Effects of Color Pattern Arrangement and Size of Color Mass on Butterfly Visitation in *Zinnia elegans*[1]

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Abstract The popular literature abounds with design suggestions for creating successful butterfly gardens. In many of these sources of information, the implication is made that greater numbers of butterflies will be attracted to gardens having large masses of single, or similar, color flowers than to those having either several colors mixed together in an area, or those with single colors planted in narrow rows. In this study we used a variety of color forms of *Zinnia elegans* N. J. von Jacquin 'Peter Pan' to examine these two aspects of butterfly gardening. We found that changing the design of plots from blocks to rows to random placement of colors had no effect on butterfly visitation. We also found that increasing the size of single color plots resulted in increased numbers of butterflies visiting those plots.

Key Words Butterfly gardening, *Zinnia*, butterflies, Lepidoptera, color mass, garden design

Over the last decade, gardening to attract butterflies has become an extremely popular pastime throughout the United States. Information on how to design an effective butterfly garden can be found in many books, magazines, television shows, and web sites dealing with gardening or conservation.

One aspect of butterfly garden design that is often stressed in these resources is that creating masses of single, or similar, color flowers will attract more butterflies than if the same area contains a mixture of flower colors (Schneck 1994, Sedenco 1991, Ajilvsgi 1990). Sedenco (1991) and Ajilvsgi (1990) have also suggested that a mass of a single color is more attractive to butterflies than if the same color is planted in a long narrow row. Tekulsky (1985) stated that increased density of flower heads created when plants are clumped together caused this increased attractiveness to butterflies.

We conducted two studies to determine whether these hypotheses of color massing were true. In 1997, the effect of color pattern was examined, and in 1998, the effect of size of color mass was investigated.

Materials and Methods

This project was conducted on an open hill at the Cherry Farm Entomology Research Laboratories of Clemson University (Clemson, Pickens Co., SC).

1997 study. Three plots of *Zinnia elegans* N. J. von Jacquin 'Peter Pan' were established. Each plot was approximately 6 m × 6 m and consisted of 64, 22 L (36.8

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cm diam × 30.5 cm deep) pots arranged in an 8 × 8 pot plot. Each pot contained approximately eight plants of one of four color forms: white, gold, scarlet, or pink. Within a plot, pots were arranged either in a block, row, or stratified random pattern (Fig. 1). The block pattern consisted of four single-color 16-pot (4 × 4) quadrants, while the row pattern consisted of four single color 16-pot (2 × 8) rows. In the stratified random pattern, the plot was divided into four 16-pot (4 × 4) quadrants, each of which contained four randomly located pots of each color. Within a plot, pots were separated by approximately 38 cm. Plots were separated by 46 m.

Butterfly observations were taken on nine dates between 28 July and 22 August. Data were obtained by conducting 20 min visual counts within each plot three times each week. In both the block and row plots, each of the four flower colors was observed individually for 5 min. Because it was not possible to efficiently observe the separated pots of each color in the stratified random plot, each of the four quadrants was observed for 5 min with all butterflies observed recorded along with the flower color they were visiting.

To eliminate any location effect, after every third sample date, plots were rearranged into one of the other patterns. The southernmost plot was in the block pattern week 1, random pattern week 2, and row pattern week 3; the middle plot was in the row pattern week 1, block pattern week 2, and random pattern week 3; the northernmost plot was in the random pattern week 1, row pattern week 2, and block pattern week 3. The number of flowers per pot in each plot was recorded on 22 July, 4 August, and 18 August.

1998 study. Eight, single-color transects were established using potted 'Peter Pan' *Z. elegans.* In addition to the four colors used in 1997 (white, gold, scarlet, pink), flame, orange, plum, and princess rose pink were added. Each transect consisted of five plots that increased geometrically from 1 to 16 pots (Fig. 2). Pots used were the same size as in 1997, with each pot containing approximately four plants. Within each transect, edges of adjacent plots were separated by 8 m, and adjacent transects were separated by 8 m in the 16-pot location. Within-plot spacing among pots was the same as in 1997.

Butterfly observations were taken on 11 dates between 2 and 25 September. On each date, a visual census was taken along each transect, with the observer spending

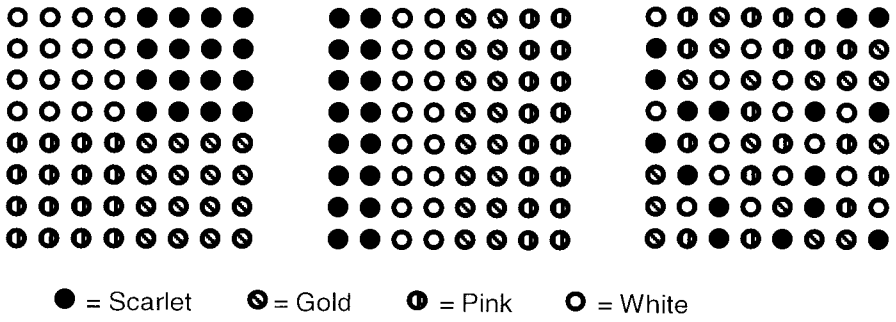

Fig. 1. Block, row, and stratified random plot patterns used in 1997. Pattern illustrated is from Week 1 with Block Pattern in the southernmost position. Each plot measured approximately 6 m × 6 m with 46 m spacing between plots.

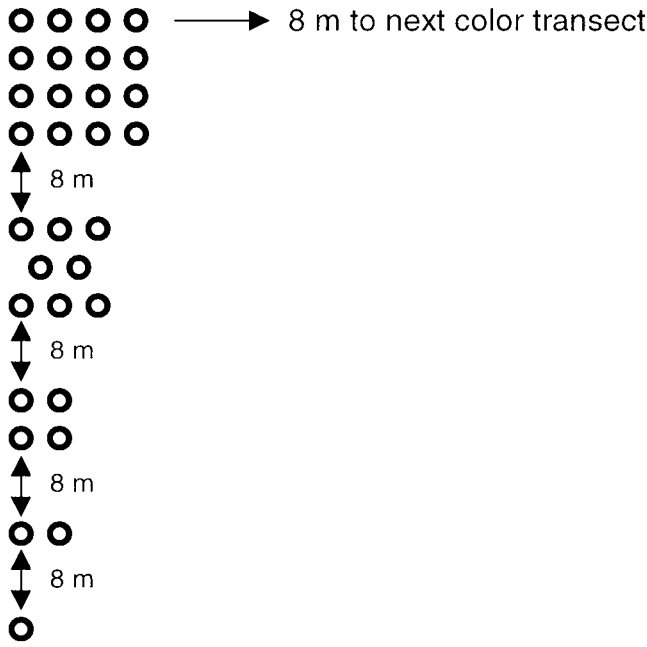

Fig. 2. Diagrammatic representation of one single-color transect used in 1998. Eight transects were used in this study with colors in the following order starting with the southernmost transect: flame, gold, orange, plum, scarlet, white, pink, princess rose pink.

as much time as necessary at each plot to ensure that all butterflies in that plot were counted. Any butterfly entering the plot once counting had begun was not included. The number of flowers in each plot was recorded on each sample date.

Glassberg (1993) was used for all butterfly identifications, and common names reported are those sanctioned by the Lepidopterists' Society. Due to the difficulty of identifying individual species of folded wing skippers (Hesperiidae) in the field, these were recorded as a single taxonomic group.

Butterfly and flower data were analyzed using analysis of variance (SAS 1999). Although determining the effects of flower color on butterfly visitation was not an objective of the study, it was examined in relation to both total butterflies and those species having more than 15 total individuals, in either years' data to determine if color influenced butterfly visitation.

Results and Discussion

1997 study. Fourteen butterfly taxa were recorded in the plots, with eight taxa having more than 15 individuals recorded during the study (Table 1). No significant differences were observed among the three plot designs (Fig. 3) for total butterflies ($F = 0.05$; df = 2,102; $P = 0.95$), folded wing skippers ($F = 0.04$; df = 2,102; $P = 0.96$), alfalfa butterfly ($F = 0.53$; df = 2,102; $P = 0.59$), buckeye ($F = 0.84$; df = 2,102; $P =$

Table 1. Butterfly taxa recorded in the 1997 study. Taxa are listed in descending order of abundance

Taxa	Total number
Folded Wing Skipper*	1294
Alfalfa Butterfly (Pieridae, *Colias eurytheme* Boisduval)	66
Buckeye (Nymphalidae, *Junonia coenia* Hübner)	30
Variegated Fritillary (Nymphalidae, *Euptoieta claudia* [Cramer])	39
Silver-Spotted Skipper (Hesperiidae, *Epargyreus clarus* [Cramer])	30
American Painted Lady (Nymphalidae, *Vanessa virginiensis* [Druryl])	29
Monarch (Danaidae, *Danaus plexippus* [L.])	21
Eastern Tiger Swallowtail (Papillonidae, *Papilio glaucus* [L.])	16
Cloudless Sulphur (Pieridae, *Phoebis sennae* [L.])	9
Spicebush Swallowtail (Papilionidae, *Papilio troilus* [L.])	5
Long-Tailed Skipper (Hesperiidae, *Urbanus proteus* [L.])	2
Black Swallowtail (Papillionidae, *Papilio polyxenes* F.)	2
Painted Lady (Nymphalidae: *Vanessa cardui* [L.])	1
Pearl Crescent (Nymphalidae, *Phyciodes tharos* [Druryl])	1
Total	1545

* Folded Wing Skippers included Fiery Skipper (Hesperiidae, *Hylephila phyleus* [Druryl]), Whirlabout (Hesperiidae, *Polites vibex* [Geyer]), and Northern Broken Dash (Hesperiidae, *Wallengrenia egeremet* [Scudder]).

0.43), variegated fritillary ($F = 0.53$; df = 2,102; $P = 0.59$), silver-spotted skipper ($F = 0.22$; df = 2,102; $P = 0.80$), American painted lady ($F = 1.71$; df = 2,102; $P = 0.19$), or monarch ($F = 1.89$; df = 2,102; $P = 0.16$). The eastern tiger swallowtail ($F = 4.36$; df = 2,102; $P = 0.015$) exhibited a significant difference among plots with similar numbers observed in the random and row plots, while no individuals were recorded in the block plot. These data contradict the traditional butterfly garden design suggestion (see, Schneck 1994, Sedenco 1991, Ajilvsgi 1990, Tekulsky's 1985) that masses of color should attract more butterflies than either rows or intermixed plantings.

Analyses of butterfly visitation in relation to flower color indicated that there were significant differences among the four colors (Fig. 4). Total butterflies ($F = 35.08$; df = 3,102; $P < 0.0001$) and folded wing skippers ($F = 27.13$; df = 3,102; $P < 0.0001$) were significantly more abundant on white than on gold, scarlet, or pink. The monarch ($F = 5.88$; df = 3,102; $P = 0.001$) was significantly more abundant on scarlet than gold or pink, and was not observed on white. The alfalfa butterfly ($F = 3.57$; df = 3,102; $P = 0.02$), silver-spotted skipper ($F = 3.61$; df = 3,102; $P = 0.02$), and variegated fritillary ($F = 2.09$; df = 3,102; $P = 0.10$) each exhibited significant differences among colors with both the alfalfa butterfly and variegated fritillary most abundant on white, and silver-spotted skipper most abundant on pink. The buckeye ($F = 0.84$; df = 3,102; $P = 0.48$), American painted lady ($F = 1.65$; df = 3,102; $P = 0.18$), and eastern tiger swallowtail ($F = 0.38$; df = 3,102; $P = 0.77$) were observed in similar numbers on all four color forms.

Although significant differences in the number of flowers were observed among both plot types ($F = 13.43$; df = 2,575; $P = <0.0001$) and colors ($F = 19.94$; df = 3,575;

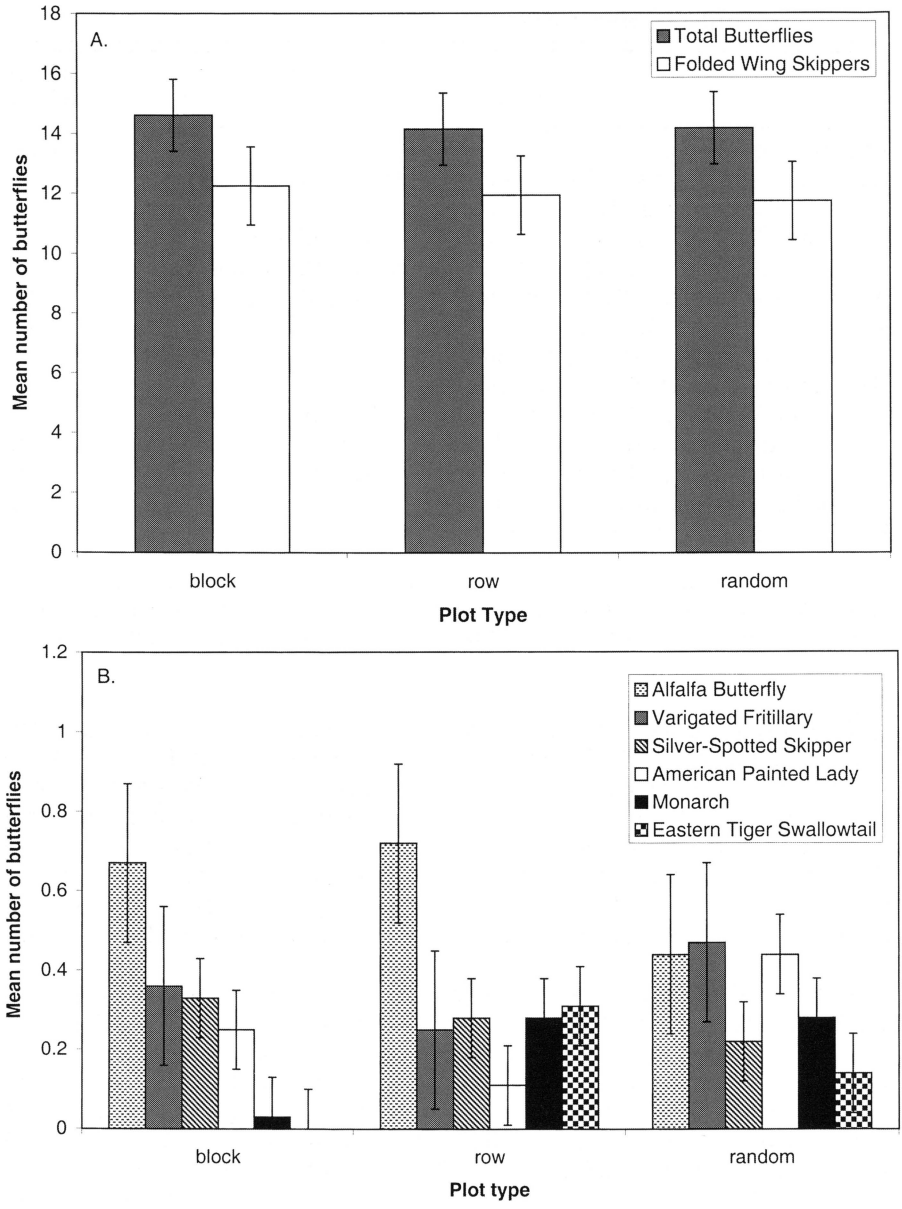

Fig. 3. (A) Mean number of total butterflies and folded wing skippers recorded in each of the three plot designs in 1997. (B) Mean number of the alfalfa butterfly, buckeye, variegated fritillary, silver-spotted skipper, American painted lady, monarch, and eastern tiger swallowtail recorded in each of the three plot designs in 1997.

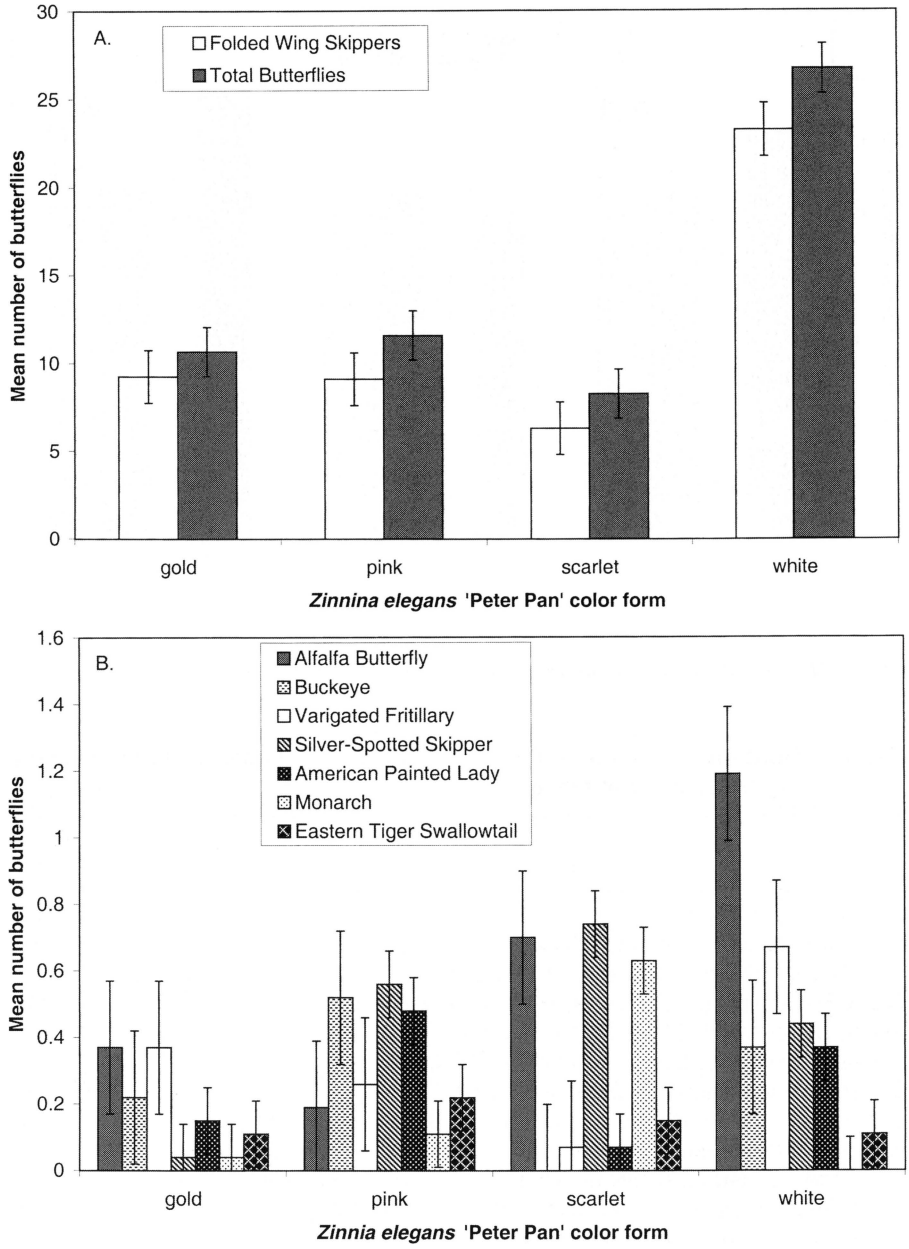

Fig. 4. (A) Mean number of total butterflies and folded wing skippers recorded on each of the four color forms in 1997. (B) Mean number of the alfalfa butterfly, buckeye, variegated fritillary, silver-spotted skipper, American painted lady, monarch, and eastern tiger swallowtail recorded in each of the four color forms in 1997.

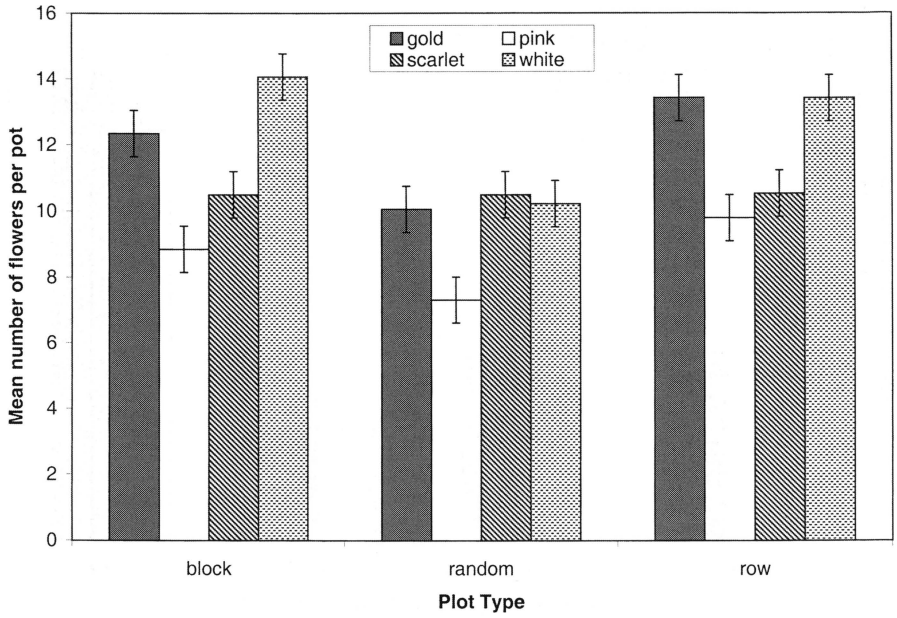

Fig. 5. Mean number of *Z. elegans* 'Peter Pan' flowers per pot.

Table 2. Butterfly taxa recorded in the 1998 study. Taxa are listed in descending order of abundance

Taxa	Total number
Folded Wing Skipper*	911
Cloudless Sulphur (Pieridae, *Phoebis sennae* [L.])	31
Gulf Fritillary (Nymphalidae, *Agraulis vanillae* [L.]	19
Black Swallowtail (Papilionidae, *Papilio polyxenes* F.)	17
Alfalfa Butterfly (Pieridae, *Colias eurytheme* Boisduval)	5
Buckeye (Nymphalidae, *Junonia coenia* Hübner)	5
Sleepy Orange (Pieridae, *Eurema nicippe* [Cramer])	4
Variegated Fritillary (Nymphalidae, *Euptoieta claudia* [Cramer])	4
Silver-Spotted Skipper (Hesperiidae, *Epargyreus clarus* [Cramer])	3
American Painted Lady (Nymphalidae, *Vanessa virginiensis*)	2
Long-Tailed Skipper (Hesperiidae, *Urbanus proteus* [L.])	2
Pipevine Swallowtail (Papilonidae, *Battus philenor* [L.])	2
Eastern Tiger Swallowtail (Papilionidae, *Papilio glaucus*)	1
Monarch (Danaidae, *Danaus plexippus* [L.])	1
Painted Lady (Nymphalidae, *Vanessa cardui* [L.])	1
Total	1008

* Folded Wing Skippers included Fiery Skipper (Hesperiidae, *Hylephila phyleus* [Druryl]), Whirlabout (Hesperiidae, *Polites vibex* [Geyer]), and Northern Broken Dash (Hesperiidae, *Wallengrenia egeremet* [Scudder]).

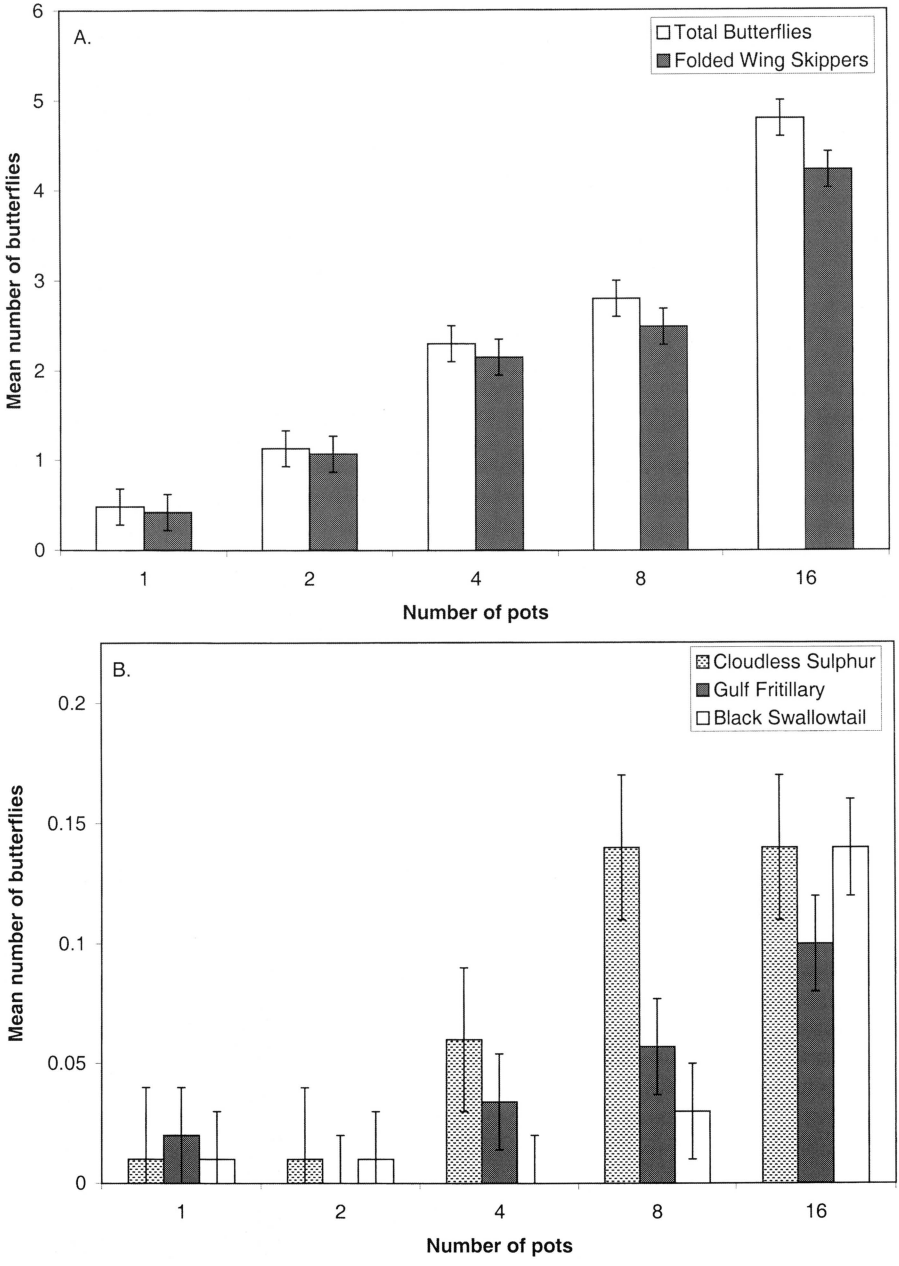

Fig. 6. (A) Mean number of total butterflies and folded wing skippers recorded in each of the five plot sizes in 1998. (B) Mean number of cloudless sulphur, gulf fritillary, and black swallowtail recorded in each of the five plot sizes in 1998.

P = <0.0001) (Fig. 5), we feel that the three plot patterns exhibited distinctly different visual patterns.

1998 study. Fifteen butterfly taxa were recorded, with four having greater than 15 individuals (Table 2). The lower number of butterflies in 1998 may have been due to the study being conducted 4 wks later than in the previous year. As the mass of color increased from 1 to 16 pots, the number of total butterflies (F = 62.51; df = 4,439; P = <0.0001), folded wing skippers (F = 52.43; df = 4,439; P = <0.0001), clouded sulphur (F = 4.12; df = 4,439; P = 0.003), gulf fritillary (F = 3.29; df = 4,439; P = 0.011), and black swallowtail (F = 6.33; df = 4,439; P = <0.0001), increased in a nearly linear fashion as the number of pots increased (Fig. 6). This supports the hypothesis that the size of the area planted in a single color did have an effect on the number of butterflies attracted.

However, when the number of total butterflies per pot was examined (Fig. 7) it was found that there were significantly more butterflies per pot in the 2-pot and 4-pot plots than in the 8-pot or 16-pot plots (F = 5.20; df = 4,439; P = 0.0004). These results contradict Tekulsky's (1985) suggestion that increased butterfly visitation in larger plantings is due to those areas containing greater numbers of individual flowers.

As in 1997, there were significant color effects (Fig. 8). Total butterflies (F = 9.80; df = 7,439; P = <0.0001) and folded wing skippers (F = 11.15; df = 7,439; P = <0.0001) were most abundant on white, pink, and princess rose pink. The cloudless sulphur was significantly more abundant on scarlet (F = 5.30; df = 7,439; P = <0.0001). The numbers of both the black swallowtail (F = 18.42; df = 7.439; P = 0.079) and gulf fritillary (F = 1.28; df = 7,439; P = 0.259) were not significantly different among the eight colors.

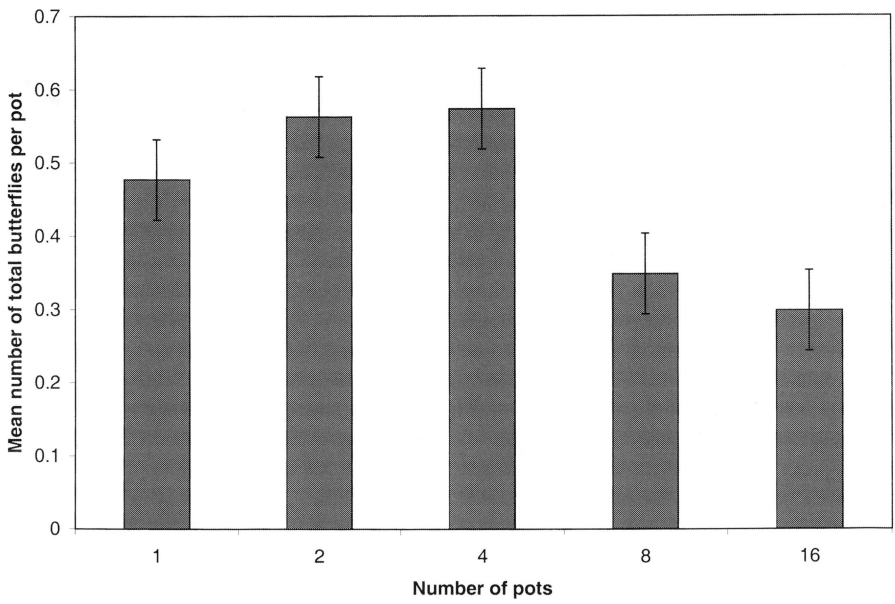

Fig. 7. Mean number of total butterflies per pot per sample date recorded in 1998.

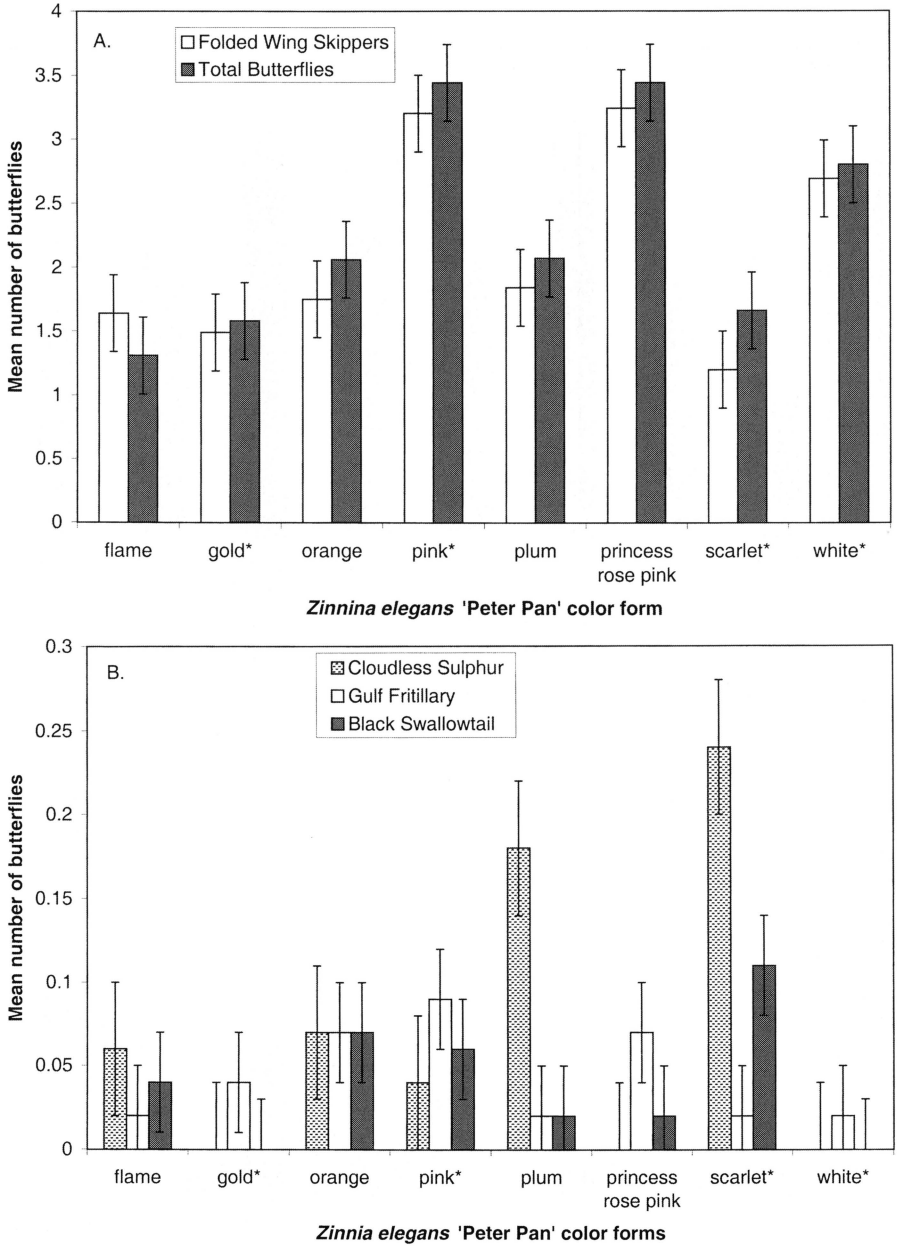

Fig. 8. (A) Mean number of total butterflies and folded wing skippers recorded on each of the eight color forms in 1998. (B) Mean number of cloudless sulphur, gulf fritillary, and black swallowtail recorded on each of the eight color forms in 1998.

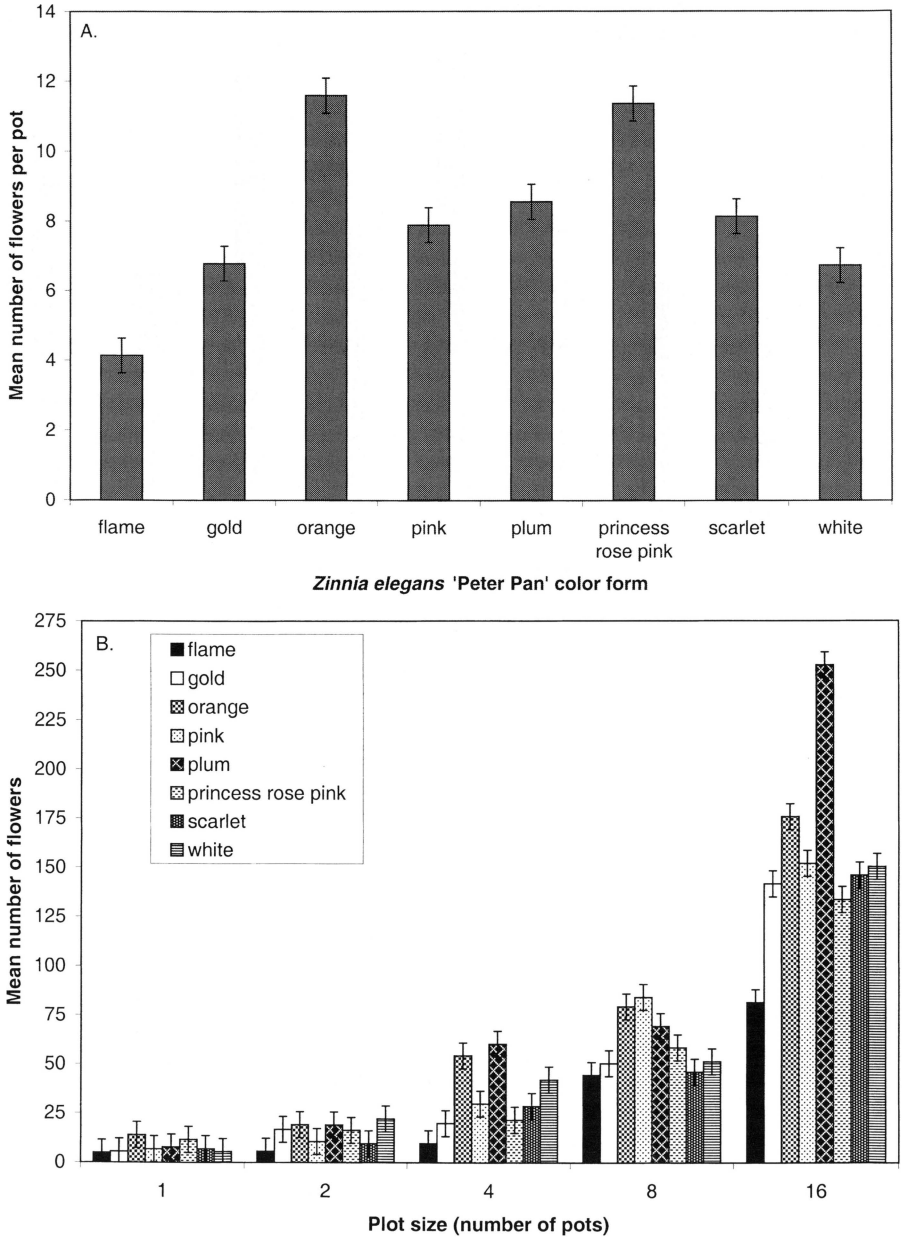

Fig. 9. (A) Mean number of total flowers recorded for each of the eight colors within each plot size in 1998. (B) Mean number of flowers recorded for each of the eight colors in 1998.

The number of flowers varied significantly among the eight colors used (Fig. 9A) (F = 18.42; df = 7,439; P = <0.0001), with the greatest numbers of total flowers recorded for princess rose pink and orange, and lowest for flame. The number also was significantly different (F = 28.93; df = 7,439; P = <0.0001) among the five plot sizes (Fig. 9B).

Conclusions

For *Z. elegans* 'Peter Pan', no significant differences were observed among the three plot arrangements in the number of butterflies present. This suggests that within a garden of a given size, similar numbers of butterflies would be attracted whether plants are arranged in single color masses, rows, or randomly. However, increasing the mass of color by increasing plot size from 1-pot to 16-pots, the number of butterflies observed increased significantly. The number of butterflies per pot reached the maximum in the 4-pot plot size and was lowest in the 16-pot plots.

Acknowledgments

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