preferences for some sugars (especially sucrose) over others (5, 8). Following the discovery of amino acids in floral nectar in the 1970s

Table 1. **Families, species, and numbers of butterflies observed feeding on zinnia flowers during morning and afternoon.**

Family/species	Common name[z]	Number in morning[y]	Number in afternoon[y]	Cultivars visited[x]
Hesperiidae				
Anclyoxpha numitor (Fabricius)	least skipper	1	5	LP, OK, SF
Atalopedes campestris (Boisduval)	sachem	65	108	LP, OK, PW, SF
Epargyreus clarus (Cramer)	silver-spotted skipper	1	1	LP, SF
Erynnis icelus (Scudder and Burgess)	dreamy duskywing	2	3	LP, OK
Euphyes vestris (Boisduval)	dun skipper	2	0	LP, OK
Hylephila phyleus (Drury)	fiery skipper	41	39	LP, OK, PW, SF
Pholisora catullus (Fabricius)	common sootywing	10	6	LP, OK, SF
Poanes zabulon (Boisduval and Leconte)	Zabulon skipper	5	21	LP, OK, PW, SF
Polites origenes (Fabricius)	crossline skipper	0	4	LP, OK, SF
Polites peckius (Kirby)	Peck's skipper	11	8	LP, OK, PW, SF
Polites themistocles (Latreille)	tawny-edged skipper	7	14	LP, OK, PW, SF
Pyrgus communis (Grote)	common checkered-skipper	9	10	LP, OK, PW, SF
Staphylus hayhurstii (Edwards)	Hayhurst's scallopwing	1	0	LP
Thymelicus lineola (Ochsenheimer)	European skipper	0	2	SF
Wallengrenia egeremet (Scudder)	northern broken-dash	1	2	LP, PW, SF
Lycaenidae				
Everes comyntas (Godart)	eastern tailed-blue	2	3	PW, SF
Nymphalidae				
Boloria bellona (Fabricius)	meadow fritillary	14	20	LP, OK, PW, SF
Chlosyne nycteis (Doubleday)	silvery checkerspot	2	6	LP, OK, PW, SF
Danaus plexippus (Linnaeus)	monarch	18	16	LP, OK, PW, SF
Euptoieta claudia (Cramer)	variegated fritillary	570	713	LP, OK, PW, SF
Junonia coenia Hübner	common buckeye	0	1	LP
Limenitis arthemis (Drury)	red-spotted purple	1	0	LP
Phyciodes tharos (Drury)	pearl crescent	9	14	LP, OK, PW, SF
Vanessa cardui (Linnaeus)	painted lady	14	12	LP, OK, PW, SF
Vanessa virginiensis (Drury)	American lady	1	2	LP, PW
Papilionidae				
Papilio polyxenes Fabricius	black swallowtail	2	0	LP, OK
Pieridae				
Colias spp.		180	199	LP, OK, PW, SF
Colias eurytheme Boisduval	orange sulphur			
Colias philodice Godart	clouded sulphur			
Pieris rapae (Linnaeus)	cabbage white	128	44	LP, OK, PW, SF
Pontia protodice (Boisduval and Leconte)	checkered white	2	3	LP, SF
TOTAL		1099	1256	

[z]Common names follow the Checklist of North American Butterflies, 2nd ed., North American Butterfly Association, Morristown, NJ.

[y]Numbers represent totals for each butterfly taxon across all seven sampling dates and all cultivars (four plots of each cultivar).

[x]LP = 'Lilliput'; OK = 'Oklahoma'; PW = 'Pinwheel'; SF = 'State Fair'; visitation may have occurred in morning and/or afternoon.

(2), several studies have shown that some butterflies show preferences for nectar with higher amino acid concentrations (e.g., 1). A recent study showed that amino acids in nectar can increase butterfly fecundity (6), thus demonstrating an effect of the behavioral preference on their fitness.

Stimart and Boyle (9) provided an excellent review of specific traits that have been emphasized by plant breeders in their efforts to improve zinnias for horticultural use. Those traits include flower color, flower doubleness, disease resistance, plant height, and leaf morphology. They further suggested that future breeding efforts should include development of disease resistance in *Z. violacea*, reduced water requirements for *Z. violacea*, and development of double-flowered cultivars and expanded flower color range in *Z. angustifolia*, a species with good drought tolerance but limited aesthetic traits. All of those traits and goals are clearly important, but it is noteworthy that the quantity and quality of zinnia nectar was not mentioned. One wonders how nectar characteristics might have been inadvertently affected during more than a century of breeding for other traits.

'Lilliput' is truly an heirloom zinnia cultivar, having been developed in the 1870s (9), but fortunately it remains readily available today at local stores and through internet sales. Our results indicate that this cultivar would be an excellent choice for inclusion in butterfly gardens.

Literature Cited

1. Alm, J., T.E. Ohnmeiss, and J. Lanza. 1990. Preference of cabbage white butterflies and honeybees for nectar that contains amino acids. Oecologia 84:53–57.

2. Baker, H.G., and I. Baker. 1973. Amino acids in nectar and their evolutionary significance. Nature 241:543–545.

3. Bruner, L.L., D.J. Eakes, G.J. Keever, J.W. Baier, C.S. Whitman, P.R. Knight, and J.E. Altland. 2006. Butterfly feeding preferences for *Buddleja* selections in the landscape. J. Environ. Hort. 24:39–44.

4. Bruner, L.L., D.J. Eakes, G.J. Keever, J.W. Baier, C.S. Whitman, P.R. Knight, J.E. Altland, and E.M. Silva. 2008. Butterfly feeding preferences of *Lantana camara* cultivars and *Lantana montevidensis* 'Weeping Lavender' in the landscape and nectar characteristics. J. Environ. Hort. 26:9–18.

5. Culin, J.D. 1997. Relationship of butterfly visitation with nectar qualities and flower color in butterfly bush, *Buddleia davidii*. News Lepid. Soc. 39:35–38.

6. Mevi-Schütz, J. and A. Erhardt. 2005. Amino acids in nectar enhance butterfly fecundity: a long awaited link. Amer. Nat. 165:411–419.

7. Reid, L.S. and J.D. Culin. 2002. Effects of color pattern arrangement and size of color mass on butterfly visitation in *Zinnia elegans*. J. Entomol. Sci. 37:317–328.

8. Rusterholz, H. and A. Erhardt. 1997. Preferences for nectar sugars in the peacock butterfly, *Inachis io*. Ecol. Entomol. 22:220–224.

9. Stimart, D., and T. Boyle. 2006. Zinnia. p. 337–357 *In*: N.O. Anderson (ed.). Flower Breeding and Genetics. Springer, Dordrecht, The Netherlands.