

Evaluation of 14 Butterfly Bush Taxa Grown in Western and Southern Florida: I. Visual Quality, Growth, and Development

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SUMMARY. Plant growth, visual quality and flowering were assessed for 14 butterfly bush (*Buddleja*) taxa planted in western Florida (Milton) and central southern Florida (Fort Pierce). In both locations, 'Violet Eyes' butterfly bush (*B. weyeriana* × *B. lindleyana*), 'Honeycomb' butterfly bush (*B. ×weyeriana*), 'Moonlight' butterfly bush (*B. ×weyeriana*), and 'Sungold' butterfly bush (*B. ×weyeriana*) generally had the greatest growth index and shoot dry weight of all cultivars. In Fort Pierce and Milton, flower dry weights of 'White Profusion' butterfly bush (*B. davidii*), 'Nanho Alba' butterfly bush (*B. davidii* var. *nanhoensis*), and 'Dartmoor' butterfly bush (*B. davidii* × *B. davidii* var. *nanhoensis*) were among the highest as compared to other cultivars at each site, although in Milton, 'Gloster' butterfly bush (*B. lindleyana*), Japanese butterfly bush (*B. japonica*) and 'Honeycomb' butterfly bush also had high flower dry weights. Peak plant performance varied by month, cultivar and location. At 12 weeks, plant

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form and color were above average for each cultivar with the exception of 'Black Knight' butterfly bush (*B. davidii*), lindley's butterfly bush (*B. lindleyana*), and 'Gloster' butterfly bush in the Fort Pierce location only. After 24 weeks at each location, visual quality was above average for 'Black Knight', 'Dartmoor', 'Gloster', 'Honeycomb', 'Violet Eyes', and Japanese butterfly bush. Peak flowering times varied with cultivar and location. At 24 weeks, flowering of 'White Profusion', 'Nanho Alba', 'Nanho Blue', and 'Nanho Purple' butterfly bush grown in Fort Pierce was 25% to 40% less than that of the same cultivars grown in Milton. At 24 weeks, 'Dartmoor' had the most flowers in both locations, covering 75% of the plant canopy.

Butterfly bush is a widely cultivated, extremely popular, flowering shrub with attractive foliage and a range of flower colors, some with exceptional fragrance. A member of Buddlejaceae, the genus *Buddleja* represents about 100–150 species that occur in North America and South America, south and east Africa, and in south-central and southeast Asia (Moore, 1961). Butterfly bush species are valued for summer flowering of large inflorescences that vary in length and attract butterflies. Native to central China and Tibet (Moore, 1949), *B. davidii* is the most commonly cultivated species. Numerous cultivars have replaced the species and account for its continued popularity over the years. Dirr (1998) lists 70 *B. davidii* taxa grouped by white, lavender/blue, pink/rose/mauve, purple/violet/magenta, and yellow flowers. Breeders have used *B. davidii* var. *nanhoensis* as a parent of several of the low-growing cultivars.

There are also many other species of *Buddleja* (Norman, 2000), but few are in commercial production (Dunnett, 1991). *B. lindleyana* display indeterminate panicle inflorescences with various shades of purple that continue to elongate and flower over extended periods of time. A Japanese species, *B. japonica*, is similar in appearance to *B. lindleyana* and the two are often misidentified. Our selection of *B. japonica* was originally accessed from the collection maintained at the University of Georgia Horticulture Farm as *B. hemsleyana* and has since been

identified as *B. japonica* (J.T. Lindstrom, personal communication).

Buddleja breeding programs began as early as 1920, when W. Van de Weyer developed interspecific hybrids resulting from crosses between *B. globosa* and *B. davidii magnifica*. Hybrids of *B. globosa* and *B. davidii* are classified as *B. ×weyeriana* and generally characterized by yellow to orange flowers that occur in interrupted patterns along the length of the inflorescence. Progeny of this breeding program ultimately led to the selections *B. ×weyeriana* 'Moonlight' and 'Golden Glow' (Moore, 1960). Several *Buddleja* hybridization programs were initiated in the late 1990s under the direction of M.A. Dirr, J.T. Lindstrom, and D.J. Werner (Adkins and Werner, 2003; Dirr, 2001; Gaus and Adkins, 2002; Lindstrom et al. 2002; Renfro and Lindstrom, 2003). These hybridization programs have focused on flower color, inflorescence morphology, compact growth habit, attractive gray pubescent foliage (leaf color), development of sterile plants, and development of novel *Buddleja* hybrids using species not commonly used in previous breeding programs.

The enormous ornamental value of butterfly bush has warranted its use in numerous research programs addressing production practices or landscape uses such as cultivar sensitivity to acute ozone (Findley et al., 1997), growth regulation during container production (Keever and Gilliam, 1994), effects of spacing on cut flower production (Armitage and Dirr, 1995), effects of dolomitic lime on growth and nutrient uptake (Gillman et al., 1998), effects of pruning time on cold hardiness (Warr et al., 2002), susceptibility to twospotted spider mite (*Tetranychus urticae*) (Gillman et al., 1999), and susceptibility to root-knot nematodes (Thetford and Kinloch, 2002). Butterfly bush is listed as one of 10 woody landscape plants commonly damaged by root-knot nematodes in Florida (Crow and Dunn, 2002) and recent work by Thetford and Kinloch (2002) identified 12 butterfly bush taxa susceptible to the root knot nematodes *Meloidogyne arenaria* and *M. incognita*.

Butterfly bush is grown in USDA Zones 5–9. In Florida, it is widely used in the upper part of the state but much less common in central-southern counties. The current study was conducted to determine how 14

butterfly bush taxa perform in western and southern Florida with relation to landscape potential.

Materials and methods

PLANT MATERIAL AND SITE CONDITIONS. Selection of taxa was based on availability, popularity, and performance in the landscape (Table 1). Each cultivar was clonally propagated, transferred to 3.8-L (1 gal) pots, and fertilized at a standard rate of 15 g (0.5 oz) per pot of 15N–3.9P–10K Osmocote Plus (Scotts Co., Marysville, Ohio) prior to planting. The experiment was conducted at Fort Pierce (USDA Zone 9B) and Milton (USDA Zone 8B) where nine uniform plants of each cultivar were planted (4 June 2002) 2.4 m (8 ft) on center on raised beds covered with polyethylene plastic. Plants were watered by seep (Fort Pierce) or drip (Milton) irrigation as needed. Plants were top-dressed again with Osmocote 6 weeks after planting. There was no need for any pesticide application at either location throughout the experiment. Field conditions for Fort Pierce were as follows: 2.5% organic matter, pH 5.3, average monthly rainfall 10.5 cm (4.13 inches), mean minimum and maximum temperatures 16.6 °C (61.88 °F) and 34.3 °C (93.74 °F), respectively, and relative humidity 79.4%. Field conditions for Milton were as follows: Orangeburg sandy loam with 2.1% organic matter, pH 5.9, average monthly rainfall 20.8 cm (8.19 inches), mean minimum and maximum temperatures 13.5 °C (56.30 °F) and 33.3 °C (91.94 °F), respectively, and relative humidity 82.0%.

DATA COLLECTION. Visual quality assessments (plant color, form, and flowering) were taken monthly by three individuals for each cultivar in each block at each location. Assessment of color and form was performed on a scale from 1 to 5 where 1 = very poor quality, not acceptable, severe leaf necrosis or yellowing; 2 = poor quality, not acceptable, large areas of necrosis or yellowing, poor form; 3 = fair to average quality, marginally acceptable, somewhat desirable form and color; 4 = good quality, very acceptable, nice color without yellowing, good form, marketable; and 5 = excellent quality, very marketable. Assessment of flowering was performed on a scale from 1 to 5 where 1 = no flowering; 2 = 25% of canopy covered with flowers; 3 = 50% of canopy covered with

Table 1. Botanical description of butterfly bush taxa evaluated during the study.

Common name	Species	Cultivar	Description ^z
Pink delight butterfly bush	<i>Buddleja davidii</i>	'Pink Delight'	True pink, fragrant (low to medium) flowers in 14.6-cm-long inflorescences; compact growth habit 0.60–1.06 m with gray-green leaves; Dutch introduction with parentage convoluted with 'Fascination', 'Nanho Alba', and 'West Hill' involved; most popular pink in the trade.
White profusion butterfly bush	<i>B. davidii</i>	'White Profusion'	White, low to medium fragrant flowers with yellow eyes in 17.2-cm-long inflorescences; upright shrub 0.68–1.04 m high with light green and narrow leaves.
Black knight butterfly bush	<i>B. davidii</i>	'Black Knight'	Very deep violet to dark purple flowers in 11.1-cm-long inflorescences; 0.35–0.92 m high; introduced in 1959.
Nanho white butterfly bush	<i>B. davidii</i> var. <i>nanhoensis</i>	'Nanho Alba'	White, low to medium fragrant flowers in 16.6-cm-long inflorescences that are larger than typical Nanho types; full dense form, haystack habit 0.76–1.08 m high with slender blue-green leaves.
Nanho blue butterfly bush	<i>B. davidii</i> var. <i>nanhoensis</i>	'Nanho Blue'	Mauve-blue flowers with low fragrance forming 7.3-cm-long inflorescences; compact habit 0.60–0.87 m high with small gray-green leaves.
Nanho purple butterfly bush	<i>B. davidii</i> var. <i>nanhoensis</i>	'Nanho Purple'	Magenta-purple flowers with high fragrance; inflorescences 10.6 cm long; spreading dwarf habit smallest of Nanho types; 0.38–1.06 m high and small blue-green foliage; hybrid between <i>B. davidii</i> var. <i>nanhoensis</i> and <i>B. davidii</i> 'Royal Red'.
Japanese butterfly bush	<i>B. japonica</i>		Purple-violet non-fragrant flowers in arching inflorescences 48.7 cm long; plants 0.83–1.14 m high. (received as <i>B. hemsleyana</i> from the University of Georgia collection).
Lindley's butterfly bush	<i>B. lindleyana</i>		Purple-violet non-fragrant flowers in arching inflorescences 27.9 cm long; plants 0.33–0.99 m high; (received as <i>B. lindleyana</i> 'Forest Hill Farm'; original source identified as <i>B. lindleyana</i> from Forest Farm Nursery, Williams, Ore.)
Gloster butterfly bush	<i>B. lindleyana</i>	'Gloster'	Purple-violet non-fragrant flowers in upright-arching inflorescences 52.1 cm long; plants 0.38–1.31 m high.
Honeycomb butterfly bush	<i>B. ×weyeriana</i>	'Honeycomb'	Yellow flowers with deep orange eye that are larger and more sweetly fragrant than 'Sungold'; cream yellow buds; inflorescences 10.3 cm long; 0.81–1.65 m high with medium green foliage; hybrid of <i>B. globosa</i> and <i>B. davidii</i> .
Moonlight butterfly bush	<i>B. ×weyeriana</i>	'Moonlight'	Cream-yellow flowers with deep orange eye and a trace of deep lavender in flower buds; inflorescences 12.5 cm long; 0.44–1.65 m high.
Sungold butterfly bush	<i>B. ×weyeriana</i>	'Sungold'	Yellow-orange, fragrant flowers with light lavender buds, occurring in interrupted patterns along the length of the inflorescence rather than in a continuum like most <i>B. davidii</i> types; inflorescences 8.5 cm long; 0.49–1.81 m high; sport of golden glow butterfly bush.
Violet eyes butterfly bush	<i>B. ×weyeriana</i> × <i>B. lindleyana</i>	'Violet Eyes'	Light lavender curved, non-fragrant flowers on an indeterminate inflorescence 25.4 cm long; plants 0.86–1.70 m high; dark-green foliage with flowers similar to lindley's butterfly bush.
Dartmoor butterfly bush	<i>B. davidii</i> × <i>B. davidii</i> var. <i>nanhoensis</i>	'Dartmoor'	Magenta flowers in large, multi-branched inflorescences 16.1 cm long; large-growing 0.35–0.97 m form; known since 1971, discovered near Yelverton on Dartmoor.

^zInflorescence length reported as the average of seven inflorescences measured for each cultivar. Plant height based on average minimum and maximum height of 18 plants in Fort Pierce (southern Florida) or Milton (western Florida) that were in the ground for 6 months; 1.0 cm = 0.39 inch, 1.00 m = 3.281 ft.

flowers; 4 = 75% of canopy covered with flowers; and 5 = 100% of canopy in full flower.

Plants were harvested after 25 weeks. After final visual quality measurements were taken (week 24), growth indices were calculated as an average of the measured height and two widths [(height + width 1 + width

2)/3]. Panicle infructescences were removed from shoots prior to severing plants at the crown. Seed capsules were removed from the infructescence (to preserve for future germination studies) and only the inflorescences and shoots were oven dried separately at 70 °C (158.0 °F) for 1 week prior to weighing.

EXPERIMENTAL DESIGN AND STATISTICAL ANALYSIS. A randomized complete-block experimental design was used with each cultivar replicated three times. Each replication (experimental unit) consisted of three plants (samples). The experiments were conducted identically in western (Milton) and southern (Fort Pierce) Florida.

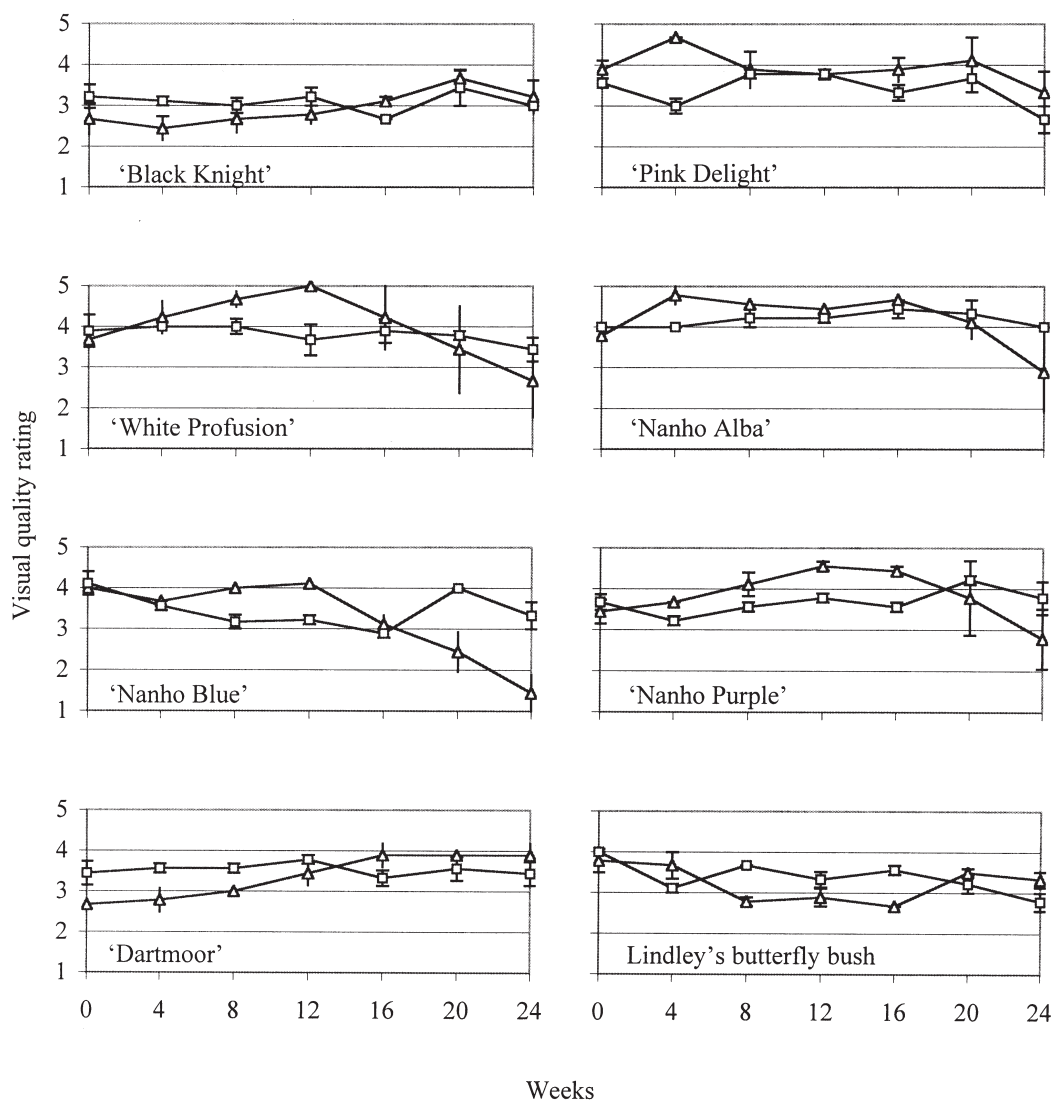


Fig. 1 (continued on next page). Monthly visual quality (foliage color and form) assessment of 14 butterfly bush taxa grown in two locations in Florida (Fort Pierce = —△— and Milton = —□—). Assessment was based on a scale of 1 to 5 where 1= very poor quality; 2= poor quality; 3= fair quality; 4= good quality; and 5= excellent quality. Each value represents the mean of three replications at each site for each month ±SE.

Visual quality data were collected monthly for each replication. At 24 weeks, growth data were collected on each plant sample. Each experiment was subjected to analysis of variance and significant means separated by least significant difference, $\alpha = 0.05$ level.

Results and discussion

VISUAL QUALITY AND FLOWERING.

Assessment of foliage color and plant form varied with time and location (Fig. 1). In the summer season at Fort Pierce, peak performance (good to excellent quality) was observed for 'Pink Delight', 'Nanho Alba', Lindley's butterfly bush, and Japanese butterfly bush after 4 weeks and for 'Sungold' and 'Honeycomb' after 8 weeks. In the fall at Fort Pierce, peak performance

was observed for 'White Profusion', 'Nanho Blue', 'Nanho Purple', and 'Moonlight' after 12 weeks and for 'Black Knight', 'Gloster', 'Violet Eyes', and 'Dartmoor' after 20 weeks. After 12 to 24 weeks in Fort Pierce, performance of 'White Profusion', 'Nanho Blue', 'Nanho Purple', 'Moonlight', and 'Sungold' noticeably declined to levels considered unacceptable for the landscape. Poor performance of these cultivars over time was attributed to fatality rates ranging from 22% to 44%. In Milton, all plants survived throughout the experiment with the exception of 'Pink Delight', where fatality occurred in 11% of the plants. In the summer at Milton after 8 weeks in the field, more than half of the cultivars assessed were of high quality,

with the exception of 'Black Knight', 'Pink Delight', 'Nanho Blue', 'Nanho Purple', 'Dartmoor', and Lindley's butterfly bush, where plant form and color was ranked between fair and good. In the late fall season at Milton, 'Nanho Alba', 'Nanho Blue', 'Nanho Purple', 'Gloster' and 'Honeycomb' all had good to excellent color and form at 20 weeks.

Flower production also varied with time and location (Fig. 2). In Fort Pierce, 75% to 100% of the canopy was covered with flowers at 4 weeks for all cultivars except 'Black Knight', 'Moonlight' and 'Sungold'. Flowering of these cultivars remained low (below 50%) throughout the experiment. Flowering of 'White Profusion', 'Nanho Alba', 'Nanho Blue', 'Nanho

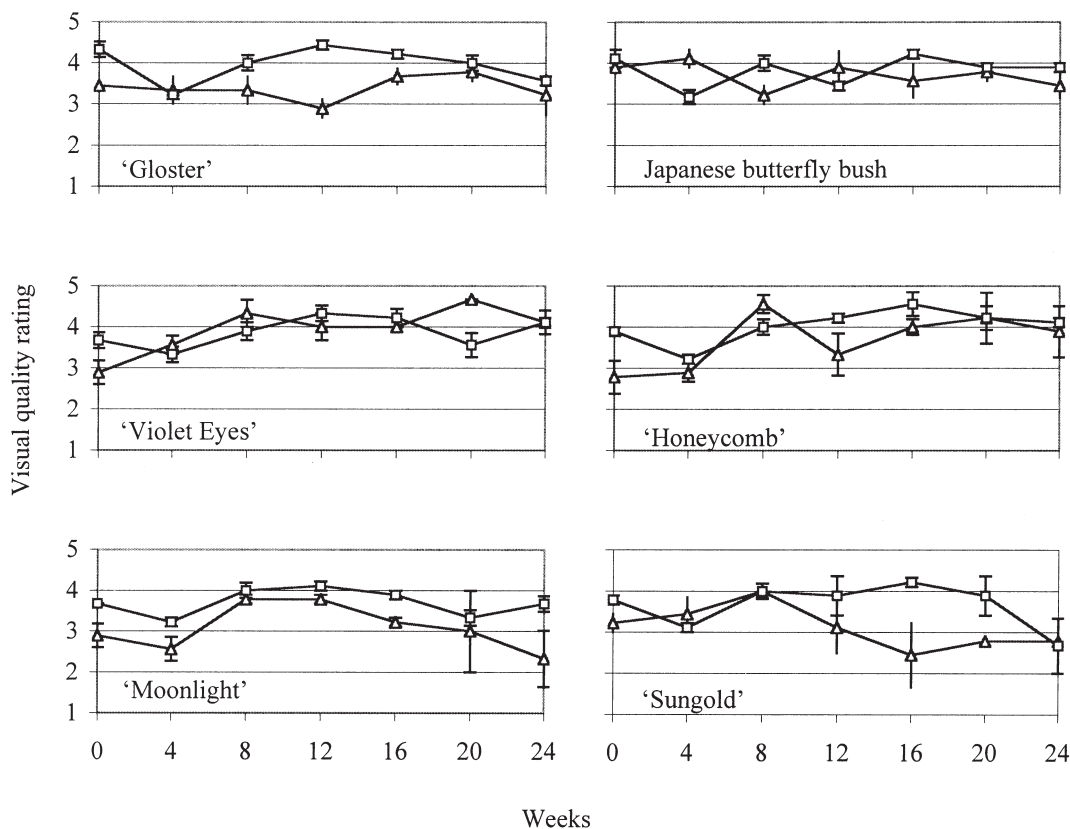


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Purple', and Japanese butterfly bush noticeably declined between 16 and 24 weeks, whereas 'Dartmoor' continued to have 50% to 75% flowering throughout the study. In Milton, consistently high flowering (50% to 100% canopy coverage) was observed for 'Nanho Alba', 'Nanho Purple', 'White Profusion', and 'Dartmoor' throughout the study. At 24 weeks, no new flowering was observed for Lindley's butterfly bush, 'Gloster', or Japanese butterfly bush. The inflorescence architecture of 'Dartmoor' differs from other butterfly bush by having a large, multi-branched inflorescence, which may have contributed to the greater flowering noted throughout the study (canopy coverage >50% from week 10 to 24).

In a 5-year study of 21 butterfly bush selections in Germany (Zone 4–8), half of the selections were rated very good, while pink delight was the only entry rated as excellent (Bundesortenamt, 2003). Similar to our study, 'Black Knight', 'Nanho Purple', and 'Nanho Blue' were among the 10 selections rated in the lower category of good. Flowering between the 21

selections also differed in the German trial with flowering periods reported as early or late with flowering for up to 7 weeks (Bundesortenamt, 2003). Plant decline in Milton and losses in Fort Pierce may be attributed, in part, to the presence of root knot nematode species for which butterfly bush has been shown to serve as a host (Crow and Dunn, 2002; Thetford and Kinlock, 2002;). Root knot nematode damage was visible on roots of dead plants from Fort Pierce and the peanut root-knot nematode (*Meloidogyne arenaria*—race 2) and southern root-knot nematode (*M. incognita*—race 1) were confirmed to be present at the Milton location (data not presented). Previous experience with butterfly bush grown in soils infested with peanut root-knot and southern root-knot nematodes has demonstrated fatality for most *B. davidii* within two growing seasons (M. Thetford, personal observation). Given the early vigor and successful flowering of butterfly bush in this trial followed by plant decline or death in the presence of root knot nematodes, specific selections may have greater market

potential as an annual or a short-lived perennial under these conditions.

PLANT GROWTH. Significant cultivar \times location interactions occurred for each measured trait. In Fort Pierce, 'Violet Eyes', and 'Honeycomb' had similar growth index to 'Sungold' and greater growth index compared to other cultivars (Table 2). In Milton, 'Violet Eyes', 'Honeycomb', 'Moonlight', and 'Sungold' had the greatest growth index compared to other cultivars. This is in agreement with results of Dunwell and Cappiello (2000) where greatest spread and height data were observed for 'Sungold' and 'Golden Glow' 7 months after planting, suggesting that these interspecific hybrids are relatively fast growing. In Fort Pierce, Lindley's butterfly bush had the lowest growth index, where plants were smaller than the compact nanho cultivars. In Milton, Lindley's butterfly bush was also compact, but similar in growth to 'Black Knight', 'Nanho Alba', 'Nanho Purple', and 'Dartmoor'. In Fort Pierce and Milton, 'Honeycomb', 'Moonlight', 'Sungold', and 'Violet Eyes' generally had

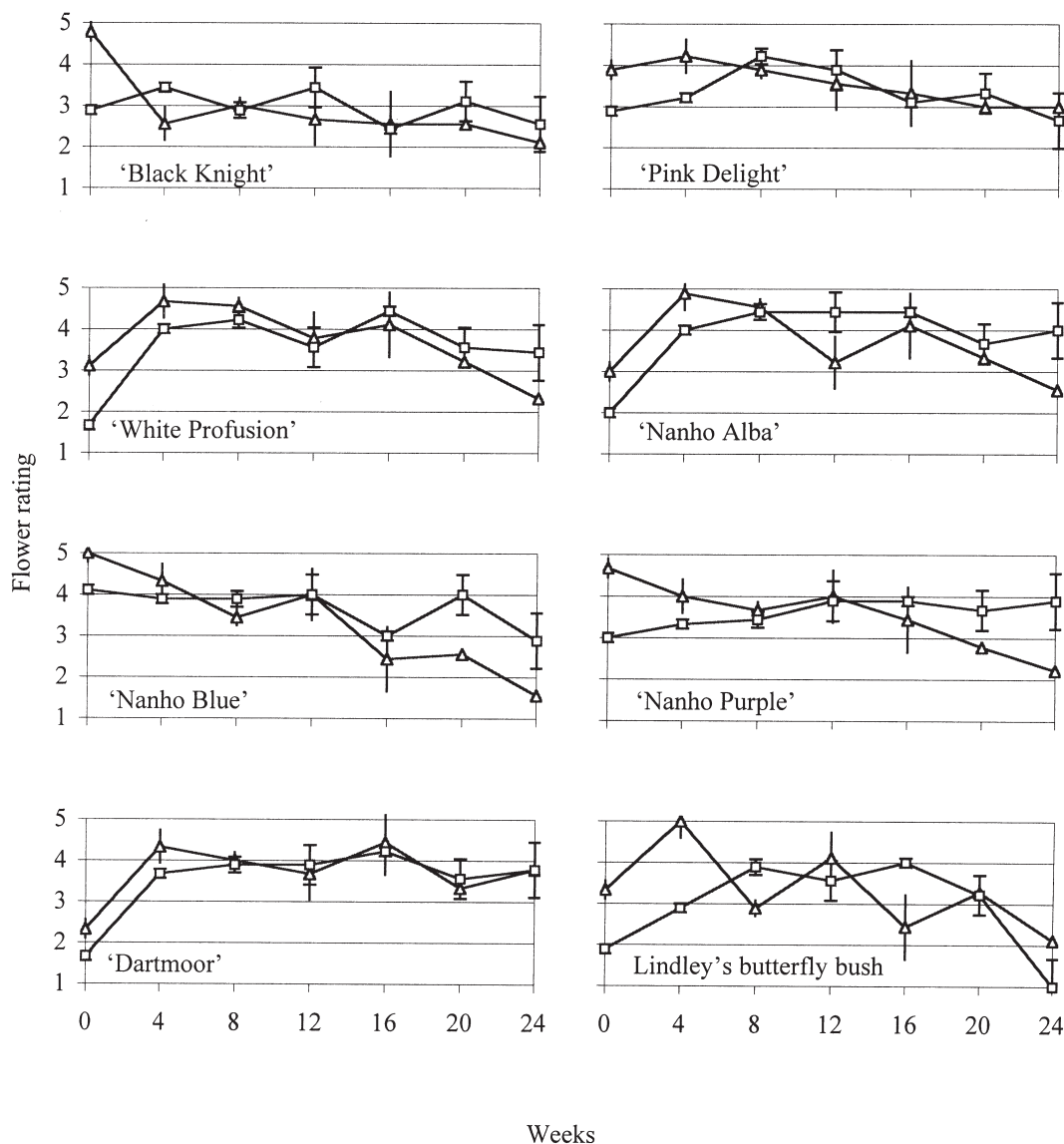


Fig. 2 (continued on next page). Monthly flowering assessment of 14 butterfly bush taxa grown in two locations in Florida (Fort Pierce = —△— and Milton= —□—). Assessment was based percent flowering coverage of plant canopy on a scale of 1 to 5 where 1= 0%; 2= 25%; 3= 50%; 4= 75%; and 5= 100%. Each value represents the mean of three replications at each site for each month ±SE.

significantly higher shoot dry weights than the other cultivars (Table 2). On a dry weight basis, flowering in Fort Pierce was greatest for 'White Profusion', 'Nanho Alba', and 'Dartmoor' as compared to all other cultivars with the exception of 'Nanho Purple' (Table 2). In Milton, flower dry weights were greatest for 'Dartmoor' as compared to the other cultivars with the exception of 'White Profusion', 'Nanho Alba', 'Gloster', 'Honeycomb', and Japanese butterfly bush. In a study by Dunwell and Cappiello (2001) reporting the first date of flower for the second growing season of 40 butterfly bush taxa, most selections initiated flowering between the end of June and the

beginning of August when grown in Kentucky. While no information was provided on the season-long flowering, the 30- to 40-d spread in first flower initiation among these 40 plants was similar to the approximately 1-month difference in the initiation of first flowers noted among selections in our trials. Additionally, vigorous vegetative growth of the interspecific hybrids and the differing flowering times of the parents of the *B. × weyeriana* hybrids may have contributed to the reduced flowering of these cultivars (Fig. 2), as compared to other cultivars. Based on the classification by Cotton (1947), *B. globosa* is an early flowering species that flowers on old wood, while *B.*

dauidii is a summer flowering species that flowers on growth of the current season (Moore, 1961).

The results from these studies suggest that landscape performance of butterfly bush differ greatly among cultivars and locations in Florida. In Fort Pierce, 'Black Knight', 'Pink Delight', 'Dartmoor', Lindley's butterfly bush, 'Gloster', 'Violet Eyes', and Japanese butterfly bush all had 100% survivability, yet visually, only 'Dartmoor' and 'Violet Eyes' ranked high among performers when considering foliage color, plant form, and flowering. In Milton, 'White Profusion', 'Nanho Alba', 'Nanho Purple', and 'Dartmoor' had exceptionally long flowering

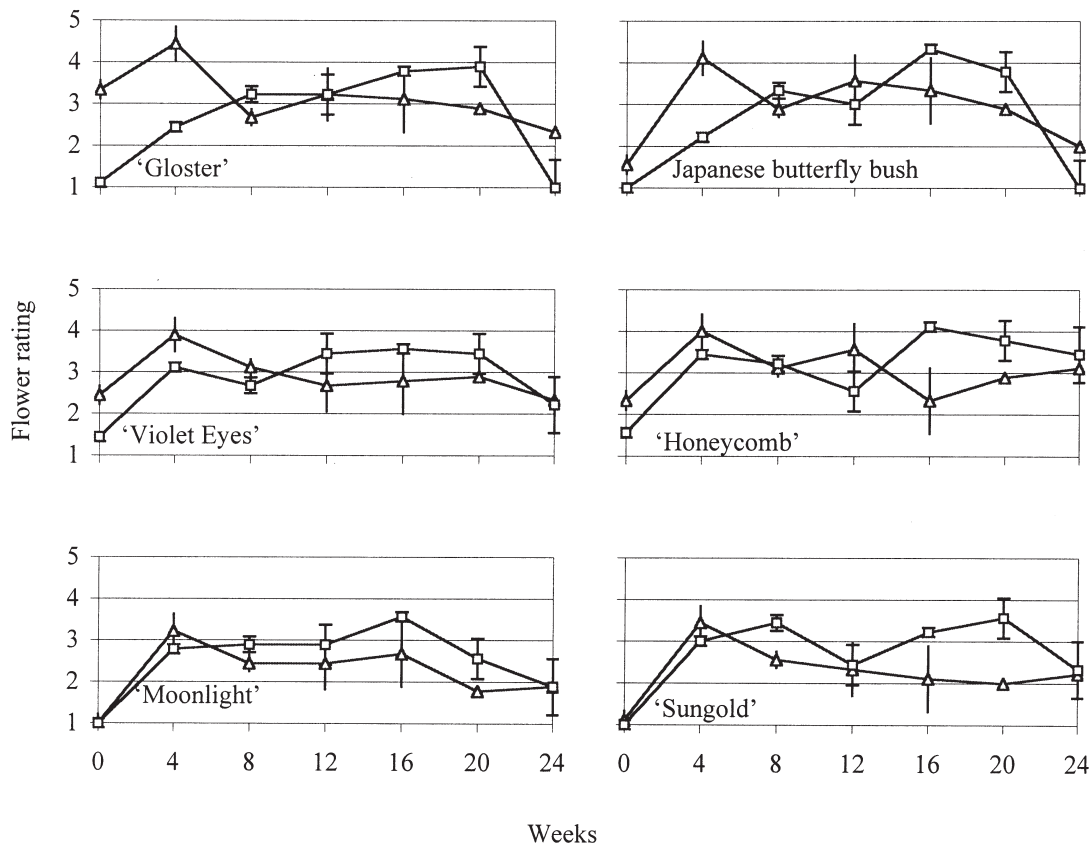


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Table 2. Growth index, shoot dry weight, and flower dry weight of 14 butterfly bush taxa planted in Fort Pierce (southern Florida) and Milton (western Florida) for 25 weeks.

Taxa	Growth index (cm) ^z		Shoot dry wt (g) ^y		Flower dry wt (g)	
	Fort Pierce	Milton	Fort Pierce	Milton	Fort Pierce	Milton
Black Knight	95.9	117.5	171.9	281.9	47.1	91.3
Pink Delight	94.5	91.0	199.9	291.6	73.9	109.4
White Profusion	118.2	138.1	382.6	769.2	136.3	252.9
Nanho Alba	120.1	144.1	461.1	943.0	160.7	207.8
Nanho Blue	95.9	110.2	217.2	405.4	44.5	100.4
Nanho Purple	109.3	126.6	314.0	580.7	117.8	167.4
Dartmoor	103.5	130.4	198.0	602.0	150.5	302.1
Lindley's						
butterfly bush	79.6	112.0	159.6	431.4	32.8	102.9
Gloster	112.5	163.0	259.2	1463.9	81.6	274.8
Japanese						
butterfly bush	103.6	146.6	220.9	1121.1	21.3	257.0
Violet Eyes	144.3	197.1	577.9	2811.4	95.3	181.1
Honeycomb	143.9	197.0	720.4	2882.4	98.0	220.6
Moonlight	124.5	193.4	692.8	2745.5	51.5	190.3
Sungold	133.4	188.0	614.9	2346.7	51.2	203.0
LSD (0.05) ^x	12.1	21.6	123.8	708.0	37.3	97.8

^z1.0 cm = 0.39 inch.

^y1.0 g = 0.035 oz.

^xMeans separated by least significant difference test at 0.05.

periods with good foliage color and form. This information may provide useful criteria when selecting cultivars for similar growing conditions or for selecting optimal traits for breeding programs. However, because butterfly bush is known as a prolific seed producer, invasive qualities should be addressed prior to landscape recommendations.

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