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Buzz Pollination

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Approximately 60% of flowering plant species have flowers with anthers opening through microscopic pores or holes. Bees efficiently extract pollen from these specialized flowers by vibrating their anthers, a behaviour that has evolved throughout time. Bee morphology and behaviour impact vibrations and their transfer from the bee to the anther, influencing pollen release and plant health. To understand the evolution of buzz pollination, researchers must investigate the biomechanics of bee vibrations and their transmission to flowers.

Key words: bees, behaviour, buzz pollination, floral evolution, sonication, vibrations

Introduction

Buzz pollination, a specialized pollination process offered by bees, most notably bumblebees, involves extracting pollen from flower anthers using vibrations generated by the bees' bodies. This mechanism enhances pollen transport to the stigma, allowing fertilization even in blooms that are not naturally suitable. The phrase "floral sonication" refers to the unique vibration-induced sound produced during pollen gathering. This specialized pollination system is found in over 20,000 flowering plant species, including economically significant crops like tomato, potato, and kiwi. Buzz pollination has been documented in 74 genera, accounting for around 58% of bee species. The interaction of floral structures with the anatomical, physiological, and behavioural characteristics of pollinators is crucial in influencing the ecological and evolutionary results of this complex plant-pollinator relationship.

What mechanism does a bee use to create vibrations in flowers?

During buzz pollination, a bee grasps anthers or other floral structures and vibrates them with its thoracic muscles while keeping its wings folded and non-flying (neopterous condition). These vibrations cause pollen to be discharged onto the bee's body, where it combs and collects it before returning to the nest. Floral vibrations are aided by the bee's flight muscles, particularly the dorsal longitudinal and dorso-ventral muscles, which are attached to the interior of the thorax and are principally responsible for flying power. These muscles contract at a pace that is not directly proportional to the frequency of brain impulses, indicating an asynchronous nature. Some insects with stretch-activated muscles can modulate their overall power output using brain signals. However, in buzz pollination, the self-sustaining cycle of muscular contractions enables a much higher frequency of vibrations than would be achievable without stretch-activated muscle involvement. The frequency of floral vibrations can exceed 300 Hz, with some species capable of reaching up to 400 Hz. The vibrations generated during buzz pollination differ slightly from those produced during flight, with the characteristics of floral vibrations being influenced by both the bee's nervous system and the biomechanics of its body.

Buzz pollination-pollinated plants

Bees buzz pollinate flowers with varied floral morphologies. Many buzz-pollinated flowers have poricidal anthers, which open only through microscopic pores or holes at their tips. These anthers are often big, brightly coloured, and easily visible to potential pollinators. Because of their size and shape, these anthers cannot be efficiently pollinated by conventional pollinators, necessitating the use of buzz pollination for fertilization. In some situations, the petals of these flowers reflex away from the anthers, which frequently create a cone-shaped structure in the center of the flower. Buzz pollination pollinates the following plants such as; Kiwi, Sesame, Cowpea, Heliamphora, Blueberry etc.

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

Common name(s)	Species	Family	Poricidal anthers	Pollinators commonly used	Place of origin	Scale of cultivation	Top producers
Kiwi	*Actinidia deliciosa*	Actinidiaceae	Yes	*Bombus*, *Apis*, wild pollinators	China	Large scale-global	China, Italy, New Zealand
Tamarillo, Tree Tomato	*Solanum betaceum*	Solanaceae	Yes	--	Andes	Large scale - global	Colombia, South Africa
Bush Tomato	*Solanum chippendalei*	Solanaceae	Yes	--	Australia	Small scale - regional	--
Wild Tomatoes	*Solanum habrochaites, S. chilense, S.*	Solanaceae	Yes	--	Ecuador, Peru	Small scale - regional	--
Tomato	*Solanum lycopersicum*	Solanaceae	Yes	*Bombus*, *Melipona*, wild pollinators	Americas	Large scale-global	China, India, United States
Eggplant	*Solanum melongena*	Solanaceae	Yes	*Bombus*, *Melipona*, *wild pollinators*	India or Africa	Large scale-global	China, India, Egypt
Pepino Dulce, Sweet Cucumber[b]	*Solanum muricatum*	Solanaceae	Yes	--	South America	Large scale – regional[b]	Chile
Currant Tomato	*Solanum pimpinellifolium*	Solanaceae	Yes	--	Ecuador	Small scale – regional	--
Lulo de	*Solanum*	Solanaceae	Yes	--	South	Small scale	--

Bee species that use buzz pollination

Only around half of the bee species, including huge carpenter bees and tiny sweat bees, can buzz pollinate flowers. Bumble bees and carpenter bees can emit buzzes with enough acceleration to release pollen from poricidal anthers, while honeybees (*Apis mellifera*) are unable to do so.

Some buzz pollinating species are as follows:

- *Bombus terrestris*
- *Euglossa* sp.
- *Melipona* sp.
- *Xylocopa frontalis*
- *Xylocopa fenestrata*
- *Xylocopa pubescens*

Bee vibration types

In the end, all vibrations created by bees can be traced back to the contraction of the energy draining indirect flight muscles. Bee buzzes are divided into three categories:

- thermogenic activity, which produces heat with little or no thoracic oscillations.
- thoracic oscillations, which drive wingbeat and enable bees‟ flight.
- non-flight vibrations, which produce air- or substrate-borne vibrations and are associated with communication, defense, and vibratile pollen collection.

Effect of buzz properties on pollen release

Floral vibrations differ in frequency, pitch, length, and volume. These factors have an impact on the amount of pollen released during buzz pollination. During floral vibrations, high velocity and high acceleration buzzes favoured more pollen release. Floral vibrations produced by buff-tailed bumble bees, *Bombus terrestris*, have higher velocities and accelerations than vibrations produced during flight or defense. Furthermore, the amount of pollen released by a particular buzz can vary over time. When buzzed at frequencies like those employed by bees (less than 400 Hz), older virgin *Primula conjugens* (Primulaceae) blooms produce more pollen than younger virgin blossoms. Because of the ecological connection between plants and bees via biomechanics and behaviour, buzz pollination is an important subject for exploring the mechanical ecology of plant insect interaction.

Conclusion

Buzz pollination is the evolution of specific flower morphologies and pollinator behaviours in which bees use vibrations (floral buzzes) to harvest pollen. This specialised pollination method has evolved in hundreds of blooming plants, including agriculturally vital crops like tomatoes and potatoes. Many plant species rely on buzz-pollinating bees for successful pollination, hence the recent global reduction in bee populations is very worrying. Buzz pollination provides an intriguing avenue for investigating the biomechanical, physiological, behavioural, and ecological interactions between flowers and pollinators, emphasizing the evolutionarily widespread and ecologically relevant mutual relationship between these species.

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