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Beetles as Forgotten Pollinators: Revisiting Ancient Alliances in Modern Ecosystems

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The most varied order of insects, beetles were among the first to pollinate flowering plants, but pollination research and conservation initiatives still mostly ignore them. This article focuses on the past and present roles of beetles in plant-pollinator relationships, stressing the fossils, synergistic associations with ancient flowering plants such as Magnolia, and modern systems, for example, *Acrocomia aculeata*. Moreover, more advanced studies show that beetles have deceptively polymorphic flowers, underscoring ecological complexity. For holistic management of ecosystems and integrated conservation planning, it is important to recognize beetles as crucial pollinators.

Keywords: Pollination Ecology, Fossil Evidence, insect-plant interactions, *Acrocomia aculeata*, Magnolia species, Coleoptera

Introduction

Pollination plays an important role in the reproduction of flowering plants and is fundamental to maintaining global food security and biodiversity. Although they are sometimes disregarded, beetles have a considerably earlier evolutionary association with blooming plants and are still crucial pollinators in a variety of environments, whereas bees, butterflies, and flies are well known for their pollination functions. Beetles belonging to colepterans are considered among the earliest pollinators of angiosperms. Despite their long-standing ecological role, they are still largely absent from mainstream pollination research, conservation programs, and policy discussions.

Beetles and the Origins of Pollination

The interaction between beetles and early flowering plants represents one of the most ancient examples of insect-plant relationships. A well-known instance of this is seen in *Magnolia* species, which are among the earliest angiosperms. These plants possess floral characteristics specifically suited for beetle pollination, including large, bowl-shaped flowers, robust floral structures, and the emission of sweet fluids and fruity aromas (Hooks and Espindola, 2020). Such traits not only attract beetles but also accommodate their relatively clumsy movements during feeding. As beetles forage, they unintentionally transfer pollen between flowers, enabling pollination. This long-standing mutualism illustrates a case of co-evolution, where both plant and insect adapt and benefit from their interaction over time.

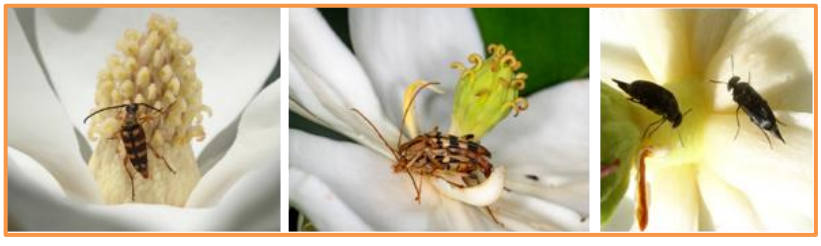

Figure 1: Beetle pollination of magnolia flowers. These images illustrate beetles feeding, mating, and inadvertently transferring pollen within the cup-shaped blooms of magnolias.

Key highlights of *Magnolia* species beetles

- An Ancient Evolutionary Bond: Magnolia species emerged over 100 million years ago, predating the evolution of bees and butterflies. During this period, beetles served as the primary pollinators—a role they continue to fulfill in many Magnolia species today.
- Floral Traits Suited for Beetle Pollination: Magnolia flowers have evolved characteristics that cater specifically to beetle pollinators. Their blossoms are typically large, bowl-shaped, and pale-colored—usually white or cream—relying more on scent than visual signals. The thick, leathery petals are well-suited to withstand beetles' chewing and movement.
- "Mess and Soil" Pollination Mechanism: Beetles often engage in rough foraging behavior, chewing through floral parts and sometimes defecating within the blooms. This process, known as "mess and soil" pollination, may appear destructive, yet it effectively facilitates pollen transfer, as grains adhere to their bodies and are carried between flowers.
- Prolonged Interaction Enhancing Pollination: Inside Magnolia blooms, beetles commonly feed, mate, and rest. This extended presence enhances the chances of effective pollination, as prolonged contact with floral structures increases the likelihood of pollen pickup and deposition during movement between flowers.

Fossil Evidence of Beetle Pollination

The ancient function of beetles in pollination is further supported by compelling fossil data. According to Bao et al. (2019), a fossilised beetle with pollen grains still attached to its legs was found in 99 million years old Burmese amber. With specialised morphological features including pollen-feeding mouthparts and a body tailored for flower visits, this specimen belonged to an extinct beetle species. These fossils shed light on the evolutionary history of pollination disorders in addition to confirming the early significance of beetles in the emergence of flowering plants (angiosperms).

Modern-Day Roles and Underappreciated Systems

In many habitats, beetles remain effective pollinators, despite being overshadowed by the captivating bees. The most common floral visitors to female-phase inflorescences of the coyol palm (*Acrocomia aculeata*) were flower weevils (*Andranthobius spp*.) and little sap beetles (*Mystrops spp*.), according to a recent study conducted in the Colombian Orinoquia by Barrera et al. (2021). These beetles produced an average fruit set of 65.5% and accounted for 90–95% of pollination activity. Characteristics like high visitor rates, floral faithfulness, and pollen-carrying ability were associated with their efficacy. These results highlight how, despite their frequent underappreciation, beetle pollinators can be both dominating and essential in some ecological settings, especially in tropical and subtropical areas with a high concentration of palms and other beetle-pollinated plants.

Deceptive Pollination Strategies

Beetles are the objects of complex floral deceit in addition to their duties as mutualistic partners. A case of sexual mimicry in South African flora was reported by Cohen et al. (2021), in which a plant imitated the look and pheromones of female beetles in order to attract male insects for pollination. Male beetles are attracted to flowers under the guise of mating in this intriguing interaction, and they unknowingly spread pollens. Examples like these demonstrate the variety of beetle methods and the evolutionary inventiveness of plant-pollinator interactions. The beetles find food sources and good places to lay their eggs by using their sense of smell. The flowery fragrances are usually sweet (like Chimonanthus), peppery (like crab apples), or even fermented (like Calycanthus).

Implications for Conservation and Land Management

Beetles are often excluded from pollinator conservation programs eventhough, beetles play major role in pollination. This narrow approach overlooks the wide variety of insects that support plant reproduction. As noted by Hooks and Espindola (2020), conserving beetle pollinators needs a multidisciplinary approach, and it is rarely seen in this case. Stakeholders such as foresters, land owners, entomologists, and conservationists must integrate both natural and agricultural systems for beetle habitat requirements. Additionally, there is also a need to promote and aware people about beetles as pollinators using their ecological importance and their longstanding evolutionary associations with flowering plants. Policies on chemical use, habitat management and provision constant food source should be adapted to support these often-overlooked but essential pollinators. This is needed to recognise the beetles other than the pollinator conservation initiatives.

Conclusion

Beetles, some of the earliest pollinators to emerge in evolutionary history, continue to play a vital role in plant reproduction across a range of species—from ancient magnolias to contemporary palms. Their interactions with flowering plants are both varied and enduring, yet they often go unnoticed in pollination discourse. Acknowledging the significance of beetle pollinators is essential—not only for scientific completeness but also for shaping more inclusive and effective conservation efforts. In the face of a global pollination crisis, expanding our focus beyond the commonly celebrated pollinators is critical to ensuring resilient and sustainable ecosystems.

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