Influence of Pistil Age on Fruit Set of Cross-Pollinated *Penstemon kunthii* Hybrids

Jessie Abruzzo and Dr. James Ault, Chicago Botanic Garden, Glencoe, IL 60022

Abstract

The *Penstemon* genus currently consists of 272 species which are not only of ecological interest for their ability to recolonize disturbed areas such as roadside cuts, mine reclamations and in post-wildfire restorations, but also of ornamental interest for their showy flowers, relative ease of cultivation and drought tolerance. The aim of this experiment was not only to examine the influence of pistil age on fruit set of cross-pollinated *Penstemon kunthii* hybrid plants, but also to observe the stigma morphology throughout maturation. In order to accomplish this objective, individual flowers on a *Penstemon kunthii* hybrid plant were tagged, emasculated, and eventually pollinated according to eleven different treatments. Percentage fruit set was then tabulated and analyzed. Overall, our results show that optimum floral stage at the time of pollination for the *Penstemon kunthii* hybrid is on days one, two, and three post anthesis (75%, 63%, 56% success, respectively). Stigma morphology during these days was straight to hooked.

Introduction

Penstemon, or more commonly called Beardtongue, is a close relative to genera such as foxglove (*Digitalis)* and snapdragon (*Antirrhinum)*. Not only is *Penstemon* native to North America, but at least one species is indigenous to every state of the mainland United States, including Alaska. In total, the *Penstemon* genus consists of 272 species which include a few that are presumed extinct.

In general, Beardtongues possess tubular corollas, ending in five petal lobes, usually with two at the top and three at the bottom. Each *Penstemon* flower typically has four fertile stamens and an enlarged fifth sterile stamen, or staminode. Although every *Penstemon* possesses the same general qualities, there is a very large diversity between species.

Beardtongues are of ecological interest for their ability to recolonize disturbed areas such as roadside cuts, mine reclamations and in post-wildfire restorations. They are also of ornamental interest for their showy flowers, relative ease of cultivation and drought tolerance.

In support of the ornamental plant breeding program at Chicago Botanic Garden, this study's purpose was to examine the effect of pistil age and morphology post-anthesis on subsequent fruit set of a cross-pollinated *Penstemon kunthii* hybrid plant. Previously, the Garden's plant breeder has, based on recommendations form other breeders, pollinated *Penstemon* around two to three days-post anthesis, when the stigma has developed a pronounced hook.

Materials and Methods

Two genotypes of a *Penstemon* hybrid derived from the Mexican species *P. kunthii* were selected for this study. One plant was selected to receive all floral pollinations and another plant was selected as the source of the pollen used for all pollinations (Fig. 1). Individual flowers on the plant to be pollinated were tagged at floral anthesis. The tagged flowers were then emasculated by removing the floral tube and the attached anthers on the day of anthesis. Lastly, the emasculated flowers were randomly assigned one of the following treatments:

Treatment #	Treatment
#1	•Control (No emasculation- open pollinated)
#2	•Control (Emasculation)
#3	•Pollinated day of anthesis
#4	•Pollinated 1 day post-anthesis
#5	•Pollinated 2 days post-anthesis
#6	•Pollinated 3 days post-anthesis
#7	•Pollinated 4 days post-anthesis
#8	•Pollinated 5 days post-anthesis
#9	•Pollinated 6 days post-anthesis
#10	•Pollinated 7 days post-anthesis
#11	•Pollinated 8 days post-anthesis

At least ten flowers were assigned to each treatment. Each flower was pollinated on the appropriate day with pollen collected within the previous 18 hours from the pollen donor plant. The stigma of each flower was thoroughly coated with pollen upon pollination. Each flower was pollinated once. Subsequent fruit set data was collected and analyzed.

Figure 1: *Penstemon kunthii* hybrid after flowers were emasculated and tagged.

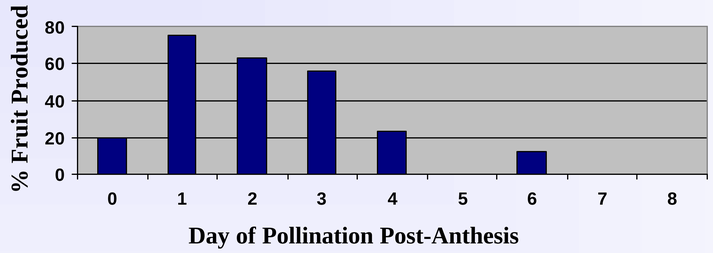

Figure 2: Fruit Production after controlled cross-pollination of a *Penstemon kunthii* hybrid**:** Flowers were pollinated 0-8 days post-anthesis. Data was analyzed and X^2 test=112.90** with 8 d.f., P= 0.01.

Figure 3: *P. kunthii* hybrid stigma morphology day of anthesis, one day post-anthesis, two days post-anthesis, and five days post anthesis (from left to right).

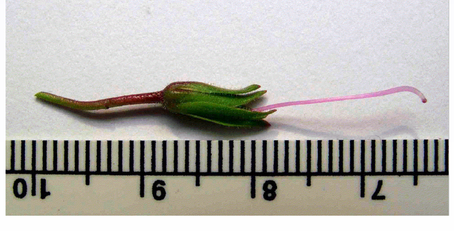

Figure 4: *Penstemon kunthii* hybrid stigma morphology three days after anthesis. Although a hook-like appearance of the stigma was thought to be correlated with peak receptivity, fruit set was already in decline by day three post-anthesis.

Results

As indicated by Figure 2, optimum floral stage at the time of pollination occurred on days one, two, and three post-anthesis. A decline in fruit production was evident after day two of pollination post-anthesis. Overall, the data resulted in a X^2 test = 112.90** with 8 d.f., P= 0.01. In addition to the treatments outlined in Figure 1, 28 flowers were emasculated pre-anthesis and all failed to produce fruit.

Discussion

According to the X^2 test (=112.90** with 8 d.f., P= 0.01), the most significant finding of this experiment was that the receptivity of the *Penstemon kunthii* hybrid varied greatly post-anthesis. As indicated by Figure 2, optimum floral stage at the time of pollination was determined to be on days one, two, and three post-anthesis (75%, 63%, 56% success, respectively). After day three post-anthesis, there was a sharp decline in fruit production. Conversely, when 28 flowers were emasculated pre-anthesis, the development of fruit failed to occur. Therefore, potential pollinators were deterred and fertilization did not take place. These results are not only beneficial to other researchers interested in the breeding or reproductive biology of *Penstemon*, but may also prove to be useful for restoration management in natural locations in which pollinators are scarce and plant species must remain receptive for several days in order for pollination to occur.

On day one post-anthesis, the *Penstemon kunthii* hybrid stigma was straight to only slightly curved, becoming more curved in a hook-like fashion by day two post-anthesis. As the stigma matured, the hook shape became more apparent. It is thought that the hook shape of the style enhances natural pollination by more effectively rubbing the stigma against insect pollinators as they crawl into and out of the petal tube. However, this study shows that fertilization effectiveness is already declining by the time the style has formed a strong hook. By day five post anthesis, disintegration of the stigma was very evident and fruit set was rare (Figure 3-4).

Depending on the species, stigma receptivity may last from several hours to several days (Kearns and Inouye, 1993). HyunJung and Niimi (2002) conducted a study with three lily hybrids and concluded that the optimum times of pollination for maximum seed production of each cross-combination were one day before anthesis, day of anthesis and one day post anthesis, respectively. In another study, the 'Agua de Aranjuez' pear was receptive for only two days (Sanzol, Rallo and Herrero, 2003). Factors such as climate may influence pollination and fruit set. For example, researchers determined that pollen tube growth and therefore fertilization of the 'Agua de Aranjuez' pear was effected by variable temperature. No similar studies appear to have been conducted on plants related to *Penstemon.*

Conclusion

In this study, the influence of pistil age on fruit set of cross-pollinated *Penstemon kunthii* hybrids was examined. As demonstrated, this plant was most receptive to pollination on days one, two, and three post-anthesis. After day one post-anthesis, a steady decline of fruit set was observed. Style morphology changes throughout this period. A slightly hooked style appears to be at the optimal stage for pollination, not the strongly recurved style, as previously thought.

Although research in this area has not been abundant, this study may lead to other experiments which test whether the data is consistent across species of *Penstemon*, whether the data varies depending on variables such as climate and altitude, and whether structures such as the floral tube delay the disintegration of the stigma. Overall, these studies would not only be useful to plant breeders and avid gardeners, but it would also prove useful to conservationists who are trying to reintroduce native species into areas that are deficient in pollinators.

References

HyunJung, K., and Y. Niimi. 2002. Frequency of viable seeds obtained from several *Lilium* spp. Cross-pollinated at different floral stages. J. Jap. Soc. Hort. Sci. 71: 231-235.

Kearns, C.A. and D.W. Inouye. 1993. Techniques for Pollination Biologists. University Press of Colorado: Niwot, Colorado.

Sanzol, J, P. Rallo and M Herrero. 2003. Stigmatic Receptivity Limits the Effective Pollination Period in 'Agua de Aranjuez' Pear. J. Amer. Soc. Hort. Sci. 128(4): 458-462.

Way, D. and P. James. 1998. The Gardener's Guide to Penstemons. David & Charles Publishers: Newton Abbot, Devon.