Gardening for Wildlife: Are Native Plant Cultivars as Effective as Native Plants Propagated from Local, Wild Populations for Promoting Native Insect Diversity?©

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Many gardeners concerned over recent declines in biodiversity in suburban areas are attempting to improve the ecological functioning of their landscapes by incorporating native plants. Native plants are important food sources for native herbivorous insects, and insects are in turn important food sources for animals in higher trophic levels. But do the native plants available in nurseries, typically cultivated varieties (cultivars) of a single genotype, fill an equivalent ecological role as the local, wild-type plants? For two herbaceous perennials, we observed significant differences in both total insect abundance and total number of insect species. However, there was a significant interaction between plant species and plant origin, suggesting that insect abundance and diversity does not depend on the source of the plant material per se, but rather on the particular characteristics of the cultivar that distinguish it from the wild form. We also observed significant differences in the insect communities among treatments, though only a small proportion of the total insect species collected contributed to these differences. Identifying which characteristics of cultivars might predict a loss of ecological function will not only help gardeners make the best choices of plants for their landscapes, but also will enable horticulturalists to select cultivars that potentially outperform the wild-type plants in terms of the ecological services they provide.

INTRODUCTION

Recent research suggests that the exotic species planted ornamentally in our suburban landscapes are inferior to natives in providing food for native herbivorous insects (Tallamy, 2004; Tallamy and Shropshire, 2009; Burghardt et al., 2010). Because herbivorous insects are important food sources for organisms in higher trophic levels, there is concern that a decline in abundance or diversity of insects in suburban areas could cause a concomitant decline in animals such as birds. This concern has spurred an interest in "gardening for wildlife" by replacing exotics with native ornamental plants in suburban landscapes. But are the native plants available in nurseries, typically cultivated varieties (cultivars) of a single genotype, equally effective as the local, wild-type plants in providing food for native herbivorous insects?

There are at least two reasons supported by research that suggest cultivars may differ from wild plants in their ability to support native insects. First, cultivars are usually asexually-propagated, and therefore contain less genetic diversity than wild-propagated plants for a given species. Because insect diversity is correlated with the genetic diversity of the host plants (Wimp et al., 2004; Johnson et al., 2006), several clones of a single genotype of a plant might support fewer insect species than multiple genotypes. Second, plant leaf chemistry determines which insect species are able to feed on a particular plant (Ehrlich and Raven, 1964), and some cultivars are selected for traits that alter leaf chemistry. For example, some plants are selected to have purple-colored leaves. The purple color is a result of increased concentrations of anthocyanins, a type of flavonoid known to function as a feeding deterrent in leaves (Harborne and Williams, 2000; Simmonds, 2003). In theory, this sort of change in leaf chemistry could affect the insects that normally feed on the plant, reducing the abundance or number of species of insects supported.

This research investigated whether these theoretical consequences of selecting cultivars actually affect herbivorous insects in a garden setting. We chose several native herbaceous perennials that occur locally in natural areas near the study site and have

cultivars available commercially. We determined whether the cultivars differed from plants grown from wild-collected seed in their ability to serve as a food source for native hemipterans (the true bugs), the dominant group of insects that feed on herbaceous plants.

MATERIALS AND METHODS

The experiment was set up following a fully-randomized two-way ANOVA design at the Mimsie Lanier Center for Native Plant Studies at the State Botanical Garden of Georgia in Athens, Georgia. The first factor was Plant Species and included five levels: *Amsonia tabernaemontana*, *Coreopsis grandiflora*, *Monarda fistulosa*, *Oenothera fruticosa*, and *Schizachyrium scoparium*. The second factor was plant origin and included two levels: cultivar and wild-type. There were five replicates for each treatment, giving a total of 50 experimental units. Each experimental unit was a 2×2 m plot containing 16 plants evenly spaced, and plots were placed 1.5 m apart. All wild-type plants were grown from seed collected from wild populations occurring within a five-mile radius of the study site. All cultivars were purchased as liners from North Creek Nurseries in Landenberg, Pennsylvania. The cultivars were *Amsonia* 'Blue Ice,' *Coreopsis* 'Tequila Sunrise,' *Monarda fistulosa* 'Claire Grace,' *Oenothera* 'Cold Crick,' and *Schizachyrium scoparium* 'Prairie Blues.' Wild-type plants and cultivars were planted in April 2013.

We collected preliminary data from a subset of the plant species on 25 Aug. 2013. Insects were vacuumed from plots in the *Coreopsis*-Wild (CW), *Coreopsis*-Cultivar (CC), *Oenothera*-Wild (OW), and *Oenothera*-Cultivar (OC) treatments with a modified leaf vacuum. The order in which the plots were sampled was randomized to reduce any systematic bias caused by insects that escaped the vacuum and moved to other plots. Sampling began at 11 A.M. and ended at 2 P.M. to coincide with peak xylem flow. The insects were killed with ethyl acetate, sorted by species, and counted. Representative specimens of each species were pinned for subsequent identification.

We analyzed the count data in three ways. First, we determined the total abundance of adult hemipterans collected from each plot. Second, we determined the total number of species (i.e. species richness) of adult hemipterans collected from each plot. We analyzed both total abundance and species richness with a two-way ANOVA using function aov in R (R Core Team, 2013). Third, we determined the relative abundance of each insect species collected from each plot. These relative abundance counts were used to determine whether the insect community differed among treatments. The distinction between the insect community and species richness is that two treatments could have the same richness but with different insect species, hence the insect community would be different. The relative abundances were used to calculate a dissimilarity metric called "percent dissimilarity" or "Bray-Curtis dissimilarity" between all possible pairs of plots (Legendre and Legendre, 2012). This metric can be interpreted as the percentage of individuals *not* shared between two plots; i.e. a value of 0 indicates exactly the same community whereas a value of 1 indicates no species in common. The percent dissimilarity matrix was used to create an ordination plot using principal coordinates analysis with function capscale and to test for treatment effects using permutational multivariate analysis of variance (PERMANOVA) with function adonis (Oksanen et al., 2013). Principal coordinates analysis is an ordination technique that is a more generalized form of principal components analysis. It is used to visualize high-dimensional data in a 2-dimensional space. PERMANOVA tests for treatment effects by random permutation of the rows of the dissimilarity matrix, which are exchangeable under true null hypotheses. After each permutation, the F statistic is recalculated. After several thousand iterations, a pseudo-F distribution is generated that can be used to calculate an approximate p-value for the observed F statistic (Anderson, 2001).

RESULTS

The results of a two-way ANOVA indicated a significant interaction between Plant Species and Origin for both total abundance and species richness ($F_{1,16}$=31.871, p<.001 and $F_{1,16}$=16.401, p<.001, respectively). The typical follow-up procedure after finding a

significant interaction is to break up the analysis into several one-way ANOVAs at each level of the other factor. However, our main interest was the comparison of wild-type plants with cultivars, so we chose to follow up with only a one-way ANOVA of Plant Origin at each level of Plant Species (i.e., we omitted the analysis of Plant Species at each level of Plant Origin). For total abundance, there was significantly higher insect abundance on wild-type *Coreopsis* vs. the cultivar ($F_{1,8}$=22.16, p=.0015), but there was significantly higher abundance on the *Oenothera* cultivar vs. the wild-type ($F_{1,8}$=11.48, p=.0095). For species richness, there were significantly more insect species on wild-type *Coreopsis* vs. the cultivar ($F_{1,8}$=15.36, p=.0044), but there was no significant difference in the number of insect species for wild-type *Oenothera* vs. the cultivar ($F_{1,8}$=2.53, p=.1501). A total of 68 insect species were collected across all plots.

The mean abundance for each treatment is shown (Fig. 1), as is the species richness for each treatment (Fig. 2). A species accumulation curve is used in lieu of a bar plot because it depicts more information. For example, when Replicates=1, the line is the mean species richness of each treatment and the error bars are ± 1 standard deviation (SD). Beyond Replicates=1, the line is the total number of insect species found in a random subsample of *i* plots (where *i* = 2, 3, 4, or 5). The error bars then represent the SD after repeating the subsampling many times. At Replicates=5, all the plots are sampled, so the line is the total number of insect species on all the plots within a treatment, and the SD is zero because there is only one possible combination of 5 replicates. The shape of the curve is useful for determining whether most of the insect species have been found or whether it is likely more will be found after further sampling. For example, after sampling 5 plots, the number of insect species found begins to level off for the *Oenothera* cultivar, but the slope is still increasing for the wild-type *Oenothera*, suggesting there are still more insect species to find.

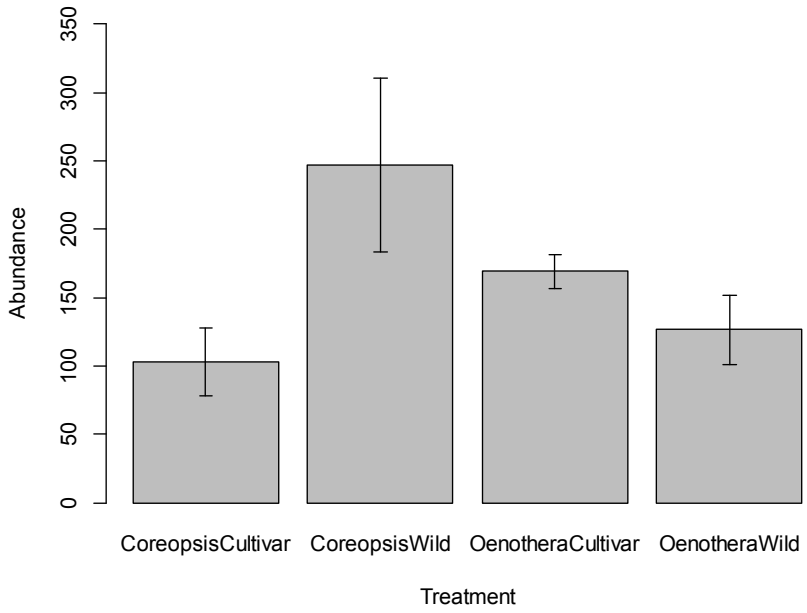

Fig. 1. Total abundance for plant species X origin. Error bars represent ± 1 SD.

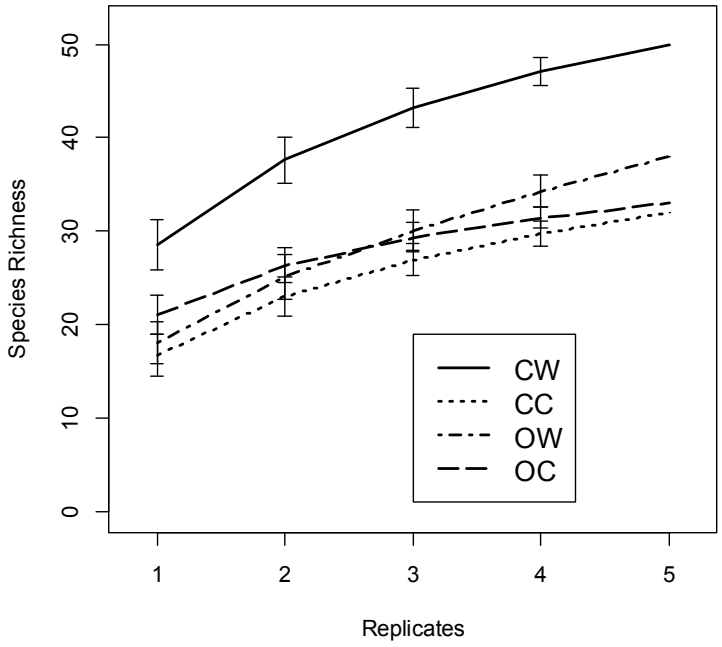

Fig. 2. Species accumulation curve for plant species X origin. See text for an explanation of the error bars.

An ordination of the treatments is shown below in Figure 3. The first axis explained 40.49% of the variation in the data and the second axis explained 27.04% of the variation in the data. The insect species that contributed most to the ordination are overlain as vectors. One notable feature of the ordination is that replicates from the same treatment tend to group together, and replicates from different treatments tend to separate. Another important feature to note is that only 6 of the 68 total insect species contributed most to the ordination; i.e. the next longest insect vector was substantially shorter than the shortest of these 6. The direction of a vector representing a particular insect species corresponds to the treatment that insect was most associated with, and the length of a vector indicates its contribution to the ordination, which in this case corresponds to the abundance of the insect. For example, the vector representing *Empoasca bifurcata* points between the replicates in the *Oenothera* cultivar treatment and the wild-type *Coreopsis* treatment, indicating that *Empoasca* is most associated with these plants. It is also the longest vector in the ordination, indicating that it was the most abundant insect collected. Also, the angle between two vectors can be interpreted as the correlation between one insect species and another in terms of their abundances.

Principal coordinates analysis is only a visualization technique for high-dimensional data, and therefore provides no information for hypothesis testing. We used PERMANOVA to test whether the insect community differed among treatments. Consistent with the univariate analyses, there was a significant interaction between Plant Species and Origin ($F_{1,16}$=19.45, p-value<.001). Again, we broke up the data and used a one-way PERMANOVA at each level of Plant Species to test for differences in the insect community between wild-type and cultivar. There was a significant difference in the insect community between cultivars and wild-type plants for both *Oenothera* and *Coreopsis* ($F_{1,8}$=16.042, p-value≈.007 and $F_{1,8}$=10.085, p-value≈.009, respectively). Although PERMANOVA assumes nothing about the distribution of the data, it does assume that the dispersion of the data is the same among groups, which is analogous to homogeneity of variances in univariate ANOVA. A test analogous to Levene's test did not indicate any violations of this assumption.

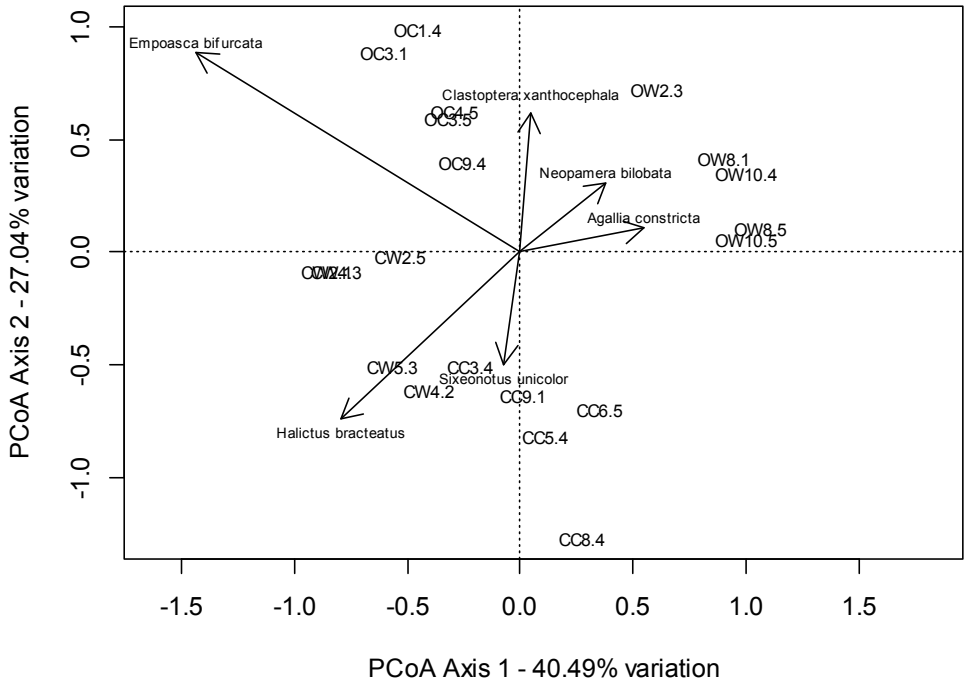

Fig. 3. Principal coordinates analysis biplot of treatments and insect species. Percent dissimilarity was used as the distance metric. Only six insect species are shown because the others contributed very little to the ordination. Replicates are identified by treatment and their location in the design (e.g., OC1.4 means *Oenothera* cultivar at row 1, column 4).

DISCUSSION

The most striking result of this research was the interaction between plant species and plant origin. In the case of *Coreopsis*, the wild-type plants supported more individuals and more species of hemipterans than did the cultivar. In contrast, the cultivar of *Oenothera* supported more individuals of hemipterans than did the wild-type plants, though there was not a significant difference in the number of insect species supported. These results suggest that the ecological value of a plant species does not depend on whether the plant material is a selection (i.e., a cultivar) or wild-propagated, but rather on the particular cultivar that is chosen. In fact, these results suggest that some cultivars may provide a greater benefit to wildlife than their wild counterparts.

If some cultivars have more of a benefit to wildlife than others, the next obvious question is: Which characteristics of a cultivar might be used to predict how well it fills an ecological role in the landscape? The results of this research may provide insight into possible answers. *Coreopsis* 'Tequila Sunrise' is quite distinct from the wild-type plants. Wild-type plants are tall, structurally complex, and produce viable seeds. 'Tequila Sunrise' plants are variegated, clump-forming, apparently sterile (at least no viable seeds were observed during this research), and produce few branching stems. For gardeners who prefer a tidy garden with plants that do not grow tall and flop over, 'Tequila Sunrise' is far superior to the wild form. However, these traits that make it a superior garden plant appear to come at the cost of reduced ecological function. Determining whether the variegated leaves, lack of structural complexity, or some other characteristic is primarily responsible for its reduced ability to support herbivorous insects would require additional research.

It is more difficult to explain why *Oenothera* 'Cold Crick' supported a higher abundance of herbivorous insects than the wild-type plants. Unlike *Coreopsis*, the *Oenothera* cultivar and wild-type plants differ very little. Both are about the same height

and have similar structural complexity. Nurseries promote 'Cold Crick' as being more compact than the wild form of *Oenothera*, but this did not appear to be true for this wild population of *Oenothera*. The main difference between the wild-type plants and 'Cold Crick' is that 'Cold Crick' is sterile. This would explain why *Neopamera bilobata*, an insect that contributed significantly to the ordination and only feeds on seeds, was found in far higher abundances on the wild-type plants than the cultivar. A quantitative measure of structural complexity and knowledge of the phytochemicals present in the leaves could help explain differences in abundances observed for other insect species. An important caveat to note is that these data represent a snapshot of a single day during the first growing season. The patterns observed for both plant species could change depending on the season and the amount of time insects have had to colonize the plots. For example, the species accumulation curve in Figure 2 indicated that the number of insect species feeding on the wild-type *Oenothera* is probably much higher than the number suggested by the mean species richness for a single day. Although there were no significant differences in species richness between the wild-type *Oenothera* and the cultivar for the preliminary data, this pattern may not hold after repeated sampling.

We will collect data from all the plant species in the experiment multiple times in 2014. This should provide better insight into whether the patterns observed in the preliminary data extend to other plant species and other seasons of the year. The cultivars used for this experiment were chosen to represent a range of deviations from the wild forms, so data from the full suite of plant species should also provide more information about which characteristics of cultivars best predict their ability (or inability) to function ecologically in the landscape.

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