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Landscape Performance of Native and Non-native Ornamentals Grown Under Two Different Irrigation Regimes in North and Northcentral Florida

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Summary

Pollinator gardening has gained momentum in recent years with an increased consumer interest in selecting native over non-native plant species to reduce water dependence and maximize biodiversity value in both public greenspaces and domestic gardens. A two-year study was conducted to determine the main effects of plant provenance (native or non-native) and moisture availability (full or partial irrigation) on landscape performance and flowering of twenty ornamental species planted in two geographic locations (north or northcentral Florida). Represented genera of paired native and non-native species included *Bidens*, *Conradina*, *Coreopsis*, *Gaillardia*, *Hibiscus*, *Ilex*, *Monarda*, *Salvia*, *Scutellaria*, and

Viburnum. A positive response of plant size was observed for native provenance and full irrigation treatments. Floral abundance of native species was also greater than non-native species at both planting locations. Across both irrigation regimes and locations, both native and non-native plants attracted a diverse population of pollinator groups. Notably there was a positive association where 2.3 times more native bees were collected from native species compared to non-native species.

INTRODUCTION

Much attention over the last decade has been directed towards ecologically friendly landscaping where plants not only require less water but bring aesthetic value and biodiversity to our gardens. Among these efforts bee-friendly gardening awareness is paramount to help mitigate the discernible global issue of bee decline. The informed selection of native and non-native plants also plays a major role in creating attractive landscapes that provide floral resources for diverse pollinators (Anderson et al., 2022; Kalaman et al., 2020). Native plants, defined as species existing in the U.S. prior to European contact, are particularly known for their resiliency in gardens, as they are locally adapted to the climate, soil conditions, and natural pests of a given region (Matrazzo and Bissett, 2020). However, the effects of plant provenance and drought tolerance of ornamental plants on pollinator preference remains unclear. For example, Salisbury et al. (2015) reported increased pollinator preference for native over non-native plants, yet Martins et al. (2017) observed no such effect. Likewise, Kalaman et al. (2020) found pollinator visitation to vary by species and planting sites while Descamps et al. (2021) showed that environmental conditions were the primary factor affecting the attractiveness, vegetative and floral traits, and resource value of plants. Thus, the overall goal of this paper was to ascertain landscape performance of a broad range of species as influenced by plant provenance, geographic planting location, and moisture availability. Specific objectives were to: 1) determine the effects of native and non-native provenance on plant growth and flowering in common garden plots, 2) determine the effects of full or reduced irrigation on these same traits, and 3) to characterize overall bee community composition visiting native and non-native plants.

MATERIALS AND METHODS

Twenty ornamental plant species were selected for use in this study based on the following criteria: 1) commercially available in nurseries and appropriate for ornamental use in landscapes, 2) able to flower prolifically and attract pollinators (and bees in particular), and 3) capable of surviving a two-year landscape trial in Florida. Resultant plants represented ten congeneric pairs of Florida native and non-native species, to analyze the effect of provenance on bee attractiveness while controlling for large variation in leaf and floral morphologies, flower colors, growth habits, and blooming periods - a key and novel component of our study design (**Table 1, Fig. 1**). Plants were sourced from as few nurseries as possible and obtained in finished one-gallon pots prior to planting.

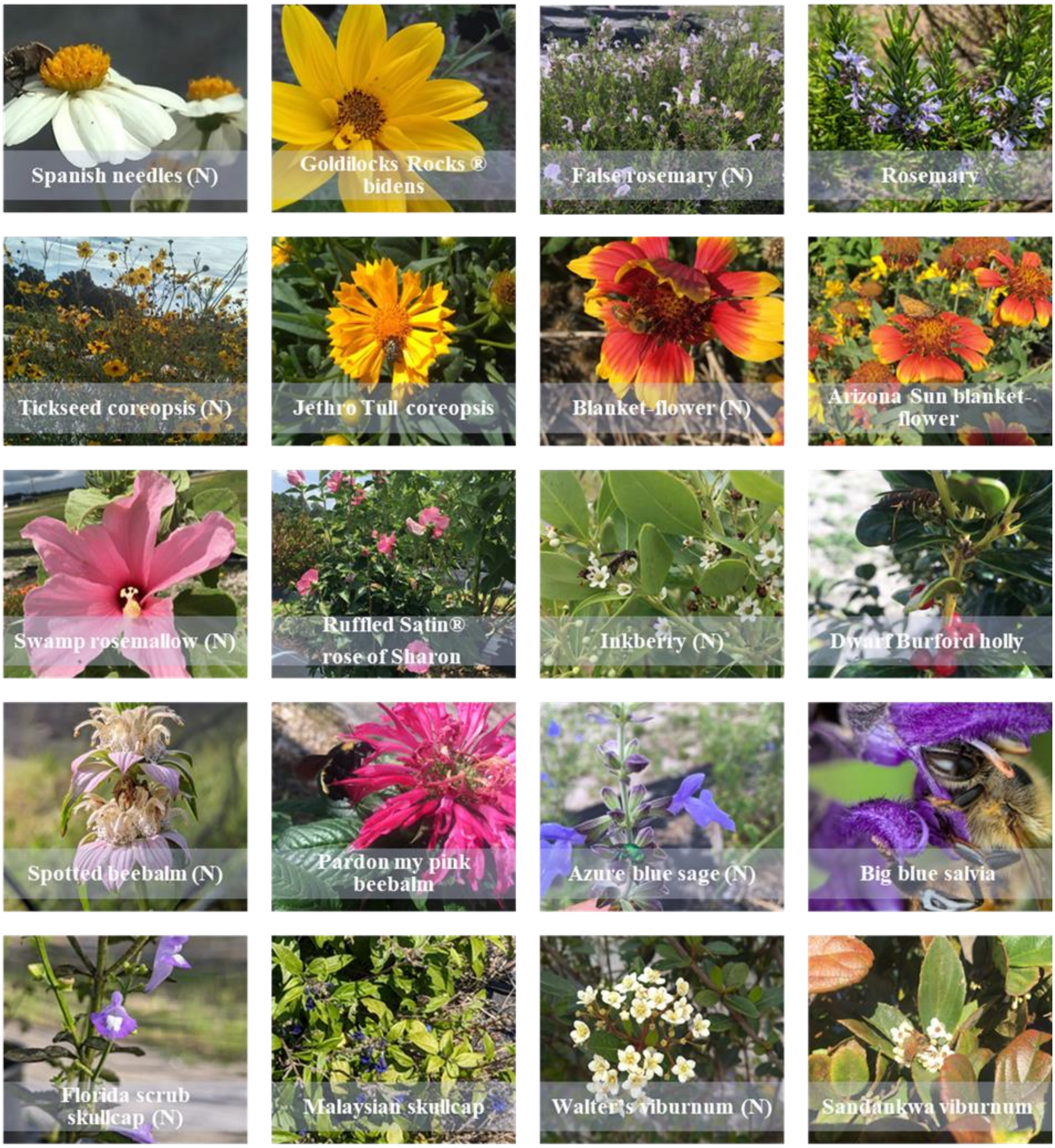
Table 1. Natural range and cultivar origin of twenty ornamental species (paired by native and non-native genera) that were evaluated for landscape performance under partial and full irrigation regimes in north and northcentral Florida.

Species	Common name	Native range and cultivar origin
Bidens alba	Spanish needles	Native to Florida and the southern U.S., South America and the West Indies. Naturally found in disturbed sites.
Bidens ferulifolia 'BID 16101'	Goldilocks Rocks® bidens	Native range of parent species is from Arizona and New Mexico to northern Mexico. This cultivar originated from a cross-pollination made by the inventor in Bozen, Italy. USPP 32,646.
Coreopsis leavenworthii	Tickseed coreopsis	Endemic throughout Florida and two counties in Alabama. Naturally found in wet flatwoods and disturbed sites.
Coreopsis× 'Jethro Tull'	Jethro Tull coreopsis	Native range of the female parent species, *C. auriculata* extends from Virginia, Kentucky to Georgia and Louisiana. Native range of male parent species, *C. lanceolata,* includes Florida and most of the U.S. This cultivar originated from crossing *C. auriculata* 'Samfir' and *C. lanceolata* 'Early Sunrise'. USPP 18,789.
Gaillardia pulchella	Blanket flower	Native to northern Mexico, and the southern and central U.S. No longer believed to be native to Florida. Naturally found in dry open spaces with sandy soils.
Gaillardia × *grandiflora* 'Arizona Sun'	Arizona sun blanket flower	Parent species of this hybrid are *G. aristata* (Native from North Dakota to Colorado west to California and British Columbia) and *G. pulchella*. This cultivar was released in 2005 from Benary Co., The Netherlands.
Hibiscus grandiflorus	Swamp rosemallow	Native to swamps and marshes of the southeast U.S. including Florida, Alabama, Georgia, and Mississippi.
Hibiscus syriacus 'SHIMCR1'	Ruffled Satin® rose of Sharon	Native range of the parent species is Asia. This cultivar is a product of a planned breeding program, originating among the progeny of a cross pollination between *H. syriacus* 'Kwangmyung' and *H. syriacus* 'Samchulli'. USPP 26,222.
Ilex glabra	Inkberry; Gallberry	Native to the Eastern coastal plain from Nova Scotia to Florida and West to Louisiana. Naturally found in peripheries of swamps and bogs.
Ilex cornuta 'Dwarf Burford'	Dwarf Burford holly	Native range of the parent species is China and Korea. The cultivar was discovered in 1947 among vegetatively propagated Burford hollies.

Monarda punctata	Spotted beebalm	Native to Florida and the Eastern U.S. where it naturally occurs in flatwoods, dry disturbed sites and sandy sites.
Monarda didyma 'Pardon My Pink'	Pardon my pink beebalm	This species is native to bottomlands, thickets and moist woods from Maine to Minnesota south to Missouri and Georgia. The cultivar was hybridized using *M. didyma* 'ACrade' and *M. didyma* 'AChall'. USPP 24,244.
Salvia azurea	Azure blue sage	Native to flatwoods, hammocks sandhills and prairies of Florida and the central and eastern U.S.
S. longispicata × *S. farinacea* 'PAS1246577'	Big blue salvia	This interspecific cross of Indigo Spires was part of a planned breeding program by PanAmerican Seed. US PVP201700218.
Salvia rosmarinus	Rosemary	Native to dry, rocky area along the Mediterranean, Portugal, and northwest Spain, northern Africa, western Asia, southern Europe.
Conradina grandiflora	False rosemary	Endemic to Florida occurring on the central and southern Atlantic coastal ridge. Naturally found in scrub areas.
Scutellaria arenicola	Florida scrub skullcap	Nearly endemic to well-drained sandhills and scrub of Florida.
Scutellaria javanica	Malaysian skullcap	Native to wet tropical biome of Hainan, Jawa, Maluku, New Guinea, Philippines, Sulawesi, Sumatera, and Vietnam.
Viburnum obovatum	Walter's viburnum	Native to floodplain forests of Florida, Alabama, Georgia, and South Carolina.
Viburnum suspensum	Sandankwa viburnum	Native to subtropical Ryukyu Islands of southwestern Japan.

Field plots were prepared similarly in two locations. The first site was located at the UF North Florida Research and Education Center (NFREC) in north Florida (Quincy, FL, USDA cold hardiness zone 8b) and the second site was located at the UF Plant Science Research and Education Unit (PSREU) in northcentral Florida (Citra, FL, USDA cold hardiness zone 9a) and Two months prior to early spring installation, slightly raised beds were disked and treated with an herbicide prior to covering with a commercial-grade black landscape fabric. Each of 40 plots at each site measured 3 m in length and 0.9 m in width, with 1 m of spacing between each row. To create full floral coverage, a minimum of two (mostly herbaceous) and a maximum of three (mostly woody) plants of each species were assigned to each plot, determined by their predicted size at full maturity. Once established (after 4 weeks), half of the plots were drip-irrigated for 2h per day, while the other half were irrigated at 10% volumetric soil moisture using a SMRT-Y- Soil Moisture Sensor Kit (Rainbird Inc., Tucson, AZ). Plants were top-dressed with a 20N–4P–7K slow-release fertilizer (Osmocote Pro, 8–9-months) upon planting and between years.

Figure 1. Floral representation of ten native (N) and ten non-native ornamental plants selected for this study.



Standard soil analysis using a Mehlich-3 extraction method revealed macro and micronutrients at both locations were within normal limits with a 6.7 and 7.0 soil pH in north and northcentral FL, respectively (UF Extension Soil Testing Laboratory, Gainesville, FL). As reported by an automated weather network system

(https://fawn.ifas.ufl.edu), field conditions in north FL were as follows: avg. monthly rainfall 0.42 cm, mean minimum and maximum temperatures 13.56 and 26.30 °C, respectively, and 78.76 % relative humidity. In northcentral FL field conditions were as follows: avg. monthly rainfall 0.35 cm, mean minimum and maximum temperatures 15.55 and 28.27 °C, respectively, and 81.5% relative humidity.

Each month, plant height and perpendicular widths were measured for each plant at both locations to generate a maximum growth index ([height + (avg. width1 + width2)]/2 for the first year of the study. Also, a floral survey was conducted monthly for the entirety of the two-year study where the total number of flowers were counted for each plot across all treatments. Capitulate inflorescences (*Bidens*, *Coreopsis* and *Gaillardia*) were notated as a single flower (**Fig. 1**). To characterize the insect community composition (bees in particular) among species from native and non-native provenances, active sampling techniques were deployed within plots where each observer (consisting of 2- 4 people) walked down each row collecting foraging insects for a period of one to three minutes per plot. Specimens were placed in vials and stored in the freezer for subsequent identification.

To evaluate the main effects of provenance and irrigation on growth and flowering, this study utilized eight rows (blocks) per planting location, with four rows receiving partial irrigation and four rows receiving full irrigation. Twenty plots containing congeneric native and non-native species were assigned to each block using a completely randomized design. Generalized linear models (GLM) were used with plant 'provenance' (native versus non-native) and 'irrigation' treatment (full versus partial) as fixed effects and 'plot' as the random effect. Data were subjected to an analysis of variance (ANOVA) using statistical software RStudio (Version 2023.06.2+561, Boston, MA) with significance determined at P=0.05.

RESULTS

The maximum growth indices measured for each species are presented in **Table 2**. A significant effect of irrigation (P=0.0124), provenance (P<0.0001), and planting location (P<0.0001) was observed with a non-significant 3-way interaction (P=0.9566). In north FL, six of the 20 species (Spanish needles, Arizona sun blanket-flower, spotted beebalm, pardon my pink beebalm, Walter's viburnum, and sandankwa viburnum) grew larger under full irrigation than partial irrigation regimes. In northcentral FL, Spanish needles, Arizona sun blanket-flower and spotted beebalm also grew larger under full than partial irrigation, as well as Jethro Tull coreopsis. Collectively, native and non-native plants grown in north FL had 1.2 times greater plant size than plants grown in northcentral FL. Across both irrigation treatments and planting locations, native plants were 1.4 times larger than non-natives plants.

Table 2. Maximum growth index (cm) [plant height (cm)+ average of two perpendicular widths (cm)/2] for each of twenty ornamental species, grown under two irrigation treatments (partial and full) at each location (north and northcentral Florida) during the first year of the study. For each planting location, means are presented ±SD with different letters indicating significant responses among full and partial irrigation treatments (*P*=0.05). Native species are indicated with a (N).

	North Florida growth index		Northcentral Florida growth index	
Species	Full (cm)	Partial (cm)	Full (cm)	Partial (cm)
Spanish needles-N	204.0 ± 12.8a	181.6 ± 14.8b	151.3 ± 7.0a	136.1 ± 13.5b
Goldilocks Rocks® bidens	83.7 ± 6.2a	76.6 ± 5.4a	44.8 ± 7.9 a	47.7 ± 7.8a
False Rosemary-N	61.5 ± 12.5a	68.2 ± 25.6a	85.6 ± 4.2a	79.2 ± 5.9a
Rosemary	78.4 ± 8.6a	84.4 ± 4.8a	64.2 ± 8.6a	63.3 ± 5.1a
Tickseed coreopsis-N	162.2 ± 47.4a	178.1 ± 16.9a	144.1 ± 15.6a	143.7 ± 16.6a
Jethro Tull coreopsis	95.5 ± 3.8a	86.5 ± 13.7a	83.1 ± 6.0a	69.7 ± 7.1b
Blanket-flower-N	193.7 ± 14.5a	173.3 ± 14.2a	150.7 ± 3.3a	154.3 ± 16.9a
Arizona sun blanket-flower	98.8 ± 7.3a	85.7 ± 7.5b	72.8 ± 13.4 a	65.4 ± 5.4b
Swamp rosemallow-N	184.8 ± 25.7a	186.3 ± 9.7a	143.6 ±12.7a	150.8 ± 12.8a
Ruffled Satin® rose of Sharon	68.6 ± 7.3a	60.3 ± 8.3a	39.6 ± 4.1a	39.9 ± 5.6a
Inkberry; Gallberry-N	106.4 ± 3.3a	105.2 ± 27.1a	90.0 ± 20.51a	78.9 ± 5.4b
Dwarf Burford holly	161.8 ± 5.7a	164.8 ± 43.1a	116.5 ± 12.7a	102.2 ± 12.3b
Spotted beebalm-N	224.5 ± 59.4a	161.5 ± 17.8b	199.7 ± 49.3a	180.0 ± 49.1b
Pardon my pink beebalm	64.9 ± 4.5a	57.2 ± 1.1b	54.3 ± 9.7a	45.9 ± 4.9a
Azure blue sage-N	159.1 ± 15.3a	167.3 ± 11.1a	144.8 ± 8.9a	143.1 ± 11.3a
Big blue salvia	162.6 ± 27.4a	150.4 ± 9.2a	142.7 ± 34.4a	131.18 ± 17.5a
Florida scrub skullcap-N	112.6 ± 14.2a	114.3 ± 6.8a	89.4 ± 6.0a	80.4 ± 15.0a
Malaysian skullcap	77.9 ± 5.8a	75.8 ± 5.5a	59.9 ± 7.1a	54.0 ± 6.1 a
Walter's viburnum-N	145.6 ± 10.0a	165.9 ± 61.8b	107.3 ± 9.4a	116.6 ± 11.8a
Sandankwa viburnum	114.3 ± 6.2a	102.9 ± 7.1b	91.6 ± 7.8a	87.3 ± 7.9a

The number of flowers counted for each species plot for the entirety of the two-year study are presented in **Figure 2**. Similar to growth responses, a significant effect of provenance ($P<0.0001$) was observed for floral abundance. However, the effects of irrigation ($P=0.2844$), planting location ($P=0.1528$), and their interaction ($P=0.6206$) were non-significant. An impressive 974,143 and 34,517 floral counts were recorded among species grown in north and northcentral FL, respectively (**Fig. 2**). In north FL, regardless of irrigation treatment, six of the ten native species (Bidens, Coreopsis, Gaillardia, Ilex, Monarda, and Rosemary) had greater floral abundance than their respective non-native congener. This same species response was observed in northcentral FL, but additionally, the native Walter's viburnum produced more flowers than the non-native Sandankwa viburnum. Interestingly, at both locations, the non-native big blue salvia was the only species to have greater floral abundance than its native congener, azure blue sage. Also, at both locations, flowering responses to provenance were not observed for *Scutellaria* and *Hibiscus*.

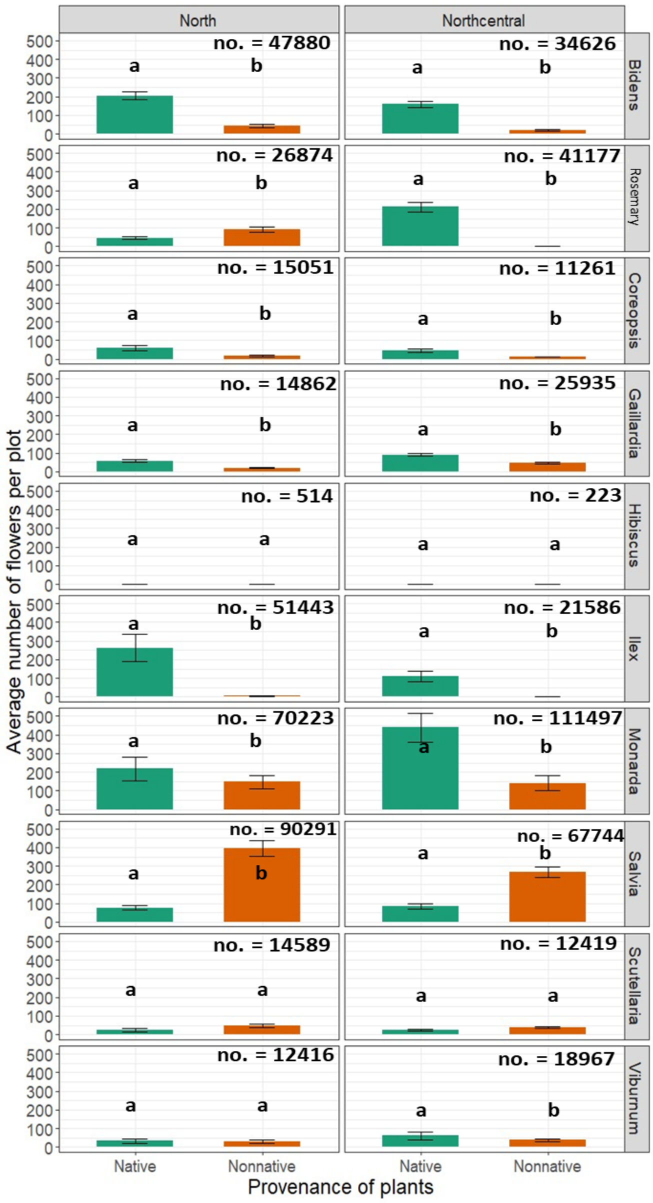


Figure 2. Average number of flowers counted for native (green bars) and non-native (orange bars) species of each genus grown in north and northcentral Florida (across combined nonsignificant irrigation regimes). Flowers were counted in each plot each month during a two-year period. Error bars denote standard deviation of the mean (n=20). Within each graph, different letters indicate response is significant at $P=0.05$. The total number of flowers per congener was included at the top of each graph as a reference to floral abundance.

We collected 937 insects visiting flowers comprising of 599 specimens visiting the native species and 338 specimens visiting the non-native plants (**Fig. 3**). Of the total insects sampled from native plants: 45.4%, 17.7%, 13.4% and 4.5% were, respectively, wild native bees, wasps, honeybees, and bumblebees. Of the total insects sampled from non-native species: 35.2%, 23.4%, 16.9% and 5.5% were, respectively, wild native bees, honeybees, bumblebees, and wasps.

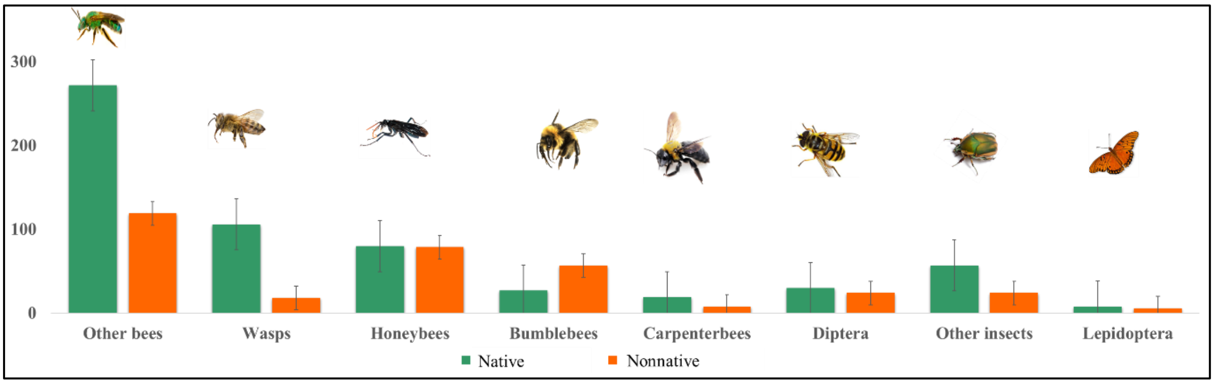


Figure 3. Number of different groups of pollinators actively collected from flowers on ten native (green bars) and ten non-native (orange bars) ornamental species across both irrigation treatments and locations.

DISCUSSION

Unique to this study, pollinator friendly, native and non-native ornamental species were used to assess the effects of moisture availability on plant growth and flowering. Of the twenty species evaluated, a positive growth response to full rather than partial irrigation was observed for less than a third of all native and non-native plants. This nominal effect of provenance on plant growth is consistent with results from Schober et al. (2010) who found irrigation frequency positively affected plant size of only 20% of the woody plants evaluated.

In addition to plant growth in the present study, floral abundance was also measured for native and non-native species. While flowering response to irrigation was non-significant, a 1.8-fold increase in floral abundance was observed for native plants compared to non-native plants. This is consistent with a 2.0-fold increase reported in an earlier study (Kalaman et al., 2020). Likewise, the type of pollinators attracted to flowers was also influenced by provenance, where native plants attracted 2.3 times more native bees than non-native plants. In their review of global pollinator decline, Potts et al. (2010) point out that non-native plants may be primarily attractive to generalist and non-native bee species. In the current study, the number of honeybees (generalists) collected were similar for native and non-native plants. Yet, more bumblebees (also generalists) were sampled from non-native rather than to native species.

CONCLUSIONS

Results presented herein show that provenance has more of an effect on plant performance than irrigation for the species evaluated in this study. Selecting plants that are both attractive, tolerant of varying environmental conditions, and rich in floral resources may be a priority for effective pollinator gardening. Further work is underway to determine the responses of pollinators to changes in floral resources (nectar and pollen), floral traits, visual signals, and volatile organic compounds (VOCs).

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