Pollination in cranberry involves many different pollinators that will transfer pollen grains from the anthers (male part) to the stigma (female part) of another flower. Pollen grains in cranberry come in form of tetrads, meaning four pollen grains adhering together. A study by Cane and Schiffauer in 2003 determined that in cranberry, only 8 pollen tetrads deposited on the stigma of a flower were sufficient to obtain optimal fruit set and berry mass. This finding is important as it allows to quantitatively assess how efficient a particular pollinator is at pollinating cranberry.

The most efficient pollinators are bees. There are ~25,000 species of bees worldwide, with ~4,500 solitary bees in North America and approximately 400 species in Wisconsin. Honeybees have been used for pollination in cranberry for decades, mainly because they are the most extensively managed pollinator in the world, accounting for 84% of all insect pollination. Honeybees are not native and were introduced in the early 1600s by settlers. In 2005, a survey conducted by USDA NASS in WI showed that 70% of operations used honeybees for their pollination services at an average of 1.8 colonies/acre; and 13% used bumble colonies. Recommendations on the number of hives per acre have not been established but numbers have increased over time to approximately 2-3 hives per acre currently (see also Hannah Gaines Day article on page 29). During this year’s school “clicker” pollination session, growers were asked how many honeybee hives per acre they brought in 2013. The majority (51%; n = 78) brought in 3-5 hives, 19% brought 1-2 hives, 9% brought in 6-8 hives and 14% brought in more than 8 hives.

Not all pollinators are equal and the effectiveness of a pollinator can be determined by looking at 1) the abundance of a specific pollinator and the frequency at which it visits flowers; 2) the pollination efficiency, such as the number of pollen grains deposited on a flower during a single visit, or the number of pollen grains collected during a visit; and 3) the fidelity to cranberry or how much they prefer cranberry over other flowers.

Honeybees are not necessarily the most efficient pollinator in cranberry as they often steal nectar without pollinating the flower and they do not show a strong preference for cranberry over other more nutritious flowers. The fidelity of honeybee colonies to cranberry varies from day to day and from colony to colony, with bees collecting 2-100% of cranberry pollen (Shimanuki et al. 1967; Cane and Schiffauer 2001).

Bumblebees are native with 49 species in the U.S. and 250 species worldwide. Bumblebees perform buzz pollination where they grasp the flower and vibrate their wing muscles rapidly.
without moving their wings, shaking the pollen out of the anthers onto their body. This buzz pollination makes them very efficient pollinators of many crops, including cranberry.

The majority of bee species (90%) are solitary, where each female builds and provisions her own nest and lays eggs. Seventy percent of solitary bees nest underground while the other 30% nest in pre-existing wood cavities, such as beetle borer holes or hollow plant stems. Some cavity nesters have been developed as managed commercial pollinators, e.g. the alfalfa leaf cutting bee for alfalfa pollination and the blue orchard bee for cherry, apple, almond,... pollination. Some solitary species have been evaluated for commercial pollination in cranberry, for example *Megachile addenda* is a ground nesting bee that nests on cranberry dikes and in beds and can withstand flooding (Cane et al. 1996).

**Comparisons of pollination efficiency between pollinator species**

In 1994, McKenzie looked at the pollination efficiency of bumblebees compared to honeybees. He found that honeybees contacted the stigma of a flower much less often than bumblebees (41% vs. 96%, respectively) and only 3% of honeybees were observed foraging for pollen compared to 74% in bumblebees. More recently, Broussard et al. (2011) observed 63% honeybees foraging for pollen compared to 89% of bumblebees.

Cane and Schiffauer (2003) compared the pollination efficiency of honeybee (*Apis mellifera*), bumblebee (*Bombus affinis*), *Megachile addenda*, and alfalfa leafcutting bee (*Megachile rotundata*) (Figure 1). This study showed that bumblebees deposited more pollen than any other bee and set fruit in 80% of flowers visited. For honeybees, even though they deposit less pollen than bumble bees or *Megachile addenda*, they still deposit the 8 pollen tetrads required for optimal fruit set and berry mass (Figure 1a). Looking at fruit set, honeybees pollinated flowers such that fruit set in 50% of flowers they visited (Figure 1b).

![Figure 1. Differences between bee species (bumblebee, *Bombus affinis*; *Megachile addenda*; alfalfa leafcutting bee, *Megachile rotundata*; and honeybee, *Apis mellifera*) in single-visit pollen deposition (a) and predicted fruit set (b) of resulting cranberries. None refers to no pollinator. Bars with different letters are statistically different.](image-url)
In a 2006 study, Evans and Spivak compared pollination services in cranberry with honeybees and without honeybees, thus relying solely on wild bees. They found that berry mass decreased by 50% without honeybees, from 0.06oz per berry with 3 honeybee hives per acre to 0.03oz with no commercial honeybees. In addition, without commercial honeybees, berry mass decreased in the center of beds as opposed to bed edges. This study also found that more pollen tetrads were deposited on stigma in mid and late bloom when honeybees were present (Figure 2a) and more flowers received at least 8 pollen tetrads with honeybees at mid-bloom than without honeybees (Figure 2b), suggesting that there might not be enough wild pollinators to pollinate cranberry flowers at mid-bloom.

Figure 2. (a) Average number of pollen tetrads on each stigma examined for different bloom stage, with or without commercial honeybees. (b) Percent stigmas that received more than eight pollen tetrads at different bloom stage, with and without commercial honeybees. * indicates statistically significant differences.

In a recent study, Cariveau and Winfree (2012) observed bees visiting flowers in cranberry beds (Table 1). In this study, they found that honeybees were the most abundant bee in cranberry, accounting for 73% of 9,300 visits observed, while bumble bees represented 17% and wild bees 10% of these visits. Honeybees deposited on average 3.8 pollen tetrads, bumblebees 7.2 and wild bees ranged from 1.2 to 9.8 pollen tetrads per visit. The overall contribution (the number of visits x number of pollen tetrads deposited per visit) of these bees to cranberry pollination was 64% for honeybees, 28% for bumblebees, and 9% for other wild bees.

Table 1. Percent visits, number of pollen tetrads deposited per visit, and overall contribution of honeybees, bumblebees, and other wild bees in cranberry beds.

<table>
<thead>
<tr>
<th></th>
<th>Honeybees</th>
<th>Bumblebees</th>
<th>Other wild bees</th>
</tr>
</thead>
<tbody>
<tr>
<td>% visits</td>
<td>73 ± 4%</td>
<td>17 ± 3%</td>
<td>10 ± 3%</td>
</tr>
<tr>
<td># pollen tetrads/visit</td>
<td>3.8</td>
<td>7.2</td>
<td>1.2 - 9.8</td>
</tr>
<tr>
<td>Overall contribution</td>
<td>64 ± 5%</td>
<td>28 ± 4%</td>
<td>9 ± 2%</td>
</tr>
</tbody>
</table>

These studies taken collectively suggest that honeybees are usually effective pollinators (~8 pollen tetrads per visit), are present in very high numbers when commercially supplemented to
cranberry marshes, thus accounting for more visits to flowers, and are able to fly longer distances than wild bees (all the way to the center of beds).

Future research will address how the location of bee hives on the marsh impact bee visitation to cranberry flowers.

References


