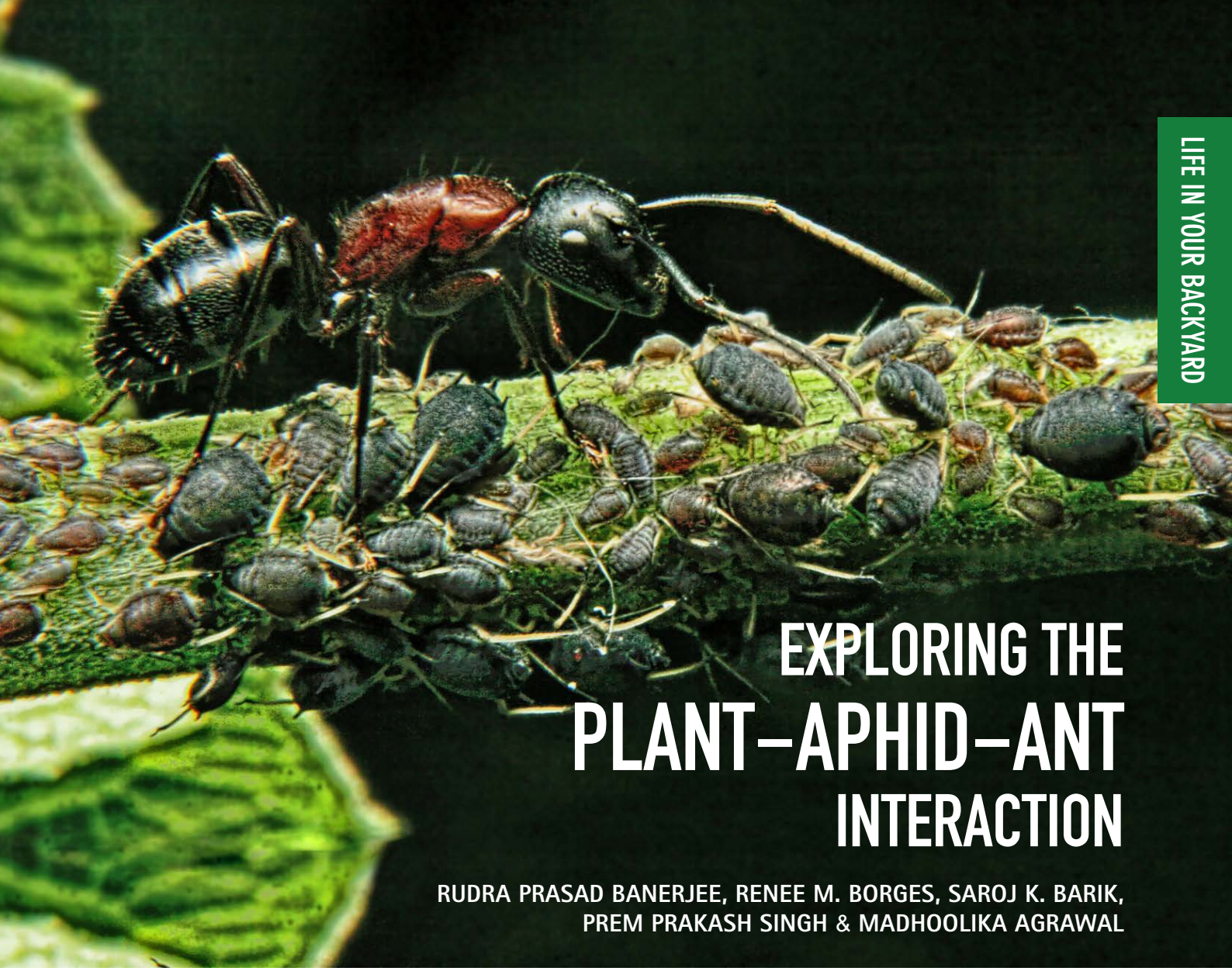

EXPLORING THE PLANT–APHID–ANT INTERACTION

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Different species interact with each other in complex and diverse ways. Why and how do we study these interspecies interactions? How do we introduce students to these interactions through real-world observations of plants, aphids, and ants from their own backyards?

Children begin observing and wondering about interspecies interactions in and around their home and school long before their science textbook introduces them to related concepts. Giving students the opportunity to study some of these interactions may help teachers connect abstract concepts in the textbook to real-world observations from their backyard. For example, have you come across a plant in your garden, school compound, or fields that seems to be covered with tiny creatures? Does it look like these parts of the plant are bustling with ants? If your answer to both these questions is 'yes', then you may be at the right place to witness a fascinating three-way interaction between ants, aphids, and plants (see **Box 1**).

The plant–aphid interaction

As you may have guessed, the tiny white, yellow, green, or black creatures are insects called aphids (see **Fig. 1**). Like mealybugs, whiteflies, and plant hoppers, aphids have needle-like mouth parts (called **stylets**) that they inject into the tender parts of the plant to feed upon the **phloem sap** that the plant makes for its own nourishment (see **Box 2**).[1] The loss of nutrition caused by these **phytophagous** (*phyto* = plants, *phagy* = to eat) or sap-sucking insects, affects the health of the plant, and causes wilting and yellowing of its parts. It may also affect the reproductive fitness of the plant, reducing its fruit and seed set.

Box 1. Finding and observing plant–aphid–ant interactions:

Interactions among plants, aphids, and ants are often opportunistic or facultative in nature. This means that ants may or may not form associations with the aphids throughout the year. The aphid–ant association is strongly dependent on the availability of food resources, seasonality, requirements of the ant colony, and phenology of the host plant (changes in the timing of seasonal events like bud bursts, flowering, and fruiting). Since the environmental conditions in winter limit the activities of aphids and ants, such interactions are best observed in summer (March/April–July) and post-monsoon (September/October–November). While such interactions may be difficult to observe on high branches or tall trees, they can be easily observed on 3-5 m tall plants or on branches at a lower height. Looking for ants on plant parts and tracking their movement can help provide important clues to the location of such interactions. Many a time, aphid infestation can also be seen on the apical portions of host plants. Once such an interaction is identified, the plant–aphid–ant interaction can be observed for a variety of features (see **Checklist for observation of plant–aphid–ant interactions**).

Fig. 1. Aphids inject their needle-like mouth parts into their host plant to feed on their phloem sap.

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Aphids may also act as vectors of deadly plant viruses such as cucumber mosaic virus and potato virus. These viruses can enter their host plant through the saliva of a feeding aphid. Weakened by the aphid infestation, the plant becomes more susceptible to these and other diseases. Since the aphid benefits at the expense of the plant, the plant–aphid interaction offers a real-world example of an antagonistic (parasitic) interaction.

The aphid–ant interaction

While the aphids feed on phloem sap, they excrete droplets of a sticky, sugary, nutrient-rich liquid, called **honeydew,** from their rectum. This attracts certain species of ants to the host plant. How? Studies show that these ants 'smell' the presence of certain **volatile organic compounds** (VOCs) in the honeydew through sensory organs called olfactory lobes that act like our nose (see **Box 2**).

These VOCs are produced by the action of specific bacteria that reside in the inner gut wall of the aphids.[2] The ants feed on the honeydew, and herd and tend to the aphids (see **Fig. 2**). Some ant species also deter the **natural enemies** of aphids (see **Box 2**).[3,5] These could include the larval and adult stages of insects such as ladybird beetles, hoverflies, and parasitic wasps that either feed on the aphid or lay eggs within its body (see **Fig. 3**). Since both

Box 2. Glossary:

- **Phloem sap:** A nutrient-rich food resource produced in plants. The name is derived from the mode of transportation that occurs through the phloem (a pipeline for transporting food across different parts of the plant). Rich in sugars and amino acids, it provides nourishment for the growth and development of the plant.
- **Volatile Organic Compounds (VOCs):** Chemical compounds that rapidly evaporate on contact with air. Secreted by organisms during interspecies interactions, these chemicals help in interspecies communication.
- **Natural enemies:** The organisms that prey on or parasitize a particular species.
- **Myrmecophilous aphids:** Derived from the combination of two words — *myrmeco* meaning 'ants', and *phily* meaning 'loving', this term refers to aphid species that are tended to by ants.

Fig. 2. Some ants extract and feed on the honeydew secreted by aphids.

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partners benefit from this association, the aphid–ant interaction offers a real-world example of mutualism.[3, 4, 5] This type of mutualism is referred to as 'food for protection' mutualism.[5]

However, like many other interspecies interactions, the ant-aphid association is more complex and dynamic than it may seem. Most ants are opportunistic foragers — eating almost anything they can find to fulfill the needs of their colony. This may lead one to wonder if ants also prey on aphids? They do, when their protein requirement exceeds their carbohydrate requirement (which can be met by honeydew). Under such circumstances, the aphid–ant interaction changes from being mutualistic to becoming antagonistic. However, studies also suggest that ants prefer

Fig. 3. Some ants protect aphids against their natural enemies.

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Box 3. Identifying the ant and myrmecophilous aphid species in your backyard:

For ants, these may be helpful: http://www.antkey.org/en and https://www.antweb.org/.

For aphids, check these out: http://aphid.aphidnet.org/credits.php or https://influentialpoints.com/Blog/How_to_identify_aphids_from_photos--the_basics.htm

to prey upon aphid species that are non-myrmecophilous rather than those that are **myrmecophilous** (see **Box 3**).[6] This raises the question — how do ants distinguish between the two kinds of aphids? Studies suggest that the body odor of every aphid has species-specific chemical signatures known as **cuticular hydrocarbons** (CHCs). Depending on the nature of these CHCs, the relationship between an aphid species and its tending ant species may be obligatory (both species depend entirely on, and cannot survive without services from each other) or facultative (the ant species is partly dependent on the aphid species). CHCs also help a partner ant species to differentiate between myrmecophilous and non-myrmecophilous aphids.[7]

The plant–ant interaction

Recent studies on interactions between plants, ants, and aphids have shown that some species of ants protect the host plant against other non-sap-sucking insect herbivores such as caterpillars and beetles.[8] Other studies show that accumulation of honeydew can attract fungal infection. By cleaning plant parts of honeydew, ants protect the host plant against these infections.[9, 10] This suggests that despite the harm caused by aphids to the host plant, the presence of protective ants might save the plant from further damage.

Parting thoughts

Detailed studies on interspecies interactions like the plant–aphid–ant interaction have helped reveal the dynamics and complexity of such interactions in general, as well as their role in maintaining ecological balance. For example, several studies show that when ants are blocked from access to aphids (using a sticky insect barrier, like Tanglefoot), aphid colony size reduces. This also causes an increase in abundance of the natural enemies of aphids and herbivory on host plants, which reduces both aphid and host plant fitness. The excluded myrmecophilous ants tend to show a preference for insect prey, suggesting a shift from carbohydrate-seeking to protein-seeking foraging behaviour.

Introducing students to some of the most interesting insights that ecologists have learnt about plant–aphid–ant interactions through scientific investigation can spark their interest and curiosity in related life science topics from their curriculum. It can also strengthen and expand their understanding of the nature and process of scientific inquiry.

Key takeaways

- Real-world observations of plant–aphid–ant interactions in their immediate surroundings can be used to introduce students to textbook concepts around interspecies interactions and their role in maintaining ecological balance.
- The plant–aphid relationship offers a relatable example of an antagonistic interaction, while the aphid–ant relationship offers a fascinating example of a mutually beneficial interaction.
- Since the aphid–ant interaction remains mutualistic only as long as the benefit that the ant gains from it is high, the context-dependent nature of this interaction can be used to illustrate the complex and dynamic nature of interspecies interactions.
- Sharing details of the kind of experiments used to understand these interactions can help expand student understanding of the nature and process of scientific inquiry.

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CHECKLIST FOR OBSERVATION OF PLANT–APHID–ANT INTERACTIONS

1. What is the habit of the host plant?
   - Herb
   - Shrub
   - Tree

2. What is the developmental stage of the host plant?
   - Vegetative
   - Reproductive (Flowering/Fruiting)

3. Which portion of the plant is infested with insects?
   - Mature branch (brown in color)
   - Young apical branch (greenish in color)
   - Flower
   - Fruit

4. Which of these species can you see in interaction with the plant?
   - Only ants
   - Only aphids (or other hemipteran insects)
   - Both

5. Which of these ant behaviours do you observe?
   - Aggregating near the aphid-infested parts of the host plant
   - Rapid movement across other parts of the plant
   - Both

6. How do the aphids look?
   - Cottony white
   - Yellowish or greenish, with tiny, pear-shaped bodies, sometimes transparent
   - Brown or black with horn-like appendages on the head

7. Did you find any other insects beside ants and sap-sucking insects?
   - Yes
   - No

8. If you answered yes to the previous question, what kind of insects did you notice?
   - Caterpillars (larva)
   - Mature adults

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