

## A review of ants' mutualistic relationship with plants and their role as pollinators

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### Abstract

Ants are considered to be most important component of the ecosystem because of their abundance. They are the classical nectar thieves and they also act as the ecosystem indicators. Among all the Hymenopteran order, such as bumble bees, honey bees, wasps, solitary bees are adapted to play a very important role in pollination. Ant-plants associations are highly different in all terrestrial habitats, resulting in complex ecological web. Ants are frequent flower visitors; they are attracted towards the floral scents of the flower and this result in cross pollination in flowering plant. The review paper incorporates about the significant role of how ants are attracted to angiospermic flowering plants and their contribution to pollination. A comprehensive study is also done on how ants –plants also play a significant live in mutualism benefitting each other. Thus, the topic ant plant mediated pollination and their mutualism requires certain study in pollination biology. Thus, this study indicates ants are strange bystanders to some angiospermic flowering plants; they are significant pollinators to some flowers.

**Keywords:** Hymenoptera, floral, nectar, ecological, angiospermic, networks

### Introduction

The various pollination techniques used by plants and the insects in both self-pollination and cross-pollination modes allow nature's elegance and beauty to transfer into the seed vessels. Like many insects, of hymenoptera insects that play a significant role in pollination likewise same ants also are frequent visitors of flowering plants, thus ants are adapted to pollination. Insect pollination of flowers is one of the best-known instances of mutualism in nature. Angiosperm plants provide nectar, have reproductive organs that are remarkably fragrant and colorful in nature and are morphologically shaped to entomophily insects in various ways. (Proctor *et al.*, 1996)<sup>[54]</sup>. The extent of this symbiosis and the intensity of interaction between both the sides significantly rely on the specific plant and animal species which are interconnected (Schoonhoven *et al.*, 2005). Hymenoptera order all the members; have developed the most extensive pollination alteration and adaptations of any insect. Specifically, solitary bees, honeybees, and bumblebees only consume pollen and nectar from the flowers. For example, honeybees have developed specialized legs that gather pollen grains in pollen baskets on the tibia after raking them from the entire body. In addition to controlling their body temperature to enable flight in temperatures too frigid for the majority of other insects, their fur is made up of hairs with hooks and teeth that enable the transportation of numerous pollen grains. It is commonly known that honeybees can recognize and differentiate between visual patterns and floral fragrances, which aids in preserving flower fidelity for a set period of moment or time, such as one or more feeding excursions (Tautz, 2008)<sup>[64]</sup>. Although fig wasps are an obvious example, other Hymenoptera also visit plants, but they are less reliant on flowers. The majority of wasps in this order belong to the suborder Apocrita; they are typically parasitoids or predators that consume arthropods while they are developing as larvae (Koffel *et al.*, 2021)<sup>[39]</sup>. Most probably, the very important Hymenoptera order from an

ecological perspective is the ants' insects. The species under consideration greatly influences their preferred food. Some are infamous predators, yet others gather nectar and seeds, or utilize plant leaves to cultivate the fungi as their food (Hölldobler and Wilson, 1990)<sup>[34]</sup>. Flowering plants (Angiospermae), on the other hand, are by far the most dominant taxon of the terrestrial plants. It is therefore not surprising that a plethora of interactions between ants and plants have evolved, which can be facultative or obligate, antagonistic or mutualistic (Rico-Gray and Oliveira, 2007)<sup>[57]</sup>. The symbiotic relationships between ants and myrmecophytic plants, like Acacia and Pseudomyrmex, are well documented. (Heil and McKey, 2003)<sup>[29]</sup>.

The co-adaptation between flowers and insects is a continuous process that builds the relationship by lowering reproductive barriers through pollen transfer. (Macior LW., 1971)<sup>[43]</sup>. When ants work with plants to spread pollen, a well-structured mutualistic relationship forms. (Kawakita A. 1984) Herbivores are repelled by plants; nonetheless, it can be expensive to keep out mutualists, such as hostile guardian ants that ward off hovering pollinators (Ness JH., 2006). As a result, the resource allotment may cause exchange between plant as defensive and their reproductive success (Strauss *et al.*, 1999)<sup>[63]</sup>. An additional "context" for defining a plant's costs may come from its interactions with other species. Foliar herbivory, for instance, can affect floral traits. (Marquis *et al.*, 1999)<sup>[45]</sup>, and thus natural enemy can exert selection pressure that are near to the pollinators' "labor" (Gomez Jm., 2000)<sup>[22]</sup>. Ants well known for being significant pollinators despite the fact that pollination is still the most well researched interaction between insects and higher plants. This chapter examines the function of ants as flyer visitors and possible pollinators. Additionally, we consider what is known about ants like locating food by exploiting ambient volatiles, such as floral odors. This Paper also enhance on the how ants show positive response and mutualism relationship with the plants and how the plants are benefitted by this tiny creature, ants.

## Discussion

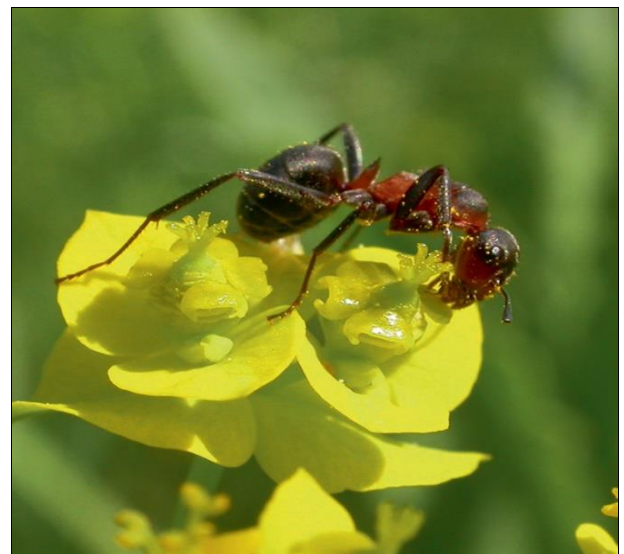
In practically, each terrestrial ecosystem, ant-plant partnerships are common and extremely varied, leading to intricate biological networks. Ant-mediated pollination is rare, despite the prevalence of ant-plant mutualism, and only a handful. Their function in pollination has been shown by research. Ants are repeated flower visitors, although their effect on plant reproductive capability is also acknowledged. The role of many flower-visiting ants in fostering crop hybrid vigor and floral development has been studied.

Ants typically explore for flowers in search of nectar and other food sources, pollinating the flowers they come across in the process. This analysis found the ant-plant pollination networks at the species and family levels. Many factors frequently influence pollination, such as the sex of the bloom, the time of year, the blossoming of flower, the ovary carries, and its position. According to published research, ants only go over on the inflorescences of the same species to encourage "geitonogamy," or also known as cross-pollination.

### 1. How ants act as pollinators

Workers of numerous ant species have frequently been seen visiting flowering plants in order to collect nectar. Therefore, it appears unexpected that there have been so few reports of the visitor group pollinating flowers (Proctor *et al.*, 1996) <sup>[54]</sup>. Although insects pollinate two-thirds of angiosperms, there are only approximately 30 reports that ants pollinate (Peakall *et al.*, 1991; Schoonhoven *et al.*, 2005) <sup>[51]</sup>, and even fewer have tried to empirically verify ant pollination. Ants are said to be nectar thieves because of their diminutive size, which allows them to take advantage of nectar without coming into contact with a flower's anthers or stigmas. Furthermore, regular grooming and a smooth cuticle may inhibit pollen attachment (Barth, 1991). Some ant species have this trait, whereas others are big and hairy because many of the crucial wings pollinators, including solitary bees. Additionally, it has frequently been documented that ants carry pollen (Peakall *et al.*, 1991) <sup>[51]</sup>. It has been suggested that because ants lack wings, they are unable to transfer pollen very far and so do not aid in out-crossing (Schubart and Anderson, 1978) <sup>[62]</sup>. (Peakall *et al.*, 1991) <sup>[51]</sup> showed that ants' foraging habits (and thus the movement of pollen) might occasionally resemble the movements of different winged pollinators by following a leptokurtic distribution with small mean distances. As a result, the authors contend that out-crossing might be possible for ants. Nevertheless, it has also been asserted that individual foragers only visit a single plant for a short time and that within-plant migration persists (Fowler, 1983). It was proposed in the 1980s that the existence of secretions from metapleural glands on the integument of different ant species was the most likely cause of the lack of ant pollination (Beattie *et al.*, 1984). Because of its antibacterial qualities, the secretion produced by these paired glands is actively dispersed throughout the bodies of both adults and larvae, shielding the bearer from harmful bacteria and fungus (Fernandez-Marin *et al.*, 2006; Hölldobler and Engel-Sieglar, 1984; Poulsen *et al.*, 2003) <sup>[33, 53]</sup>. The significant impact on pollen grain viability is a significant side effect of metapleural gland secretion (Beattie *et al.*, 1985) <sup>[4]</sup>. Interestingly, honeybees and wasps do not exhibit such a significant drop in pollen viability, despite the fact

that a large population in their nests creates an environment that is conducive to the growth of numerous diseases (Harriss and Eattie, 1991) <sup>[28]</sup>. However, because ant species differ in the strength of the secretion's biocidal properties, enough viable pollens may still remain adherent on the ant's surface to permit pollination and seed set (Garcia *et al.*, 1995; Gomez and Zamora, 1992; Hull and Beattie, 1988; Ramsey, 1995) <sup>[18, 23, 35, 56, 73]</sup>. Pollen of the ant pollinated orchid *Microtis parviflora*, e.g., did not lose their germinability after contact with the cuticle of *Iridomyrmex gracilis* (Peakall and Beattie, 1989) <sup>[49]</sup>. It remains to be elucidated whether the ant-pollinated plants are characterized by the pollen that is more resistant to the action of metapleural gland secretion. Additionally, if ants developed a secretion that was safe for pollen grains yet powerful against bacteria, it might be an adaptation to pollination. Since only a tiny portion of the pollinia's stalks have an opportunity to adhere to the ant's cuticle, it appears that orchids are frequently better suited for ant pollination. Additionally, a case of a particular city has only been documented within this plant family: *Leporella fimbriata* is pollinated by *Myrmecia urens* ant males through faux copulation. (Peakall, 1989) <sup>[49]</sup>. By harming anthers and pistils or driving away other possible pollinators, ants—who are seen as nectar thieves or even robbers—can occasionally lower a plant's reproductive success (Galen and Butchart, 2003; Gaume *et al.*, 2005) <sup>[17, 19]</sup>. It appears that floral aroma is essential for foraging ants, and floral volatiles are crucial in drawing numerous insect pollinators. Interestingly, there is no clear correlation between volatiles and ants.



**Fig 1:** *Formica* spp. worker bee envelope with colour yellow pollen grains from *Euphorbia cyparissias* flower. (Credit: C. Muller.)

### 2. How plants and ants help in mutualism relationship

The hundreds of mutualisms that ants and plants engage in can be divided into two main categories: defense and dispersal mutualisms. The elaiosome, an appendage of the seed that is utilized as a reward, typically aids in myrmecochory, the process by which ants spread plant seeds. Dispersal mutualisms are facultative since elaiosomes are a nutritional supplement rather than a complete meal. Ants only build their carton nests using the scattered epiphytes as support in ant gardens, and these mutualisms are typically obligatory. In facultative-defensive

mutualisms, plants give foraging ants rewards like extra floral nectar (EFN) or cellular food bodies (FBs) as an indirect defense against herbivores. In contrast, the supply of nesting space is the foundation of obligatory defensive mutualisms. Most terrestrial ecosystems are dominated by ants. They seem to be ideal partners for plant defense and dissemination because of their social structure and mobility. Ants and plants interact in a variety of ways, ranging from highly complex herbivory (exemplified by harvest insects ants or leaf-cutter ants) to mutualisms that are both defensive and transport the mutualism. Mutualism requires that one partner serve the other in order for the other to repay them. While it becomes more difficult for the receiving organism to accomplish this activity on its own when the value of a service increases, the cost of award provisioning falls when the awards can that be generated more simply. As a result, when a mutualism is formed between partners with radically different capacities, the cost-benefit ratio is typically higher. In contrast to plants, ants are mobile, aggressive, and frequently predatory, and they need organic food while plants are primary producers. As a result, the majority of beneficial ant and plant cooperation are either protection or transit mutualisms: Ants protect plants from herbivorous animals or carry seeds, which helps with dissemination. (Rico-Gray and Oliveira, 2007; Heil, 2008) <sup>[57]</sup>. Ants, on the other while, rarely participate in pollination because they are often hairless and do not travel great distances. Ants can receive food rewards, nesting space, or both from plants as compensation for being spread or protected. Talk about the primary kinds of mutualistic ant-plant interactions in this contribution.

### 3. Dispersal by Ants

Myrmecophily, the term for ant dispersal of seeds and fruits, is a very common pattern: ant seed dispersal has evolved over 100 times and is present in four of the seven ant subfamilies and more than 11,000 species from at least 77 plant families (Lengyel *et al.*, 2009) <sup>[41]</sup>. Ant species may disseminate up to 50% of all plants in a given habitat (such as Australian dry forests and European geophytes). The seeds typically have a little, fleshy appendix called an elaiosome. Due to their chemical makeup, elaiosomes can resemble insect prey chemically in certain situations (Brew *et al.*, 1989) and provide ants with valuable food sources (Fischer *et al.*, 2008) <sup>[15]</sup>. The valuable elaiosome is thus chopped off before it is transported to the nest and eaten as food because the ants gather elaiosomes and treat the seeds as garbage. While brood production was significantly decreased, foundresses fed elaiosomes had survival rates comparable to those of foundresses fed a regular diet (Marussich, 2006). As a result, elaiosomes appear to enhance rather than completely replace ants' nutrition. The plants spread extensively because the ants carry the seeds, which frequently make it to the nest and other locations that are identified by nutrient-rich soil. Although the dispersal distances that ants can travel as vectors seem to be limited, myrmecochory is a crucial evolutionary innovation that has significantly fueled the evolution of angiosperm diversity and plays a significant role in ecosystem structuring (Lengyel *et al.*, 2009) <sup>[41]</sup>. When the elaiosome is removed and the seed is placed in the soil, the majority of dispersal mutualisms cease. Due to its proximity to the ant nest, good ventilation, and high nutrient content, this soil will be especially ideal for plantlet germination. As they create their

so-called "ant gardens," which are collections of epiphytes where the roots and occasionally the shoots of the plant provide a structure that the ants use to build their nests, some ant-dispersed epiphytes in the tropics can establish more stable relationships with their specific vectors. Ant gardens have been seen in South America and Southeast Asia, and for many species, the relationships are typically obligatory and particular. (Davidson, 1988; Kaufmann and Maschwitz, 2006; Youngsteadt *et al.*, 2008; Orivel and Leroy, in press) <sup>[10, 38, 71]</sup>. In tropical arboreal ecosystems, ant gardens are an essential structural component. Ant garden colonies can occupy more than one-third of the forest area in the lowland Amazon, for example, and they are the predominant ant species in arboreal ant samples (Davidson, 1988) <sup>[10]</sup>. Seed distribution is the main benefit of growing plants in ant gardens. When seeds are planted in a nutrient-rich, well-structured microsite in an ant garden, they get even more advantages (Blüthgen *et al.*, 2001). Furthermore, because ants often feed on the plants that comprise the garden, they indirectly protect plants against herbivores and drought (Schmit-Neuerburg and Blüthgen, 2007; Heil, 2008) <sup>[61]</sup>. In return, ants receive shelter, which is advantageous to them. Building carton nests is made easier when they can utilize pre-existing plant structures, which offer support similar to that of frameworks or reinforced concrete. Additionally, these plants provide protection from intense rains and help to dry the nests by transpiration (Schmit-Neuerburg and Blüthgen, 2007) <sup>[61]</sup>. Nevertheless, nothing is known about the process by which foraging ants identify seeds. It is currently unknown how ants recognize elaiosomes, which are absent from the majority of ant garden species' seeds. According to preliminary study, certain seed smells may contribute to this interaction (Youngsteadt *et al.*, 2008) <sup>[71]</sup>.

### Conclusion

The generalizations on the significant of the ant as pollinators may be premature, even if an increasing number of studies using rigorous exclusion experiments have shown that ants play a beneficial role in plants growth and reproduction. On the other hand, Ants' role as pollinators may be underappreciated, especially in environments where they the most highly prevalent. This implies that a closer examination of the quantitative component of pollen vectoring is necessary. However, monitoring seed that set might not be enough to demonstrate that ant visits benefit plants, particularly those that depend on allogamy. Future research must demonstrate that ants improve plant fitness by showing that plants pollinated by ants also generate a sizable number of various seedlings. More research is needed to determine if floral scents serve as attractants to aid ant pollination or as repellents to deter honey theft. Ants seem to be especially well-suited as defensive mutualistic due in large part to their social structure, but why do plants depend on animals at all rather than creating harmful chemicals? Ants primarily offer two advantages that secondary plant chemicals can scarcely match. First, a lot of herbivores have developed defense mechanisms against features that plants have developed to withstand them. There are at least some specialized herbivores that target every single plant species. Herbivores can effectively deal with chemical plant defense mechanisms since they have hundreds of detoxifying enzymes and other, even behavioral, techniques. On the other hand, it seems more

challenging to develop a defense feature that is mobile, has stings and mandibles in addition to chemically complex venoms, and can quickly concentrate at the assault location. Actually, ant recruitment behavior seems to be another important characteristic that makes ants an excellent choice for a plant defense strategy. Ants recruit by using prey items that are too big for a single worker to carry, and plant ants exhibit the same recruitment behavior, quickly appearing at any location where defense is now required. This mobility resolves a significant dilemma in plant defense and belongs to the category of induced plant defenses.

According to 'optimal defence' taken into considerations (McKey, 1974)<sup>[44]</sup>, Particularly in the most valuable and susceptible organs, plants should concentrate their defense chemicals. However, these are typically the still-growing organs, where "growth-control" limits secondary metabolism and differentiation balance' as their trade-offs (Herms and Mattson, 1992). Ants may readily migrate to the areas of the plant that truly need defense because they can provide rewards on fully formed sections, avoiding a growth-differentiation trade-off (Heil *et al.*, 1997). A plant can meet the requirements of the optimal defense hypothesis without experiencing growth-differentiation trade-offs by using animals as a mobile and highly inducible resistance strategy. Ants, because of their social lifestyle, seem to be the ideal animal group to defend a continuously growing plant.

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