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Field Observations on Pollination of Cultivated Zinnias

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ABSTRACT

Zinnia L. (Asteraceae: Heliantheae) have historically been used as common summer bedding plants. In summer 2020, we conducted a field trial to observe pollinators on different zinnia cultivars (n=12). To better understand the variance of pollinator preference, we grew flowers that were large-and-tall (common for cut floral displays), short-and-small (typical of bedding plants), and intermediaries of differing qualities. Floral characteristics varied from those that exhibited a single ring of petiolate ray florets on the inflorescence to those with nearly fully double flowers consisting of essentially entirely petiolate ray florets. Floral morphology was documented in addition to insect floral visitation. Nectary guides were determined under ultraviolet light. We found differential preferences of pollinators towards select cultivars in the species *Zinnia elegans* Jacq. Furthermore, we found no significant correlation between anther count and total number of insect visitors; however, we found a correlation between anther count and the type of pollinator visiting the cultivars.

Additional index words: *Zinnia* spp., Lepidoptera, Hymenoptera, Diptera, Coleoptera, Hemiptera, Orthoptera, pollinators, floral morphology

Zinnia is a common genus of garden flowers, with 22 species being native to North America (Grissell, 2020). Since the early 1800's several species in this genus that have been commercially cultivated, including *Zinnia elegans* Jacq., *Z. angustifolia* Kunth, *Z. haageana* Regel, and *Z. pauciflora* L. (Grissell, 2020). In modern gardens, the most popular bedding plant among zinnias is *Z. elegans*, or the elegant zinnia, which is commonly grown for its wide variety of bright colors and tight petal structure (Grissell, 2020). Recently, cultivars of *Zinnia* x *marylandica* D.M. Spooner, Stimart & T. Boyle have become widely available (Grissell, 2020). Prior research suggested that *Z.* x *marylandica* was not a sufficient pollinator attractant species for companion fruit-set plantings (Montoya, 2018). However, the extent to which certain pollinator species are attracted to zinnia cultivars is still unknown. Furthermore, despite the current decline of managed honey bee (*Apis mellifera* L.) populations in the U.S. (Wood et al., 2020), it is unknown if this trend of declining managed pollinator populations directly correlates to a decline in populations of native bees within the United States, including native bumble bees (*Bombus* Latreille) (Graves et al., 2020). In this study, multiple species of bees in the genus *Bombus* were collected on zinnia cultivars during our field trial to investigate pollinator preferences and attractiveness of popular garden zinnias. The alarming decline of these generalist species suggests the importance of food sources that can contribute to their diet, particularly in developed landscapes.

MATERIALS AND METHODS

Our study was conducted at Texas A&M University's Horticulture Teaching Research and Extension Center (30°37'24.24"N, -97°22'0.17"W) in Burleson County, TX. In the summer and fall of 2020 we grew *Zinnia elegans* 'Queen Red Lime', *Z. elegans* 'Peppermint Stick', *Z. elegans* 'Cupid Mix', *Z. elegans* 'Cupcake Mix', *Z. elegans* 'Zinderella', *Z.* × *marylandica* 'Profusion Cherry', *Z. angustifolia* 'Starbright Mix', *Z. haageana* 'Persian Carpet', *Z. tenuifolia* 'Red Spider', and *Z.* × *marylandica* 'Zahara Double Brilliant Mix'. Among these cultivars, there is a high degree of variation in plant size, flower color, single or double flowering, and flower shape. Seedlings were germinated on mist benches in a glass greenhouse and were grown in BWI potting mix (Schulenberg, TX) in standard 4-in pots (0.47 L, Dillen Products, Middlefield, OH). Once plants were established under mist benches, they were acclimated in an outdoor nursery, then transplanted into field plots on 14 July 2020. Cultivars were planted following a pattern of four plants grouped at 4-ft (1.2 m) centers with three replicates of each group per cultivar. Bed-shaped rows 4-ft (1.2 m) wide were covered in black plastic mulch and watered daily using dual drip-irrigation lines (T-Tape Model 505, Deere and Company, Moline, IL).

To determine pollinator attraction of each zinnia cultivar, we recorded inflorescence diameter, along with anther counts (both ray and disk flowers), collected pollinators drawn to each taxon, and noted the presence or absence of ultraviolet light nectar guides (Free, 1970). Pollinator collection took place from 8:30 am to 10:30 am on 12 occasions between 3 August and 13 September 2020. Pollinators were collected with aerial nets and insect kill jars (BioQuip Products, Rancho Dominguez, CA), and were then frozen and pinned. An insect was considered a potential pollinator if it made contact with the inflorescence. Following collection, insects were identified to species whenever possible, or sorted to morphotype in cases when local expertise did not allow for species-level identification (Table 1). The insects were additionally separated by order and flower visited to determine the type of flower that was significantly attracting specific pollinators (Fig.1). Species diversity was calculated using total species richness (S_T) and the Shannon-Wiener diversity index:

$$H' = \sum -p_i \ln p_i$$

where p_i is the proportion of the total number of individuals belonging to species i (Shannon and Weaver, 1949). Insects were separated by order, date, and the inflorescence upon which they landed. Data was analyzed using Statistical Analysis Software (Version 9.4, Cary, NC) using the general linear models procedure to compare least squares means for both orders visited and anther counts, and the CORR procedure to determine correlations among pollinator orders with petal layers, height, and number of anthers. If one of the cultivars showed a significantly greater level of visitation by pollinators ($P \leq 0.05$), then that was considered as evidence of flower preference by insects.

RESULTS AND DISCUSSION

The unique characteristics of flowers of each cultivar were determined prior to field planting (Table 2). We found that the cultivar 'Queen Red Lime' had the highest number of anthers, which was approximately double that of 'Starbright Mix' and 'Zahara Double Brilliant Mix', and was slightly greater than that of most remaining cultivars (Fig. 2). 'Red Spider' had significantly fewer anthers than all other cultivars except 'Persian Carpet' and 'Cupid Mix' (Fig. 2). Insect floral visitors of six different orders were collected through the sampling period (Table 1, Fig. 1). The primary visiting pollinators were comprised of various species of butterflies (order: Lepidoptera) and bees (order: Hymenoptera). The number of petal layers and anthers were not significantly correlated with visitation numbers of any order of insects ($P \leq 0.05$), nor for the total number of visitations ($P \leq 0.05$). However, height was positively correlated ($P \leq 0.05$) with total visitations (r=0.65) and visitations for insects in the orders Coleoptera (r=0.63), Orthoptera (r=0.71), and Hymenoptera (r=0.65).

There were three cultivars that had significant preference by insects (Fig. 1). *Z. elegans* 'Zinderella' had greater visitation than all other cultivars. *Z. elegans* 'Peppermint Stick' and *Z. elegans* 'Cupid Mix' had greater visitation than the remaining cultivars, except for *Z. elegans* 'Cupcake Mix'. This indicated that, of the six species grown, only cultivars of *Z. elegans* attracted more pollinators than the remaining taxa. During collection, the two cultivars 'Red Spider' and 'Zahara Double Brilliant Mix' had no observed pollinator visits (Fig. 1). Interestingly, flowers of these two cultivars showed no clear nectary guides under ultravi-

Table 1. Unique insects collected on flowers of Zinnia cultivars in field plots in Somerville, Texas.

Insect Visitors			Zinnia Cultivars									
Order	Family	Species	*Zinderella	*Cupid	*Pepp. Stick	Prof. Cherry	Queen Red Lime	Pers. Carpet	Red Spider	Cupcake	Zahara	Starbright
Lepidoptera	Hesperiidae	*Lerodea eufala* (W.H. Edwards) 1	1	1								
Lepidoptera	Hesperiidae	*Lerema accius* (W.H. Edwards) 1				1						
Lepidoptera	Pieridae	*Colias eurytheme* (Boisduval) 1								1		
Lepidoptera	Lycaenidae	*Strymon melinus* (Hübner) 1	1									
Lepidoptera	Hesperiidae	*Atalopedes campestris* (Boisduval) 1		1		1				1		
Lepidoptera	Hesperiidae	*Urbanus proteus* (L.) 1		1								
Lepidoptera	Nymphalidae	*Vanessa cardui* (L.) 2	2		2							
Lepidoptera	Pieridae	*Pyrisitia lisa* (Boisduval & Leconte) 1				1						
Lepidoptera	Nymphalidae	*Agraulis vanillae* (L.) 2	7	3	1			1		3		
Lepidoptera (Caterpillar)			1		1							
Coleoptera	Chrysomelidae	*Diabrotica balteata* (LeConte) 4	2	1								
Hymenoptera	Halictidae	*Agapostemon texanus* (Cresson) 2	5	1	3		2			1		
Hymenoptera	Apidae	*Bombus pensylvanicus* (De Geer) 2	3	1								
Hymenoptera	Apidae	*Xylocopa virginica* (L.) 2	1									
Hymenoptera	Halictidae	*Halictus ligatus* (Say) 2	5	1	1							
Hymenoptera	Halictidae	*Lasioglossum* (Dialictus) *disparale* (Smith) 2	4	1	3							
Hymenoptera	Halictidae	*Lasioglossum* (Dialictus) spB (Smith) 2		1								1
Hymenoptera	Formicidae (Bolton)	Unknown				2	1					
Hymenoptera	Vespidae	*Stenodynerus propinquus* (Sauss.) 3		1				1				
Orthoptera (Nymph)					1		1			2		
Orthoptera	Grylloidae	*Oecanthus* sp. (Walker) 3	1	1								
Hemiptera	Pentatomidae (Thyanta) 3	Unknown	1	1								
Hemiptera	Cicadellidae	*Acinopterus* sp. (Van Duzee) 3								1		
Hemiptera	Clastopteridae	*Clastoptera* sp. (Germar) 3		1								1
Hemiptera	Miridae	*Polymerus basalis* (Reut.) 3						1				
Diptera	Bombyliidae	*Geron* sp. (sistr.) 3			1							
Diptera	Syrphidae	*Eristalis stipator* (O.S). 3	1									
Diptera	Syrphidae	*Palpada vinetorum* (Fabricius) 3		1								
Diptera	Syrphidae	*Allograpta obliqua* (Say) 3		1								
Diversity Measures		Richness	14	16	8	4	3	3	0	6	0	2
		Shannon-Weiner	0.37	0.32	0.28	0.17	0.13	0.11	0.00	0.23	0.00	0.08
Determinations: 1. James McDermmot, 2. Karen Wright, 3. Vassili Belov, 4. Edward Riley												
* Indicates cultivars upon which significantly greater numbers of pollinators were collected.												

olet light (Table 2). Anther counts of all cultivars varied substantially, but with no clear trend connected to total insect order collection (Fig. 2). Although cultivars had differences in their flower type, size, and ratio of ray to disk florets, there did not appear to be consistent patterns related to pollinator visitation (Table 2, Fig. 1).

Observationally, the inflorescences that had a considerable proportion of disk florets tended to be among those cultivars more frequented by insects than those without defined central disk florets. Of the four most frequented cultivars, all but 'Cupid Mix' were among the ones with the lowest ray to disc floret inflorescences, indicating a larger proportion of disc florets (Table 2). During collection, there were multiple arachnids (class: Arachnida Lamarck) and other insect predators near the flowers. In addition, hummingbirds (family: Trochilidae Peterson) often visited the site and competed for nectar with the insect pollinators.

Attraction of pollinators varied substantially among

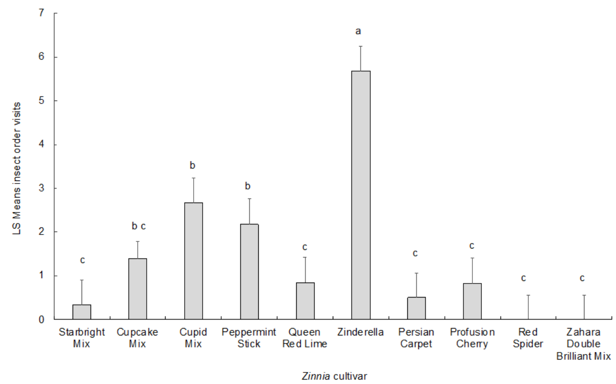

Figure 1. Least Squares Means (± standard error of the mean) of total visits of all orders (Hemiptera, Hymenoptera, Diptera, Orthoptera, Lepidoptera, and Coleoptera) collected from each cultivar within the collection time period. Means with the same letter are not statistically different at $P \leq 0.05$.

Table 2. Morphological traits of *Zinnia* cultivars sampled during field testing.

Cultivar	Average Flower Diameter (cm)	Unicolor(U) or Bicolor (B)	Single (S), Double (D), or Mix (M) Flowering	UV Light Nectar Guide Present (P) or Absent (A)	Low Growing (L) or Tall Stems(T)	Ratio of Ray: Disk Flowers
Z. pauciflora 'Profusion Cherry'	4.5	B	S	P	L	2:07
Z. elegans 'Queen Red Lime'	6	B	D	P	T	25:02
Z. angustifolia 'Starbright Mix'	3	U	S	P	L	1:05
Z. haageana 'Persian Carpet'	4	B	S	P	T	4:07
**Z. elegans* 'Peppermint Stick'	6.2	B	M	P	T	5:04
**Z. elegans* 'Cupid Mix'	4.4	U	D	P	T	11:06
Z. tenuifolia 'Red Spider'	3.5	U	S	A	T	9:05
Z. elegans 'Cupcake Series Mix'	4.5	U	S	P	T	1:02
**Z. elegans* 'Zinderella'	5	U	S	P	T	3:05
Z. x marylandica 'Zahara Double Br	5.7	U	D	A	L	45:11

** Indicates cultivars upon which significantly greater numbers of pollinators were collected*

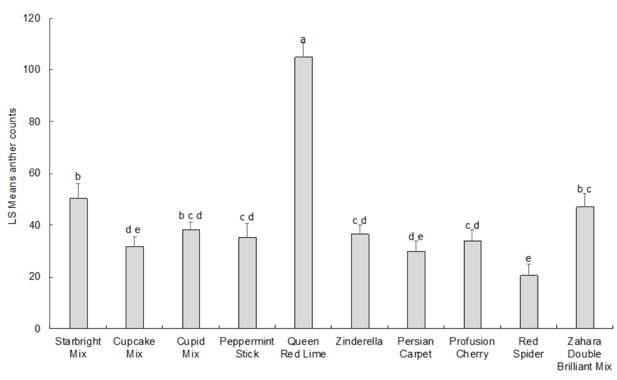

Figure 2. Least Squares Means (± standard error of the mean) of total anthers of each cultivar. Means with the same letter are not statistically different at $P \leq 0.05$.

the cultivars of *Zinnia* within our study, and could potentially be a factor in landscape design specifications for urban areas. Composition of flowers in urban green areas and gardens has been linked to differing pollinator communities (Dylewski et al., 2020). Interestingly, we consistently found that the native butterfly *Agraulis vanilla* L., the Gulf Fritillary, was attracted to the zinnias. Wróblewska et al. (2016) highlighted that *Z. elegans* can serve as a significant attractant for butterflies in urban areas compared to other Asteraceae flowers (Wróblewska et al., 2016). However, the authors did not specify a particular cultivar of *Z. elegans*. With pollinators declining, there is a potentially massive impact on the world economy and environment (Khachatryan & Rihn, 2018). Thus, prioritizing and marketing ecologically sustainable flowers could be an important marketing tool for retailers. Future research should explore whether this preferential trend among pollinators is significant for additional floral characteristics, such as petal colors, and over other seasons and varied regions for *Zinnia elegans* flowers.

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