Flower Morphology in Blueberry Species and Hybrids

Rogério Ritzinger and Paul M. Lyrene
Department of Horticultural Science, University of Florida, Gainesville, FL 32611

Additional index words. Vaccinium ashei, V. corymbosum, V. constablaei, V. simulatum, corolla length, corolla width, corolla aperture, style length, anther-to-stigma distance, insect pollination

Abstract. Several morphological features of Vaccinium ashei Reade, V. constablaei A. Gray, their F1 hybrids, V. simulatum Small, and southern highbush blueberry (V. corymbosum L.) hybrids flowers were compared in Gainesville, Fla. Desirable characteristics that could increase the extent of honeybee pollination, such as a large corolla aperture and a short anther-to-stigma distance, were common in V. constablaei but not in V. ashei. F1 (V. ashei X V. constablaei) hybrids were generally intermediate between the two parents. Thus, it appears that V. constablaei could be used to breed V. ashei cultivars with improved flower morphology. Vaccinium simulatum and V. constablaei flowers were similar in all features. The corollas of southern highbush blueberry flowers were wide and had wide apertures, but the distance between stigma and anther pore was also large.

Fruit set in blueberries may be related to the flower structure and attractiveness to pollinating insects (Shutak and Marucci, 1966). The blueberry flower is morphologically adapted to facilitate cross-pollination by bees. The distance between the stigma and the anther pores from which the pollen is discharged, together with the stigma shape, with angled pores from which the pollen is discharged, overall stigma position in relation to the corolla apex, and color of the petals could be used to breed V. ashei cultivars with improved flower morphology with flower shapes more favorable for pollination by honeybees.

Materials and Methods

Flower features were determined for 23 V. ashei, 12 V. constablaei, 13 V. ashei X V. constablaei F1 hybrids, four southern highbush blueberry (V. corymbosum hybrids), and one V. simulatum clones in Mar. 1993. The V. constablaei and V. simulatum flowers originated from dormant branches cut on 23 Dec. 1992 from plants growing wild at altitudes above 1600 m in the mountains of western North Carolina near the Shining Rock Wilderness Area south of Asheville. Vaccinium constablaei, which was growing on an open meadow with few or no trees, was extremely abundant, with hundreds of clones 1.1 to 1.7 m tall, each of which had hundreds of densely packed canes that formed colonies 4 to 10 m in diameter. The V. simulatum plants, which were growing within 2 km of the V. constablaei, were 2 to 3 m tall and produced only a few major canes. Enough dormant branches were taken from each clone to provide 50 to 100 inflorescence buds containing several hundred flowers. The cut branches were enclosed in plastic bags with wet paper towels to maintain moisture, and were immediately placed on ice in a chest (0 °C). On 4 Jan. 1993 they were transferred to a cold room (7 °C). At the time of collection, the branches had already received many hours of chilling.

The bags were opened and checked every 2 weeks, and, if necessary, the wet paper towels were replaced. On 4 Feb., the bases were cut and the branches were placed in a greenhouse in 4-L plastic buckets, each containing 1.5 L of a preservative solution [sucrose (5%) + citric acid (5.93 x 10−4 M) + 8-hydroxy quinoline hemisulfate salt (5.93 x 10−4 M)]. Once a week, the bases of the branches were cut and the preservative solution was renewed. The greenhouse was heated except by the sun during the day and by heaters that kept the temperature above 5 °C at night.

The V. ashei and V. corymbosum clones used in the experiment were cultivars or advanced selections from the Univ. of Florida breeding program. The F1, V. ashei X V. constablaei hybrids had been produced several years earlier by hand crosses, and had been grown for 2 years in a high-density field nursery in Gainesville, Fla. The V. constablaei parents of these F1 plants were from the U.S. Department of Agriculture, National Clonal Germplasm Repository in Corvallis, Ore., and the V. ashei parents were advanced selections from the Univ. of Florida blueberry breeding program. In Dec. 1992, the V. ashei, V. corymbosum, and F1 hybrid plants were dug from field nurseries, potted, and placed in a dark chamber at 7 °C for 6 weeks. In February, they were removed from the cooler and placed in the same greenhouse in which the V. constablaei and V. simulatum branches were being forced. Ten fully opened flowers were assessed per clone. The following features were evaluated: corolla length, measured from the deepest indentation of the calyx to the apex of the corolla; corolla width, representing the widest diameter at the middle of the corolla tube; corolla aperture, which was the mean diameter of the opening at the apex of the corolla tube; style length, from the top of the ovary to the distal end of the stigma; anther-to-stigma distance, measured from the pore of the anthers up to the stigma; overall stigma position in relation to the corolla apex; and color of the petals.

A possible source of error in this experiment was the comparison of flowers forced on cut branches (V. constablaei and V. simulatum) with flowers opening on potted plants for the other taxa. This procedure was necessary because the mountain species cannot be grown to maturity in the field in Florida. A few fall flowers that have been observed on V. constablaei and V. simulatum seedlings grown in the field in Florida were morphologically similar to flowers on the cut branches forced in the greenhouse. Lyrene (1994b) found that flower morphological parameters were little affected by the amount of chilling the dormant plants received before flowering or by the temperature in the forcing environment.

Statistical analyses were performed for all characteristics, except stigma position and color of the petals, using a completely randomized design with varying numbers of replicates. For each parameter, the clone mean was obtained by averaging the measurements from the 10 flowers per clone. The taxa were then compared using the variance among clones within taxa as the error variance. When analysis of variance indicated significant differences among taxa for a parameter, taxa means were compared using Tukey’s mean separation procedure.

Results and Discussion

Flowers of Vaccinium ashei, V. constablaei, their F1 hybrids, V. corymbosum (southern highbush), and V. simulatum differed inGrab the text content.
Table 1. Flower morphological features of Vaccinium ashei, V. constablaei, their F1 hybrids, V. corymbosum (highbush), and V. simulatum. All measurements in mm.

| Vaccinium taxa | No. clones examined | Corolla length | Corolla width | Corolla aperture length | Style length | Anther-to-stigma distance |
|----------------|---------------------|----------------|---------------|-------------------------|--------------|--------------------------|
| V. ashei       | 23                  | 9.1 ± 0.3a     | 6.6 ± 0.1a    | 2.7 ± 0.1a              | 10.0 ± 0.1a  | 2.3 ± 0.1a               |
| F1             | 13                  | 7.2 ± 0.3b     | 6.2 ± 0.1bc   | 3.3 ± 0.1b              | 7.9 ± 0.1b   | 1.4 ± 0.1b               |
| V. constablaei | 12                  | 5.3 ± 0.1c     | 5.2 ± 0.1c    | 3.8 ± 0.1a              | 5.2 ± 0.1c   | 0.7 ± 0.1b               |
| V. corymbosum  | 4                   | 8.9 ± 0.1a     | 7.9 ± 0.1a    | 3.6 ± 0.1a              | 9.1 ± 0.1a   | 2.9 ± 0.1a               |
| V. simulatum   | 1                   | 4.8 ± 0.1      | 6.1 ± 0.1     | 4.1 ± 0.1               | 5.1 ± 0.1    | 0.4 ± 0.1                |

a Mean separation within columns by Tukey’s test P ≤ 0.05.
F1 hybrid of V. ashei x V. constablaei.

Table 2. Number of clones having various corolla colors for Vaccinium ashei, V. constablaei, their F1 hybrids, V. corymbosum (highbush), and V. simulatum.

| Vaccinium taxa | No. clones examined | Light yellow | White w/ yellow veins | Red-yellow |
|----------------|---------------------|--------------|-----------------------|------------|
| V. ashei       | 23                  | 22 ± 1       | 1 ± 0                 | 0 ± 0      |
| F1             | 13                  | 4 ± 7        | 7 ± 0                 | 2 ± 0      |
| V. constablaei | 12                  | 1 ± 1        | 11 ± 0                | 0 ± 0      |
| V. corymbosum  | 4                   | 2 ± 1        | 1 ± 0                 | 0 ± 1      |
| V. simulatum   | 1                   | 0 ± 1        | 1 ± 0                 | 0 ± 0      |

F1 hybrid of V. ashei x V. constablaei.

Table 3. Stigma position in relation to the corolla apex of flowers of clones of Vaccinium ashei, V. constablaei, their F1 hybrids, V. corymbosum (highbush), and V. simulatum.

| Vaccinium taxa | No. clones with stigma located: | Inside or at the corolla apex | At the corolla apex | Exserted beyond or at the corolla apex | Exserted beyond corolla | Total |
|----------------|---------------------------------|-----------------------------|---------------------|----------------------------------------|-------------------------|-------|
| V. ashei       | 0                              | 1                          | 10                  | 12                                     | 23                      |       |
| F1             | 1                              | 4                          | 3                   | 5                                      | 13                      |       |
| V. constablaei | 0                              | 12                         | 0                   | 0                                      | 12                      |       |
| V. corymbosum  | 1                              | 1                          | 2                   | 0                                      | 4                       |       |
| V. simulatum   | 0                              | 0                          | 0                   | 0                                      | 1                       |       |

F1 hybrid of V. ashei x V. constablaei.

Phyology. Vaccinium ashei and V. corymbosum had larger flowers, as measured by the length of the corolla and style (Table 1). Their large size may have been due, in part, to selection for cultivars with large fruit. V. ashei and V. corymbosum (highbush) differed significantly from V. constablaei and V. ashei x V. constablaei F1 hybrids in corolla length and width. Highbush corollas were significantly wider than those of the other taxa. Despite their small size, V. constablaei flowers had large corolla apertures, similar to those of highbush flowers and significantly larger than the apertures of V. ashei flowers. As measured by the anther-to-stigma distance (Table 1), the pore at the end of the anther, where the pollen is released, was much closer to the stigma in V. constablaei than in the cultivated blueberries V. ashei and V. corymbosum (highbush). The single V. simulatum clone that was sampled had flowers that were short and had a wide corolla aperture and a short anther-to-stigma distance.

The data show that V. constablaei flowers have several desirable features, including large aperture and short anther-to-stigma distance. Eck and Mainland (1971) and Lyrene (1994a) suggested that short and wide corollas, short distance between stigma and anther pore and large corolla-tube apertures could make the blueberry flower more amenable to honeybee pollination, possibly resulting in higher fruit set. The V. ashei flower lacked these features but might be altered by crossing with V. constablaei. In the present study, mean values for all flower parameters measured in the F1 (V. ashei x V. constablaei) hybrids were intermediate between the two parents.

Vaccinium ashei and V. constablaei also differed in petal color (Table 2) and stigma position in relation to the corolla apex (Table 3). Vaccinium ashei clones tended to have white petals and stigmas exserted beyond the corolla apex. Vaccinium constablaei, on the other hand, had light-yellow flowers and stigmas that were even with the corolla apex. It is not known what effect these two flower characteristics have on insect attraction and pollination in blueberries. F1 hybrids had some variation in petal color and stigma position relative to the corolla apex as a result of segregation; therefore, selection in the F1 generation should be possible.

The small corolla tube apertures and stigmas exserted beyond the corolla apex indicated that V. ashei flowers were not amenable to pollination by insects such as honeybees that must penetrate the flowers (Cane et al., 1993). Instead, V. ashei flowers seem best adapted for pollination by sonicating bees, some of which are native to the V. ashei natural habitats. Such insects are very effective in blueberries, whose flowers shed pollen through terminal pores in the anthers in response to vibrations caused by the flight muscles of sonicating insects (Corbet et al., 1988). Sonicating bees are effective pollinators of V. corymbosum (highbush blueberries), which also seem to be pollinated efficiently by honeybees (Goodman and Clayton-Green, 1988). Highbush cultivars vary in the attractiveness of their flowers to honeybees. This may be related, in part, to differences in the amount of nectar produced (Jablonski et al., 1985; Marucci and Moulter, 1977). However, honeybee efficiency in pollinating highbush blueberry can also be explained in part by the large corolla width and wide aperture of the flower (Table 1). These two characteristics make it easier for honeybees to obtain pollen and nectar, consequently increasing pollination.

Morphological features of V. constablaei flowers, including the large corolla apertures and stigmas at the same level of the corolla apex, could indicate that these flowers are adapted to both sonicating and nonsonicating pollinating insects. Vaccinium constablaei and V. simulatum are quite distinct in plant form. V. constablaei is highly rhizomatous and less than 2 m tall, with hundreds of stems per mature clone. Vaccinium simulatum is a taller shrub, growing up to 4 m tall with fewer canes per clone. Both V. constablaei and V. simulatum are native to the mountains of North Carolina and their flowers are much alike. The flowers of both species may have evolved in harmony with the pollinating insects native to those mountains. The difference in chromosome number (V. constablaei is hexaploid and V. simulatum tetraploid) and the fact that V. constablaei is probably more tolerant of fire and less tolerant of shade are two factors that may help keep the species distinct in nature.

Literature Cited

Cane, J.H., K. Mackenzie, and D. Schiffauer. 1993. Honey bee harvest pollen from the porose anthers of cranberries (Vaccinium macrocarpon) (Ericaceae). Amer. Bee J. 133:293–295.

Corbet, S.A., H. Chapman, and N. Saville. 1988. Vibratory pollen collection and flower form. Bumble-bees on Actinidia, Symphytum, Borage and Polygontum. Funct. Ecol. 2:147–155.

Eck, P. and C.M. Mainland. 1971. Highbush blueberry fruit set in relation to flower morphology. HortScience 6:494–495.

Goodman, R.D. and K.A. Clayton-Green. 1988. Honeybee pollination of highbush blueberries (Vaccinium corymbosum). Aust. J. Expt. Agr. 28:287–290.

Jablonski, B., S. Krol, K. Pliszka, and Z. Zuwroswska. 1985. Nectar secretion and pollination of the blueberry (Vaccinium corymbosum L.). Acta Hort. 165:133–144.

Lyrene, P.M. 1994a. Variation within and among blueberry taxa in flower size and shape. J. Amer. Soc. Hort. Sci. 119:1039–1042.

Lyrene, P.M. 1994b. Environmental effects on blueberry flower size and shape are minor. J. Amer. Soc. Hort. Sci. 119:1043–1045.

Marucci, P.E. and H.J. Moulter. 1977. Blueberry pollination in New Jersey. Acta Hort. 61:175–186.

Shutak, V.G. and P.E. Marucci. 1966. Plant and fruit development. p. 179–198. In: P. Eck and N.F. Childers (eds.). Blueberry culture. Rutgers Univ. Press, New Brunswick, N.J.