POLLINATORS: THE PLANT PROPAGATORS

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Plants court a variety of animal pollinators to ensure their own genetic diversity. This article explores the diversity of mechanisms that plants use to attract specific pollinators, showing how these co-evolving mutualistic relationships matter to life on Earth.

"Life did not take over the globe by combat, but by networking" – Lynn Margulis.

The famous evolutionary biologist Lynn Margulis held the view that life evolved on this planet not through a competition for survival but by collaboration between life forms in order to survive. What better example of this than the process of pollination, where plants and animals interact for mutual benefit!

Pollination is vital to the survival and propogation of a variety of plant species on Earth, especially those that reproduce by sexual means. Such plants have evolved to minimize self-fertilisation by separating their mature male and female reproductive cells in space or time (or both). One example of this is seen in plant species where mature male and female reproductive organs are located in different flowers on

Fig. 1. Lynn Margulis.

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Origins of pollination studies:

Our understanding of pollination by animals is based on the work of many scientists.

Joseph Gottlieb Kölreuter (1733-1806) played a pioneering role in this field. He published a "preliminary report" called Vorläufige Nachricht in 1761. This report described different modes of animal-mediated pollination, the sexual characters of flowers, as well as the hybridization of plant species. Kölreuter's work was based on a series of experiments where plants secluded from insects failed to produce fruit.

His initial findings were subsequently supported by the results of extensive studies conducted by scientists like Sprengel (1793), Vogel(1996), Charles Darwin (1859), Hermann Müller(1873) and Grant(1952) among others.

Fig. 2. Joseph Gottlieb Kölreuter.

Source: Materialscientist, Wikimedia Commons. URL: https://commons.wikimedia.org/wiki/File:Josef_Gottlieb_Koelreuter.jpg. License: CC-BY.

the same or two different plants. The only way fertilization can occur in such plants is through a mediator, one that is capable of transferring the pollen from one flower (called the pollinizer) to the stigma of another. These mediators, indispensable to cross-fertilisation, are what we commonly call pollinators.

Current estimates suggest that about 200,000 species of animals pollinate about 75% of all flowering plants! Animal pollinators come in different sizes and shapes – ranging from insects and birds to mammals and reptiles. It is no wonder, then, that plants have evolved a variety of features to attract a particular type of pollinators. Ranging from bright colours for those with great eyesight to fragrance for those who don't – these features are called pollination syndromes. This coevolution of flowering plants and their pollinators shows one of nature's most conspicuous examples of adaption and specialization. It also reveals how the interaction between two groups of organisms can be a font of biodiversity.

Let's take a look at some interesting examples of pollinizer-pollinator associations, exploring how these mutualistic relationships shape both interacting partners.

Insects as pollinators

Insects constitute the largest community of pollinators. As Joseph Gottlieb Kölreuter said *"und wahrscheinlich leisten[Insekten]wo nicht den allermein pflanzen, dochwenigstens einem sehr großen Theil derselben, diesen ungemein großen Dienst"* meaning, *"Insects probably provide this uncommonly great service, if not to most plants, then at least to a very large portion of them."* Prominent among them are bees, butterflies, moths, beetles, wasps, flies and ants.

Fig. 4. Pollen baskets on pollinating honey bees.

Source: Fifamed, Wikimedia Commons. URL: https://commons.wikimedia.org/wiki/File:Honeybee_pollen_basket.JPG. License: Public Domain.

With about 20,000 species involved in plant pollination, bees are some of the most important insect pollinators. Bees depend on plants not only for the nectar they provide – their main food source, but also for pollen – which they use to feed their larvae. The "intelligence" of these pollinators is evident in their ability to perceive, differentiate between, and remember the appearance of flowers they visit. On each visit, bees rub their bodies against the anthers of the flower they land upon. The pollen from these anthers sticks to dense hairs on their hind legs, referred to as a pollen basket, and is transferred to the next flower the bee visits. Bee-pollinated plant species use a variety of mechanisms to look appealing to these insects. Since bees rely heavily on their sense of smell, flowers of these plants often have a strong fragrance. Their flowers are bright yellow or blue in colour, attracting bees even from a distance. This is because bees have trichromatic vision, with their eyes containing pigments sensitive to green, blue, and ultraviolet light, but blind to red colour (which appears black to them). Many floral species offer a special landing platform, in the form of a broad lower lip, to their bee pollinators. Thus,

The idea of co-evolution:

This idea of coevolution was first proposed by Charles Darwin who predicted that a long-spurred Madagascar orchid, *Angraecum sesquipedale*, must be pollinated by a hawkmoth with an extraordinarily long tongue.

This idea was supported by naturalists like Alfred Wallace, and a hawkmoth matching the expected tongue-length profile was finally discovered in Madagascar during the early twentieth century.

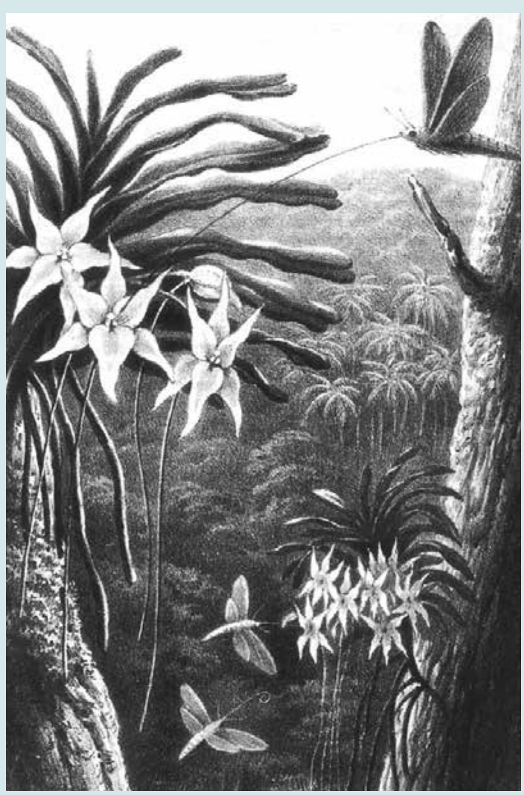

Fig. 3. An illustration by Thomas William Wood, based on Alfred Russel Wallace's description, showing a moth pollinating *A. sesquipedale*. Remarkably, this was drawn in 1867, before the moth was even discovered.

Source: Wallace, Alfred Russel (October 1867). "Creation by Law". The Quarterly Journal of Science 4 (16): p. 470. London: John Churchill & Sons. Retrieved on 2009-07-30. Uploaded by Dmitriy Konstantinov, Wikimedia Commons. URL: https://en.wikipedia.org/wiki/File:Wallacesesquipedale.jpg. License: CC-BY.

bee-pollinated flowers generally show bilateral rather than radial symmetry. Often, flowers have lines or other distinct markings, with special UV reflection patterns, which may function as honey guides or nectar guides. Ostensibly, these may seem to have evolved to lead bees to nectar; in reality, they ensure that bees reach the places that the flower 'wants' them to reach. Bee pollinated flowers also offer large amounts of nectar and pollen to their visitors. In fact, the pollen collected by a single honeybee colony may amount to more than 28 kg per year.

Fig. 5. UV-reflective nectar guides on flowers of *Potentilla reptans* visible to bees.

Source: Wiedehopf20, Wikimedia Commons. URL: https://commons.wikimedia.org/wiki/File:Flower_in_UV_light_Potentilla_reptans.jpg. License: CC-BY-SA.

Although bees are the most talked about insect pollinators, beetles comprise the largest set of pollinators, responsible for pollinating about 85% of all flowering plants, including species like spicebush and magnolia. Since beetles don't have good sense of vision, flowers pollinated by them are usually white or dull coloured. Some beetle-pollinated flowers don't produce nectar; instead they provide these insects with pollen, or have food present on the petals in special storage cells, which pollinating beetles consume. Beetles often eat their way through floral parts, and even defecate within flowers – they are hence nicknamed as 'mess and soil' pollinators.

Although the sight of their colourful bodies perching on flowers is always a treat to the eyes, butterflies are less efficient than bees at transferring pollen between plants. Not only do they not

Fig. 6. An example of beetle pollination – a scarab beetle on *Encelia californica*.

Source: Marshal Hedin (uploaded by Jacopo Werther), Wikimedia Commons. URL: https://commons.wikimedia.org/wiki/File:Scarab_beetle_on_Encelia_californica_(3376142862).jpg. License: CC-BY.

possess any specialized structures to collect pollen; with their slender bodies held high on their long thin legs, not much pollen sticks to their bodies. Butterflies are often found hovering around bright yellow, blue or orange flowers, and sometimes red flowers too, for nectar. The nectaries of these flowers are at the bases of their spurs or corolla tubes that are accessible to only moths and butterflies with long proboscis. Night-flying moths visit flowers that are white- or pale-colored and stand out against their darker backgrounds in moonlight or starlight.

Fig. 7. An example of a butterfly pollinator – the Dark Blue Tiger.

Source: Jeevan Jose (Jkadavoor), Wikimedia Commons. URL: https://commons.wikimedia. org/wiki/File:Dark_Blue_Tiger_tirumala_septentrionis_by_kadavoor.JPG. License: CC-BY-SA.

Other insects like short-tongued flies pollinate flowers, like the Stapelias of Africa, that smell like rotten meat. These flowers are dull red or brown and are, often, called carrion flowers due to their pungent odour and appearance.

Fig. 8. An example of night-flying moth pollination – *Manduca sexta* (Carolina sphinx moth) feeding from a *Datura wrightii* flower.

Source: Kiley Riffell Photography. For use with credit by Henry Art Gallery. URL: https://www.flickr.com/photos/115381928@N03/14255320758. License: CC-BY-NC.

Fig. 9. *Stapelia gigantea* being pollinated by flies.

Source: Ton Rulkens, Wikimedia Commons. URL: https://commons.wikimedia.org/wiki/File:Stapelia_gigantea_-_fly_pollination_(5587930978).jpg. License: CC-BY-SA

The orchid family, with about 35,000 species, is visited by all these types of insect pollinators. The pollen grains of most orchids are produced in tiny sac like structures called pollinia that have special sticky pads at the bases. When an insect visits such a flower, the pollinia stick to its head. The 'glue' of the sticky pads dries immediately, causing the pollinia to attach strongly. In some orchids, the pollinia are forcibly slapped onto the pollinator through a trigger mechanism within the flower. *Ophrys*, a genus of orchids found in North

Africa and Europe, has a modified petal resembling a female bumblebee or wasp. Male bees or wasps that emerge from their pupal stage a week or two before the females, mistake the orchid flowers for potential mates. While they are trying to mate with the flowers, pollinia get attached to their heads. When they move on to another flower, the pollinia gets caught in the sticky stigma. On every visit by a pollinator, the pollinia removed from one flower is replaced by the pollinia it has collected from the previous flower it has visited. The pollinia of orchids that are pollinated by butterflies and moths get attached to their long proboscis with sticky clamps instead of pads.

Fig. 11. Bog orchids are pollinated by mosquitoes.

Fig. 10. ***Ophrys speculum*** **or bee orchids which get pollinated by pseudo-copulation.**

Source: Carsten Niehaus, Wikimedia Commons. URL: https://commons.wikimedia.org/wiki/File:Ophrys_speculum_d.JPG. License: CC-BY-SA.

Some bizarre pollination mechanisms have also been observed in orchids. In some bog orchids, for example, pollinia get attached to the eyes of their pollinators – female mosquitoes. Thus, with repeated visits, these mosquitoes get blinded. In another weird mechanism, the pollinator gets plunged in a pool of watery secretion produced by the orchid. The only way the pollinator can escape from this pool is by pushing itself through a trapdoor, the route to which is such that contact with pollinia and the surface of the stigma is ensured. Some orchids produce very strong narcotic scents intoxicating pollinators before slowly attaching their pollinia to them. As soon as the transfer of pollinia is completed, the fragrance of the orchid fades abruptly. The temporarily dazed insect comes back to its senses and flies away, carrying the pollinia along with it.

Birds as pollinators

Birds do not have a strong sense of smell, but they have exceptional vision. They visit flowers that are bright red or yellow in colour, with mild or no odour. Bird-pollinated flowers are usually large, in the form of an inflorescence (flower cluster) and, in some cases, grow on tree trunks. They also produce large

Unusual Pollinators:

The role of lizards in pollination has only been recognized recently. Studies have revealed that lizards help the survival of many plant species, particularly on islands, by pollinating them. This unusual behavior can be attributed mainly to the high population densities of island lizard species, an excess of floral food, and relatively low risk of predators as compared to the lizards on the mainland. Island lizards often drink nectar from flowers and eat the pulp of fruits of many plant species, even though the protein content of both these food sources is quite low.

Fig. 12. A lizard pollinating a flower.

In New Zealand, Hoplodactylus geckos are only attracted to the nectar in flowers, not the pollen. Strongly scented flowers are another important attraction as lizards have an acute sense of smell. Also, flowers must be robust enough to support the weight of the pollinator while feeding.

A more intricate pollination system suggesting a common evolutionary history is that between *Phelsuma* geckos and the many different plants found on the islands in the Indian Ocean. In 1998, Olesen and co-workers reported that the puzzling blood-red nectar produced in the flowers of the endemic Mauritian plant species, *Nesocodon mauritianus* and *Trochetia boutoniana*, and the yellow nectar in *Trochetia blackburniana* acted as an attractant for *Phelsuma* geckos, who preferred visiting flowers with coloured nectar rather than those with colourless nectar.

Fig. 13. Hummingbird pollinating *Fuchsia*.

Source: Togzhan Ibrayeva, Wikimedia Commons. URL: https://commons.wikimedia.org/wiki/File:Hummingbird_in_search_for_nectar.jpg. License: CC-BY-SA.

amounts of nectar, often in long floral tubes that keep most insects out.

Some birds, like the sunbirds of Africa and hummingbirds of America, are uniquely adapted to the flowers they pollinate. Hummingbirds are attracted to many types of flowers, including Hibiscus, Cannas, honeysuckles, Salvia, Fuchsia, etc. Some Fuchsia have long threads projecting from each pollen grain. When a hummingbird inserts its typically elongated bill into such a flower, the pollen grain threads stick on to the short, stiff hairs located toward the base of its bill. In this way, the bird unsuspectingly transfers pollen from one flower to another.

Bats as pollinators

Most bat species that act as pollinators are found in Southeast Asia, Africa and the Pacific islands. Plants pollinated by bats often have white or pale flowers that bloom at night and are large or have ball-like inflorescences. Many of these flowers have large amounts of nectar, and emit a strong fruity or musky odour that attracts bats. This smell is produced due to the presence of sulphur-containing compounds, specially found in those flowers that are pollinated by bats. Bats use these chemical signals to locate these flowers.

This relationship is of great significance as about 500 tropical plant species, including mangoes, litchi, bananas, and guavas, depend – either partially or completely – on bats for pollination. Pollination by bats has also greatly influenced the genetic diversity of plants in these regions.

Fig. 14. Mexican long-tongued bat pollinating Agave flowers.

Source: U.S. Fish and Wildlife Service Headquarters (uploaded by Dolovis), Wikimedia Commons. URL: https://commons.wikimedia.org/wiki/File:Choeronycteris_mexicana,_Mexican_long-tongued_bat_(7371567444).jpg. License: CC-BY.

Conclusion

Although we've explored only a few plant-pollinator associations as examples, these are sufficient to show how strongly these mutualistic associations influence the propagation of plant species, and thus play a pivotal role in the survival of all life on this planet.

The significance of pollinators is aptly highlighted in these words of E. O. Wilson, an American biologist, researcher, theorist, naturalist and author, *"If we were to wipe out insects alone on this planet, the rest of life and humanity with it would mostly disappear from the land. Within a few months."*

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