

BUZZ POLLINATION: A STUDY BEE VIBRATIONS ON FLOWERS

Yashwant^{1*}, Dr. Gajendra Chandrakar² and Dr. Sonali Deole²**Abstract: -**

Buzz pollination is a specialized process in which bees use rapid body vibrations to release pollen from flowers with concealed or poricidal anthers. The vibrations produced by bees are transferred through their bodies to the flower and anthers, causing pollen grains to be expelled. Bee size, behaviour, vibration frequency, amplitude, and duration influence the efficiency of pollen release. The structure, stiffness and material properties of flowers also affect vibration transmission. This process plays an important role in the relationship between bees and flowering plants.

Introduction:

Buzz pollination, also called buzz sonication, is a specialized feeding and pollination behavior where certain bees vibrate their flight muscles to shake trapped pollen out of tubular or pore-bearing flower structures.

Buzz pollination is a type of pollination in which because vibrations to remove and collect pollen from flowers incidentally fertilising them (Buchmann, 1983). Recently, there has been a surge of interest in the study of buzz pollination, from documenting the macroevolution of buzz-pollinated floral morphologies (Dellinger *et al.*, 2019) to

characterising buzz pollination ecology and behaviour in both field (Mesquita Neto *et al.*, 2018) and laboratory settings (Whitehorn *et al.*, 2017). The balance between antagonistic and mutualistic interactions between plants and pollinators (Mesquita-Neto *et al.*, 2018).

Examples of bees visiting buzz-pollinated flowers. Clockwise from top left: Sweat bee (possibly *Augochlora* or *Augochloropsis*, Halictidae) on *Tibouchina* sp. (Melastomataceae) in Brazil; carpenter bee (*Xylocopa* sp.) on *Tibouchina* sp. in Brazil; unidentified bee on *Solanum houstonii* (Solanaceae) in Mexico; bumblebee (*Bombus*

Yashwant^{1*}, Dr. Gajendra Chandrakar² and Dr. Sonali Deole²

^{1*} Ph.D. Scholar, Department of Entomology, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya Raipur, Chhattisgarh, India

²Principal Scientist, Department of Entomology, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya Raipur, Chhattisgarh, India

sp., Apidae) on *Senna alata* (Fabaceae).

Buzz-pollinated crops produce can also have non-food uses. The Kangaroo apple or Poroporo (*Solanum aviculare* G. Forst.) is used in pharmaceuticals (Weavers 2010) and the fruits of the American black nightshade (*Solanum americanum* Mill.) have been identified for their medicinal properties (Lim 2015).

producing bees are thought to pollinate plants with poricidal anthers the most frequently or exclusively, bees employ vibrations to harvest pollen from a variety of blooms (Kaundil and Singh., 2022).

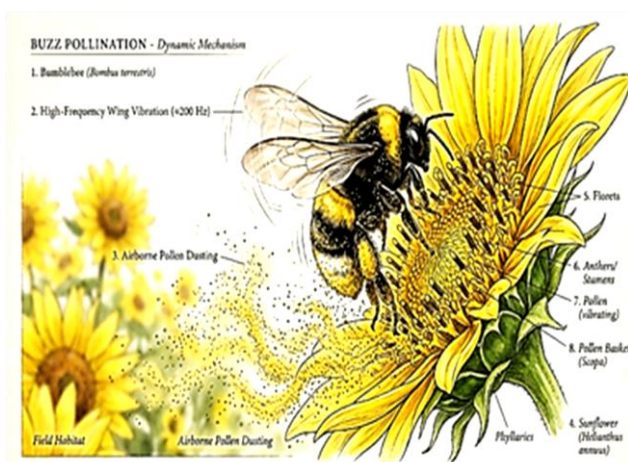
Buzz pollination is a bee-flower interaction that combines two related but distinct phenomena: (1) bee vibration production and (2) the impact of those

Table 1. Buzz-pollinated food crops consumed on global or regional scales

Common name	Species	Family	Poricidal anthers	Pollinators commonly used
Kiwi	<i>Actinidia deliciosa</i>	Actinidiaceae	Yes	<i>Bombus</i> , <i>Apis</i> , wild pollinators
Tomato	<i>Solanum lycopersicum</i>	Solanaceae	Yes	<i>Bombus</i> , <i>Melipona</i> , wild pollinators
Eggplant	<i>Solanum melongena</i>	Solanaceae	Yes	<i>Bombus</i> , <i>Melipona</i> , wild pollinators
Lowbush Blue berry	<i>Vaccinium angustifolium</i>	Ericaceae	Yes	<i>Bombus</i> , <i>Apis</i> , <i>Osmia</i> , wild pollinators
Cranberry	<i>Vaccinium oxycoccos</i>	Ericaceae	Yes	<i>Bombus</i> , <i>Apis</i> , <i>Osmia</i> , wild pollinators

Buzz pollination: Interaction between bees and flowers

Buzz pollination is the interplay between plants with distinctive flower morphologies and a specific sort of behaviour exhibited by some bees-bees are the only creatures that harvest pollen using vibrations. Although bees harvest pollen from flowers of various morphologies using vibrations, most of these flowers feature poricidal anthers, which are found in about 6% of angiosperm species across many families. Although vibration-



vibrations on pollen release. There are more than 20,000 species of flowering plants with poricidal anthers and these are mainly

pollinated by bees that use floral vibrations to remove pollen. Classic examples of buzz-pollinated flowers with poricidal anthers include the 1,300 or so species of *Solanum* (including tomatoes, potatoes and aubergines) as well as most species in the tropical family *Melastomataceae*.

Bee vibrations

Floral vibrations are affected by bee species, shape and behaviour: The mechanical parameters of vibrations are influenced by bee features like as species identity, individual size, and behaviour. Vibrations are produced by bees in a variety of situations, including communication, defence and pollen gathering. Despite the fact that these various vibrations are produced by the same process of thoracic muscular contractions. Even while visiting the same plant species, bee species fluctuate in the frequency of floral vibrations they create, and the same bee species produces vibrations of varying frequency and length when visiting various plant taxa.

Characterising floral vibrations

Buzz pollination takes its name from the audible component or buzz, that can be heard when a bee vibrates a flower (Macior, 1964). For this reason, the behaviour in which bees produce vibrations while collecting pollen from flowers is often called sonication (Cardinal *et al.*, 2018). The vibrations produced by the thoracic muscles are

transmitted to the flower via direct physical contact of the bee's body including the head (bees usually bite the anthers while vibrating (Russell *et al.*, 2016) thorax, abdomen and to a lesser extent the legs. Sonication (applying sound to agitate particles), therefore, may be a misleading term when used in the context of pollen extraction, and it may be best to use floral vibrations or vibrations on flowers.

Bee vibrations: acoustic and substrate-borne components

Floral vibrations are relatively complex. The vibrations produced by bees during pollen collection, can consist of a single continuous vibration lasting up to a couple of seconds or of multiple short vibrations lasting from a few tens to hundreds of milliseconds (Arroyo-Correa *et al.*, 2018). Buzz is an uninterrupted vibration, independently of its duration. Floral vibrations contain a fundamental frequency (100–400 Hz), which often coincides with the peak or dominant frequency and multiple harmonics of rapidly decreasing magnitude (King, 1993).

Measuring vibrations transmitted from the bee to the anther

Direct measurement of the anthers' movement is complicated as the bee partially or entirely covers the anthers while vibrating the flower (Buchmann, 1983), and measuring the vibrations on the bee itself during natural pollination is practically difficult. An indirect

approach consists of using accelerometers attached to another part of the flower, for example, the pedicel (King & Buchmann, 1996) or the calyx (Arroyo-Correa *et al.*, 2018).

Accelerometers can measure movement with high precision, but have the disadvantage of adding a mass to the flower (Cocroft *et al.*, 2014). In contrast, laser vibrometers can measure movement without mass loading (King and Buchmann, 2003). Measurements using either laser vibrometers or accelerometers are usually not taken on the anthers (De Luca *et al.*, 2013).

Impact of vibrations on pollen release

The pollen grains should be expelled out of the apical pore due to centrifugal forces created by the anther tip's acceleration during vibrations, according to theory. Pollen grains are discharged as a result of kinetic energy transmitted from the vibrating anther's interior walls to the pollen grains via elastic collisions. Pollen ejection is a function of anther geometry as well as the frequency and amplitude velocity of the anther's vibrations. In addition to mechanical impacts, electrostatic interactions between pollen grains and anther walls have been reported to play a substantial role in pollen expulsion from anthers.

Is buzz pollination an evolutionary dead end?

Many buzz-pollinating bees, like bumblebees (*Bombus* spp.), are generalists and will seek pollen on buzz-pollinated and non-buzz pollinated flowers. Other bees rely more strongly on buzz-pollinated flowers. Several mining bees in the subfamily Oxeinae strongly prefer buzz-pollinated flowers for pollen collection. An exception might be those bees specialising in nectariferous buzz-pollinated flowers, such as the anthophorid (digger) bee *Habropoda laboriosa*, a blueberry specialist.

Conclusion

Buzz pollination is a specialized bee–flower interaction in which rapid bee vibrations release pollen from poricidal anthers. Vibration frequency, amplitude, duration, bee traits and floral structure determine pollen-release efficiency. This mechanism is essential for the reproduction of many plants and the complex mutualistic relationship between bees and flowering plants.

References

1. Arroyo-Correa, B., Beattie, C.E. & Vallejo-Marín, M. (2019). Bee and floral traits affect the characteristics of the vibrations experienced by flowers during buzz pollination. *Journal of Experimental Biology*, 222(4), jeb198176.
2. Buchmann, S. L. (1983). Buzz pollination in angiosperms. In C. E.

- Jones & R. J. Little (Eds.), Handbook of experimental pollination biology. Scientific and Academic Editions. pp. 73-113.
3. Cardinal, S., Buchmann, S. L. & Russell, A. L. (2018). The evolution of floral sonication, a pollen foraging behavior used by bees (Anthophila). *Evolution*, 72(3), 590-600.
4. Cocroft, R. B., Hamel, J., Su, Q. & Gibson, J. (2014). Vibrational playback experiments: Challenges and solutions. In R. B. Cocroft, M. Gogala, P. S. M. Hill, & A. Wessel (Eds.), *Studying vibrational communication*. Springer, pp. 249-274.
5. De Luca, P. A., Bussière, L. F., Souto-Vilarós, D., Goulson, D., Mason, A. C., & Vallejo-Marín, M. (2013). Variability in bumblebee pollination buzzes affects the quantity of pollen released from flowers. *Oecologia*, 172(3), 805–816.
6. Dellinger, A. S., Chartier, M., Fernández-Fernández, D., Penneys, D. S., Alvear, M., Almeda, F., Michelangeli, F. A., Staedler, Y., Armbruster, W. S., & Schönenberger, J. (2019). Beyond buzz-pollination—Departures from an adaptive plateau lead to new pollination syndromes. *New Phytologist*, 221(2), 1136-1149.
7. Kaundil, P., & Singh, S. (2022). Bee vibrations on flowers: A study of buzz pollination. *Just Agriculture Multidisciplinary e-Newsletter*, 2(9), 18-21.
8. King, M. J. (1993). Buzz foraging mechanism of bumble bees. *Journal of Apicultural Research*, 32(1), 41-49.
9. King, M. J., & Buchmann, S. L. (1996). Sonication dispensing of pollen from *Solanum laciniatum* flowers. *Functional Ecology*, 10(4), 449-456.
10. Lim, T. K. (2013). *Edible medicinal and non-medicinal plants: Volume 6, fruits*. Springer. <https://doi.org/10.1007/978-94-007-5628-1>
11. Macior, L. W. (1964). An experimental study of the floral ecology of *Dodecatheon meadia*. *American Journal of Botany*, 51(1), 96-108.
12. Mesquita-Neto, J. N., Blüthgen, N., & Schlindwein, C. (2018). Flowers with poricidal anthers and their complex interaction networks-Disentangling legitimate pollinators and illegitimate visitors. *Functional Ecology*, 32(10), 2321–2332.
13. Russell, A. L., Leonard, A. S., Gillette, H. D., & Papaj, D. R. (2016). Concealed floral rewards and the role

of experience in floral sonication by bees. *Animal Behaviour*, 120, 83–91.

14. Weavers, G. M. (2010). *Ecological, genetic and cultural status of Solanum aviculare, poroporo (Solanaceae)* [Doctoral dissertation, The University of Waikato]. University of Waikato Research Commons.
15. Whitehorn, P. R., Wallace, C., & Vallejo-Marín, M. (2017). Neonicotinoid pesticide limits improvement in buzz pollination by bumblebees. *Scientific Reports*, 7, Article 15562.

