Ants and Plants: Some friendship tales

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Ants (Formicidae: Hymenoptera), one of the most numerous groups of animals on our planet, interact with plants in various ways. In some instances, the interaction may be negative, affecting the associated plant (like in the case of leaf cutter ants and seed harvester ants), and in the other case it may be positive with a mutual benefit. Flowering plants are thought to have facilitated ant diversification by providing novel sources of food and habitat, and ants to have facilitated plant diversification by providing defense and dispersal (Nelsen *et al.,* 2018). Here, in this article, we have tried to summarize some of the extraordinary and spectacular friendly relationships of plants with ants.

Myrmecophily: Friendship for Pollination

A wide range of flying insects (Bees, butterflies, moths, flies, etc.) are well known to pollinate various plants while visiting the flowers. But some plant species have also managed to orient ants to help them in pollination (myrmecophily) by providing the ants with reward (nectar) in return. Can pollination be achieved by flightless insects like ants?

Yes, ants can help in pollination in those plants which need to transfer pollen from male flower to female flowers of the same plant. The first record was in worker ants belonging to the species complex *Iridomyrmex gracilis* as effective pollinators of orchid, *Microtis parviflora* (Peakall and Beattie (1989). This orchid is self-compatible but not autogamous (Autogamy is the kind of pollination in which pollens are transferred from the anther to the stigma of the same flower). Flightless workers of *Iridomyrmex gracilis* ants forage the orchid persistently, visiting individual flowers and inflorescences repeatedly. They actually do this to take nectar from the flowers. But while doing so, the pollinia (mass of pollen grains) from one flower sticks to head of the ants and get transported to the stigma of another flower of the same plant. Another such example of pollination is also observed in orchid, *Dactylorhiza viridis* by the ant *Formica exsecta* in Alps, Italy (Claessens and Sheifert, 2017) (Fig.1).

Myrmecochory: Friendship for Seed Dispersal

Seed harvester ants carry away the seeds of some plant species to their nests for consumption. Few plants have managed to manipulate this relationship to fool the ants and get some benefits from them. Some plants take the help of ants for dispersal of their seeds (myrmecochorous plants) and this phenomenon is called myrmecochory. These plants have special seeds with lipid rich portion, called elaiosome which stimulate ants to carry these seeds back to the nest. The elaiosome is removed and the seeds are then discarded in an abandoned

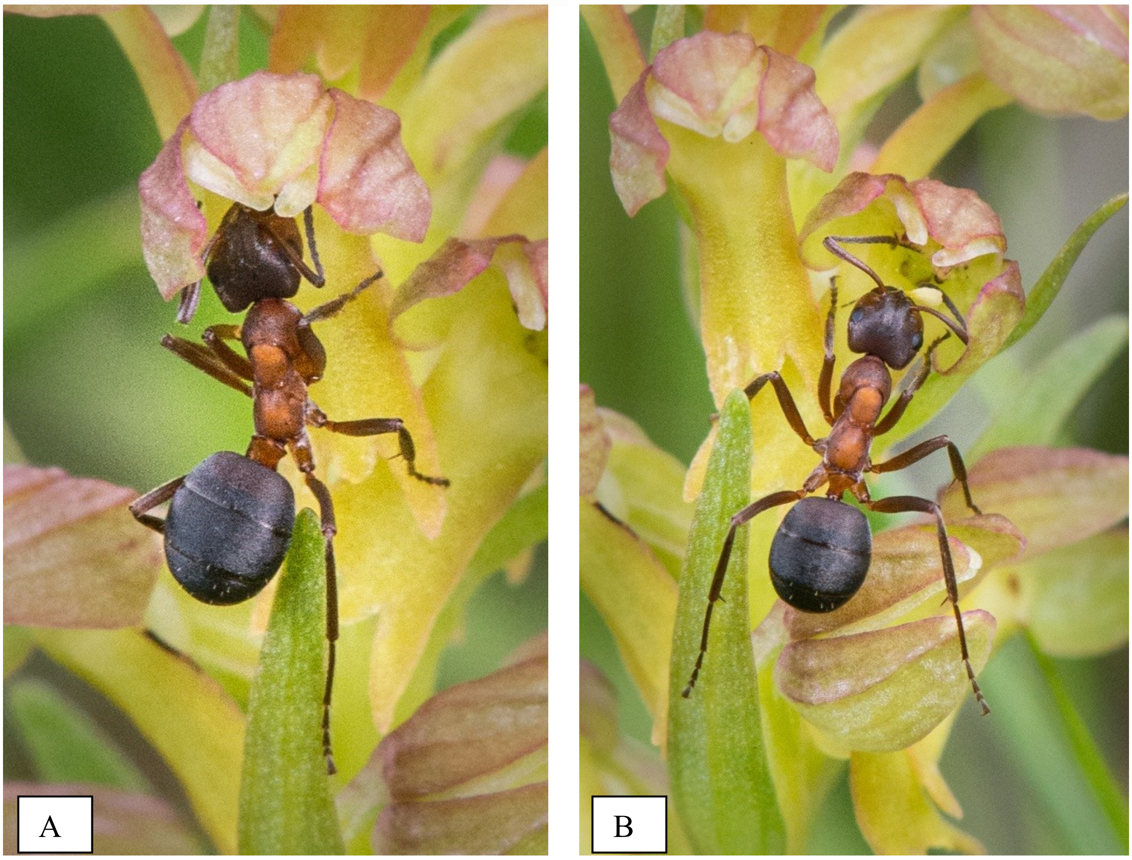

Fig. 1. A) *Formica* (*Coptoformica*) *exsecta* inspecting a flower of *Dactylorhiza viridis*, B) *F. exsecta* visiting a flower of *D. viridis* with a pollinarium attached to its head. Photo Credit: Jean Claessens (Reproduced with permission)

gallery of the ant nest. This is exactly what the plant wanted, a safe and suitable place for germination of its seeds. Brainy plant!!

Myrmecochory can be called a mutualism, but the relationship is not specific between a single plant and an ant species. There is no evidence that any myrmecochorous plant relies on a single ant species to collect its seeds (Gullan and Cranston, 2010). For example, five ant species (*Camponotus piceus*, *Lasius alienus*, *Lasius bombycina*, *Lasius fuliginosus* and *Tapinoma erraticum*) were observed to disperse the elaiosome bearing seeds of *Sternbergia colchiciflora* (Amaryllidaceae) (Fig. 2). Ant workers remove the seeds from the rifts of ripening fruits and carry them one by one (Molnar *et al.,* 2018).

Myrmecophytes: Friendship for Defense

Plants suffer the load of a variety of herbivores starting from early stages of their growth to maturity. How can these herbivores be deterred? Some plants have developed appreciable strategies to do so by the help of ant-partners. Certain plants remain closely associated with ants, called as myrmecophytes or ant-plants, where both the partners get benefit from each other. Ants either get a nesting site on the plant and/or nectar & nutrients from the plant. And they in return act as soldiers by defending herbivores attacking the plant.

One such classical example is the *Pseudomyrmex-Acacia* association, in which the *Acacia* plant offers three types of

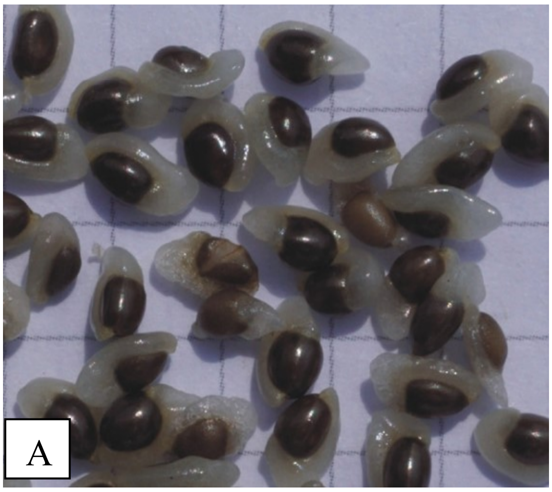

Fig. 2. A) Elaiosome bearing seeds of *S. colchiciflora;* B) Workers of *Camponotus piceus* carrying the seeds from ripened fruits of *S. colchiciflora* (Reproduced from Molnar *et al.,* 2018 with permission)

resources to the partner-ants (i.e., 1. Extrafloral nectar, 2. Beltian food bodies and 3. Domatia in hollow thorns) in exchange for defense from herbivores and encroaching vines. Extrafloral nectaries located at the petiole provide solution of water, sugars, and amino acids. Beltian bodies produced by the plant at the leaf tips provide protein and lipids to the ants. Whereas, the greatly enlarged hollowed thorns provide the nesting site (Domatia) to the ants. The whole ant colony is distributed among the numerous hollow thorns of a tree. Worker ants patrol the tree 24 hours a day, both guarding the colony against predators and searching for food. Since the tree contains their nest, obligate acacia ants (*Pseudomyrmex*) react strongly to any disturbance of the tree. If alarmed, ants will pour out of the thorns to attack, defending the acacia by both biting and inflicting a painful sting on any animal in contact with the tree. The ants keep the plant free not only of insect and vertebrate herbivores, but of fungi and other plants as well.

Like the Beltian bodies of *Acacia,* several other plants are also known to produce food bodies. For example: Mullerian bodies of *Cecropia* (Cecropiaceae) contain glycogen and lipids, Beccarian bodies of *Macaranga* (Euphorbiaceae) are especially rich in lipids and Pearl bodies of *Ochroma* (Bombacaceae) are rich in sterols. All these food bodies produced by different plants are meant for attracting ants and consequently deriving defense benefits from them (Rico-Gray and Oliveira, 2007).

Many myrmecophytes, however, do not offer any direct food reward for their ant inhabitants and provide only the domatia space where the ant colony develops. They rather harbor honeydew-producing homopterans inside the domatia and their honeydew constitutes the main energy source for ant inhabitants. Such myrmecophytes, though have to invest some energy for feeding its sap to the homopterans, but ultimately the reward it gets from the ants is much more compensatory. One such phenomenon is the association between *Macaranga* trees, *Crematogaster* (subgenus *Decacrema*) ants and *Coccus* scale insects in tropical forests of Southeast Asia. The plants are protected against vines and herbivores by the ants that, in turn, gain residence in domatia created by hollow stems and nutrients from the plants indirectly via the exudates of *Coccus* scale insects.

Myrmecotrophy: Friendship for Nutrition

There are certain insectivorous plants which derive their nutrients from insects trapped in specialized structures (pitchers, sticky mass, etc.). What if the plant can get its nutrients from the animal partner in a mutually beneficial manner?

It's a tedious job for the ants to construct their nests. If someone can provide a ready-made nest it will be easier. Some species of plants came forward to offer rooms for the ants to establish their colony. But the plants don't do that for free. The debris deposited in the ant colony is rich in organic matter and nutrients which is absorbed by the host plant.

This seems particularly important for epiphytes that often face severe nutritional constraints. A diversity of epiphytes is known to house ants. One such example is *Dischidia major* (Asclepiadaceae) which is an epiphyte on the trunk of *Dipterocarpus* tree. *D. major* possess pouched leaves with a hollow space inside, called 'pitchers' and adventitious roots that grow at the leaf joints to attach the stem to the host plant. But one root grows into the pitcher cavity through an opening at the base. This root proliferates inside pitchers that are inhabited by ants, usually *Philidris sp.* (subfamily Dolichoderinae). *Philidris* build partitions by using the internal roots as framework and shape their nest for brood rearing. They bring debris from outside and use it as a construction material to build walls, which causes extensive root growth and branching, and in turn more roots may encourage the ants to continue building. Roots are used as a frame for the partitions, thus creating intimate contact appropriate for absorption. The epiphyte is now ready to absorb the ant-deposited debris, in addition to faeces and discarded food, as a nitrogen source. Moreover, stomata located inside the pitchers can also absorb ant-respired carbon dioxide (Peeters and Wiwatwitaya, 2014).

The driving force behind these associations is the necessity to fulfill their own lacunas by sharing, what they can, with their partners. These stories of mutualism explain how two species can live happily in nature by helping each other. Nature is full of wonders and surprises. Especially these spectacular products of evolution are always making mankind to explore and reveal the secrets of nature. There exists thousands of such fascinating tales in nature. Some are already been told and many are yet to be…..

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