Flower Morphology Influences Pollinator Community with Implications for Cross-Pollination: Observations in Rabbiteye Blueberry (*Vaccinium ashei* Reade)

Shelley R. Rogers, David R. Tarpy, and Hannah J. Burrack

Department of Entomology; North Carolina State University; Campus Box 7634; Raleigh, NC 27695-7634

Blueberry pollination

Abstract

The narrow, long corolla of rabbiteye blueberries (*Vaccinium ashei*) presents a challenge to foraging pollinators, particularly honey bees (*Apis mellifera*), and variations in this floral morphology appear to alter the species composition of the visiting bee community. In particular, the rabbiteye var. 'Premier' exhibits abnormal flower morphology, with shortened and split corollas that appeared to affect the community of bee pollinators visiting flowers. We conducted observations to compare bee visitation rates at 'Premier' flowers to other common rabbiteye varieties ('Powderblue' and 'Brightwell') that have more typical flowers. Timed observations were conducted during 2009 and 2010, and significantly more *A. mellifera* and significantly fewer wild bees visited 'Premier' flowers when compared to other rabbiteye cultivars. This apparent resource partitioning may reduce cross-pollination, which is important for successful rabbiteye blueberry production but may also increase *A. mellifera* visitation. A similar visitation rate increase by *A. mellifera* in blueberries has been suggested to occur following nectar robbing by carpenter bees (*Xylocopa* spp.).

Index words

Vaccinium ashei var. Premier, pollination services, bee diversity, *Apis mellifera*

Introduction

Rabbiteye blueberry (*Vaccinium ashei*) is commercially cultivated throughout the southeastern United States. Compared to other commercially grown blueberry species, *V. ashei* flowers have a particularly long corolla with a narrow aperture (Fig. 1a; Lyrene 1994). This constricted flower morphology is presumed to restrict shorter-tongued nectar foragers, particularly honey bees (*Apis mellifera*), from accessing nectaries, resulting in reduced visitation and pollination (e.g., Lyrene 1994, Ritzinger and Lyrene 1999). In a different blueberry species, *V. corymbosum*, Courcelles et al. (2013) showed that flowers with wider apertures received more *A. mellifera* visits and set a larger proportion of their fruit.

Unlike other rabbiteye cultivars, 'Premier' often has abnormal flowers (Fig. 1b) in which the corolla is irregularly shortened, and, in some cases, does not extend beyond the calyx. Fittingly, Sampson and Cane (2000) described these flowers as "slipper-shaped." This morphological mutation may provide easier access to nectaries, making them more attractive to *A. mellifera*, which forage primarily for nectar in blueberry crops (Dogterom 1999). Rabbiteye cultivars are typically self-sterile and thus are interplanted with other compatible rabbiteye cultivars to promote cross-pollination (Delaplane and Mayer 2000) necessary for adequate fruit set. We took advantage of the distinct and atypical corolla of 'Premier' to determine how varying floral morphologies might influence pollinator visitation more generally.

Materials and Methods

In 2009 and 2010, we observed bees visiting rabbiteye flowers at commercial blueberry farms in eastern North Carolina as part of a larger survey of blueberry pollinators (Rogers et al. 2014). While conducting transect observations during 2010 in a field of 'Premier' (Fig. 1b) interplanted

with ‘Powderblue’ (Fig. 1a), we noted a distinct difference in the species and quantity of bees at these adjacent cultivars. Accordingly, we conducted 15-min paired observations of ‘Premier’ and ‘Powderblue’ plants, repeated four times using different plant pairs. Two investigators observed one plant each, counting all *A. mellifera* and wild bees (predominantly *Bombus* spp. and *Habropoda laboriosa*) visiting flowers, and we alternated cultivars between observational periods so as to reduce observer bias. We then compared these data with 15-minute plant observations from 2009 from multiple sites (3) and sampling days (10) in which rabbiteye cultivars ‘Premier’ (n = 15), ‘Powderblue’ (9), and ‘Brightwell’ (28) were observed on their own.

We analyzed our data to determine if ‘Premier’ plants attracted a different community of bees than rabbiteye cultivars with normally-shaped flowers (‘Powderblue’ and ‘Brightwell’). Using a generalized linear mixed model, we tested for an interaction between cultivar and bee taxa (*A. mellifera* or wild bee). We treated sites, nested within year, as random factors. For our analyses, we log-transformed bee-count data [log(x+1)] for normality; however, because the relationship for raw and transformed data was the same, the untransformed means and standard errors are presented. To account for unbalanced sample sizes between sites and years, we employed the Satterhwaite method for estimating degrees of freedom. We conducted our analysis in SAS Proc GLIMMIX (SAS version 9.2, SAS Institute, Cary, NC, USA).

Results

Rabbiteye blueberry cultivars ‘Brightwell’ and ‘Powderblue’ did not differ from one another in bee visitation (P = 0.39) and were thus pooled for future analyses. There was variability among sites in the number of *A. mellifera* and wild bees. We observed a mean of 3 to 39 *A. mellifera*

per plant and 1 to 14 wild bees per plant among sites. There was a significant interaction effect between cultivars ('Premier' and other cultivars) and bee taxa ($F_{1,113} = 64.8$; $P < 0.0001$; Fig. 2). 'Premier' was visited by more *A. mellifera* (19 ± 5) than other rabbiteye cultivars (5 ± 2; $P = 0.0001$) but received fewer visits from wild bees (1 ± 1) than the other cultivars (10 ± 2; $P < 0.0001$) (Fig. 2).

Discussion

We find that the rabbiteye blueberry cultivar 'Premier' attracted a pollinator community distinct from other cultivars. We expect that this difference is the result of the abnormal flower morphology of 'Premier' rather than among-cultivar differences in nectar volume, concentration, or volatile profiles (Rodriguez-Saona et al. 2011). We posit that *A. mellifera* were abundant at 'Premier' flowers due to the ease of access to their nectaries. However, wild bees were more abundant at other rabbiteye cultivars than 'Premier'. Wild bees visit blueberry primarily for pollen, not nectar (Dogterom 1999), and may prefer flowers with a complete corolla, enabling more uniform handling. We commonly observed *Bombus* and *Habropoda* bracing themselves at the aperture of the corolla while sonicating flowers to release pollen. Alternately, wild bees may be avoiding interspecific competition with *A. mellifera* at 'Premier' flowers (Rogers et al. 2013). Our findings suggest a kind of within-crop niche partitioning that may in fact reduce cross-pollination in among interplanted cultivars: *A. mellifera* may skip over less-attractive 'Brightwell' or 'Powderblue' plants to preferentially forage at 'Premier', and wild bees may do the opposite, avoiding 'Premier'. Despite the potential for reduced cross-pollination, Sampson and Cane (2000) found that *A. mellifera* were efficient pollinators of 'Premier,' with a single

flower visit resulting in an increased proportion of fruit set than in cultivars 'Tifblue' and 'Climax.'

The attraction of *A. mellifera* to abnormal blueberry flowers is also worth considering in relation to the phenomenon of 'nectar-robbing' (Inouye 1980). The carpenter bee, *Xylocopa virginica* frequently robs nectar from blueberry flowers by creating a perforation in the base of the corolla. In the presence of these perforations, *A. mellifera* readily and rapidly switch to nectar-robbing (Cane and Payne 1993) as a more efficient way of extracting nectar from flowers (Dedej and Delaplane 2005). Abnormal 'Premier' flowers are effectively similar to *Xylocopa*-perforated blueberry flowers; both facilitate access to the floral nectaries. Our findings, interpreted in this context, suggest that nectar-robbing by *Xylocopa* may increase blueberry visitation by *A. mellifera* and may potentially enhance pollination (Sampson et al. 2004), as observed in other systems (Maloof and Inouye 2000). Blueberry flower shape has been shown to alter *A. mellifera* visitation patterns more generally. Making use of a *V. ashei* cultivar with a distinct and atypical corolla, we demonstrate how floral morphology influences multiple pollinator species and may shape the effective forager community.

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Figures

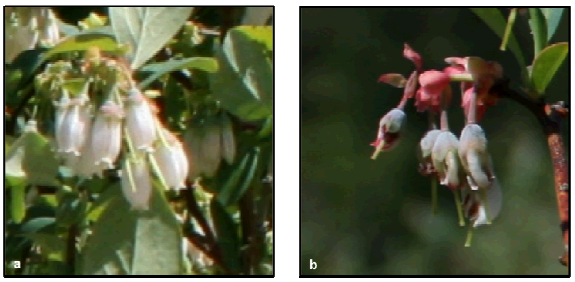

Figure 1. (a) Flowers of a rabbiteye blueberry, *V. ashei*, cultivar ‘Powderblue’ have long, constricted corolla, typical of this species. (b) Flowers of *V. ashei* cv. ‘Premier’ are deformed, with shorted corollas.

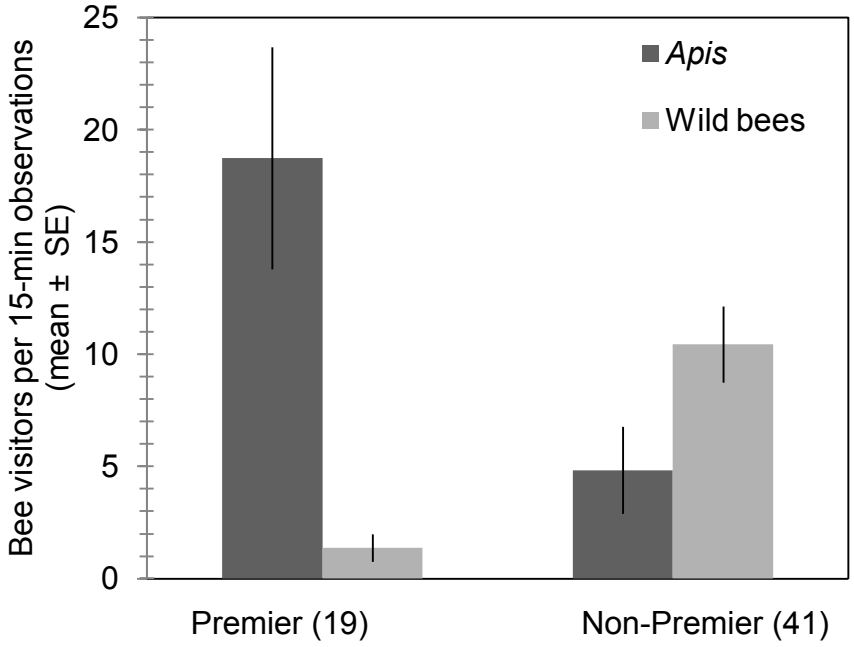

Figure 2. Number of *Apis mellifera* and wild bees observed visiting rabbiteye blueberry, *V. ashei*, cultivar ‘Premier’ or other, non-Premier cultivars ('Powderblue' and 'Brightwell'), in 15-minute observational periods (*n*).