

Sonication, or Buzz Pollination: constructing habitats for effective fertilization of blueberries, cranberries, tomatoes, squash, and other crops

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Some crops, including those in the Ericaceae family, such as blueberries and cranberries, and those in the Solanaceae family, such as tomatoes, peppers, eggplants, and potatoes, contain their pollen in poricidal anthers located inside of long narrow flowers with only small pores through which pollen is released. Approximately eight percent or 300,000 species of flowering plants have poricidal anthers (Buchmann, 1985). To obtain this closely held pollen, insects have to shake the anthers in a process called sonication, or buzz pollination. Other crops with non-poricidal anthers, including those in the Cucurbitaceae family, such as squash and pumpkins, also benefit from sonication.

Bombus (bumblebees) and bees from the families Andrenidae (mining bees), and Halictidae (sweat bees), provide very effective buzz pollination to these crops (Cardinal *et al.*, 2018). They loosen and release the pollen by placing their thoraxes close to the anthers and contracting their flight muscles at a frequency of about 400 Hz.

Farmers are particularly interested in native pollinators for their potential as effective substitutes for, or simply to complement the work of honeybees. Replacing honeybees would not be an easy task, as greater than 30,000 honeybees may live in a single hive. Although nonmanaged native pollinators will probably not be able to achieve such population densities, they possess significant advantages over honeybees. The most



Lasioglossum imitatum of the Halictidae family*



Andrena carlini of the Andrenidae family*

effective pollen-

harvesters, *Bombus* species queens, *Bombus* species workers, *Andrena* species, and *Halictus* species pollinate 6.5, 5.4, 3.6, and 2.7 flowers, respectively, in the time it would take a nectar-foraging honeybee to pollinate a single flower (Javorek *et al.*, 2002). Not only do wild, native pollinators display greater pollination efficiency than honeybees, many have been shown to have a superior impact on fruit set and yields (Willmer *et al.* 1994, Javorek *et al.*, 200).

Bumblebee Life Cycles, Behaviors, and Energy Expenditures



Bombus impatiens, queen*

Bumblebees and honeybees have distinctly different life cycles, foraging behaviors, nesting habits, and other traits that have impacts on when and where they get their sustenance. These factors require special consideration when developing habitats.

- Unlike honeybees, which have perennial life cycles in which portions of their colonies survive each winter by living off the honey they produce during the rest of the year, **bumblebees have annual life cycles** in which the founding queens and their colonies die at the end of the growing season and the gynes – which become the queens for the coming year’s colony – hibernate until the beginning of the next season. The majority of bumblebees native to the Northeast United States **nest underground, using pre-existing**

abandoned holes created by rodents and other small mammals. By exploiting these abandoned holes, bumblebees can form their nests by using the materials left behind, such as moss, hair, dry grass, feathers, and other insulating materials.

- The queen gathers pollen and transports it to the nest, where she molds it into a lump within which she lays her eggs. She then covers the pollen lump with a layer of wax she secretes from her abdominal surface. To incubate her brood, she sits in a groove on top of the pollen lump and replenishes her energy reserves by feeding from a nectar pot she creates and situates in front of the clump, thus ensuring she never loses contact with the brood clump. Once the eggs hatch in four days, the larvae consume the pollen in which they were encased. However, **it is critical for the queen to continue to forage to supplement the pollen from the clump once the larvae start to feed.** In his book, *Bumblebees: Behaviour, Ecology, and Conservation* (2010), Dave Goulson asserts that “this stage of the life cycle is precarious since the queen must leave the nest to replenish her reserves, but in early spring nectar-rich flowers tend to be few and far between.”
- A review of lists of native plants that attract pollinators in the New England and Northeast United States not only omit many **early flowering plants** but fail to stress the importance of including a variety of such plants. The ability of bumblebees to become active during cold periods in early spring when other insects are still in hibernation results from their **ability to thermoregulate their body temperatures** many degrees above ambient temperatures. Bumblebees generate the power needed for flight by shivering their flight muscles and thereby raising the temperature of these muscles to above 30°C. A queen also uses thermoregulation to incubate their broods by producing heat in their thorax that is transferred to her abdomen by pulsating contractions of her abdomen.

A bumblebee queen expends **a great deal of energy** during thermoregulatory activities. Since her brood requires her close physical presence, otherwise they would rapidly cool, **queens**

require plentiful supplies of flowers near the nest to ensure the viability of the coming season's colony.

- Even if a flower has a morphology that allows a bumblebee to readily access its rewards, **it takes time for the bumblebee to learn to handle flowers with complex structures** (Goulson, 2010). Research has shown that insects frequently do not retain or quickly recall effective handling methods when foraging among several plant species with varying flower structures. Therefore, considering the fact that bumblebee flights consume significant amounts of energy, they must make economic decisions when presented with fields containing a selection of flowers with varying nutritional rewards, structures, fragrances, and colors, with each species spread out unevenly.

Constructing bumblebee habitats

The following recommendations for constructing bumblebee habitats take the above-mentioned factors into consideration:

- **Use block plantings:** Habitats with blocks of flowers within which bumblebees can forage from the same species allow them to conserve their energy both in terms of distance flown and decision making. In addition, we have found from our own research involving the establishment of biodiverse meadows from seed that certain species, including *Monarda fistula* and *Solidago* spp., tend to dominate the plantings. As a result, although a seed mix may contain species with various bloom periods during the year, the proportion necessary to support pollinator populations throughout the growing season rarely exists. Block plantings mitigate this problem.
- **Early blooming species** are critical. Include early spring, nectar-rich flowers such as pussy willows (*Salix discolor*), spice bush (*Lindera benzoin*), and American Hazelnut (*Corylus americana*).
- The percentage of **land in bloom at any one time would increase as the season progresses** since the number of pollinators would grow as the daily temperatures increase. Therefore, if the average New England growing season lasts nine months and a perennial crop, such as blueberries, presents floral resources for one of those months, a pollinator habitat would need to provide resources for eight additional months. The months of June, July, and August require a greater number of floral units compared to that of the other months (Dicks *et al.*, 2015), the size of those blocks in summer bloom would need to be proportionally larger while also taking into account the relatively higher density of floral units summer species tend to present.
- Neighboring habitats with native wildflower plantings to support pollinator populations should equal 1-3% of the area occupied by the crop requiring pollination services (Dicks *et al.*, 2015).
- Linear habitats (hedgerows, fence lines, and woodland edges) benefit buzz pollinators. Lands with linear features usually have a higher density of bumblebee nests (20-37 nests per Ha) compared to non-linear features such as woodlands or meadows (11-15 nests per Ha) (Osborne *et al.*, 2008). Hedgerows, which can provide a significant portion of the early spring blooms, such as willows and ??? should equal between 500 and 2000 meters for each 100 hectares of crops.

- Include native warm-season bunch grasses as nesting habitats for wild, native ground-nesting bee species, such as *Bombus*.

References:

Buchmann, S.L. 1985. Bees Use Vibration to Aid Pollen Collection from Non-Poricidal Flowers. *Journal of the Kansas Entomological Society*. 58: 517-525.

Cardinal S, Buchmann SL, Russell AL. 2018. The evolution of floral sonication, a pollen foraging behavior used by bees (Anthophila). *Evolution* 72: 590-600.

Dicks L.V., Baude M., Roberts, S.P.M., Phillips, J., Green, M., Carvell, C. 2015. How much flower-rich habitat is enough for wild pollinators? Answering a key policy question with incomplete knowledge. *Ecological Entomology*. 40 (S1), 22-35

Goulson, D. 2010. *Bumblebees: Behaviour, Ecology, and Conservation*. 2nd edition. Oxford University Press.

Javorek S.K, Mackenzie K.E, Vander Kloet S.P. 2002. Comparative pollination effectiveness among bees (Hymenoptera: Apoidea) at lowbush blueberry (Ericaceae: *Vaccinium angustifolium* Ait.). *Annals of the Entomological Society of America*. 95, 245–351.

Osborne, J. L., Martin, A. P., Carreck, N. L., Swain, J. L. , Knight, M. E., Goulson, D., Hale, R. J., and Sanderson, R. A . 2008. Bumblebee flight distances in relation to the forage landscape. *Journal of Animal Ecology*. 77: 406–415.

Willmer, P.G., Bataw AAM, & Hughes JP. 1994. The superiority of bumblebees to honey bees as pollinators: insect visits to raspberry flowers. *Ecological Entomology*. 19: 271–284.

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