Insect and Plant Interactions

Thought Question

Question: What does the Cold War and Insect/Plant Interaction have in common?

Answer

Believe it or not, plant/insect interaction is very much like the cold war and the accompanying arms race between the United States and the former Soviet Union. However, plant/insect interaction began much earlier than the beginning of the cold war in 1945. One has to go back approximately 400 million years ago when plants and animals first appeared on the Earth.

Plants evolved onto land before insects, and when insects followed they found plants to be succulent food. To keep from being eaten, plants had to combat insects with a variety of defenses which will be discussed within this unit. Read on to find out how the war turns out!

Objectives

1. Explain the connection between the rise of flowering plants (angiosperms) and the expansion of the number of insect species.
2. Using examples, explain how insects can protect and help propagate plants.
3. Describe the major ways in which insects gain nutrition (phytophagy) from the plant.
4. Describe the ways plants protect themselves from herbivorous insects.

Introduction

Plants and insects have both benefited and harmed one another through the ages. Many plants provide sweet nectar as food to bees, wasps, moths and butterflies. In return, these insects carry pollen caught on their bodies to other plants. This aids their benefactor plants in the reproduction process.

On the other hand, harm may come to the plant as insects prey on the plant for food. Those nice tender leaves are just too tempting and provide food for hungry caterpillars, the main consumers of leaves. Plants can be defoliated in short order by these feeding machines. In fact, more than half of all insects are plant feeders.

It is not uncommon for insects to consume about 8.8% of the leaves in a forest. The major concern happens when there is an outbreak, like the Biblical plagues of locusts. There are outbreak conditions in which insects can defoliate entire plants or fields of crops resulting in major economic loss.

Throughout the rest of this unit you will learn about both kinds of plant/insect relationships, beneficial and harmful.

The Beginning

Plants and insects have had a long, intimate relationship. Early in the world’s history, it is believed that plants evolved onto land first and insects followed. The insects pressured the plants by feeding on them, so the plants had to develop defenses to overcome the feeding. The insects then had to evolve ways to overcome the defenses, and so on.

This pressure back and forth accelerated evolution of these two groups of organisms. For example, insects may have first eaten plants on the ground. This selected for plants that thrived high up in trees. However, insects that evolved wings could then take advantage of these higher plants for forage. Eventually some insects became more and more selective and specialized regarding the kinds or parts of the plants they ate, such as sucking the nectar out of flowering plants.
Flowering Plants

Most angiosperms (flowering plants) can only reproduce if their pollen is spread to another plant. The pollen must land on a sticky stigma. This is usually the part of the flower that sticks out of the flower head. Once it has landed on the stigma, the pollen will eventually turn into seeds that develop deep inside the flower’s ovary. When the seeds are ready, they are released, and the plant propagates its species.

At first, flowering plants probably relied on the wind to spread their pollen. But this can be inefficient because a lot of pollen must be released in order to insure pollination. Insects became attracted to the sweet smelling nectar in the flower. As they fed, they inadvertently collected pollen on their antennae, body hair or legs. This pollen would fall onto the next plant one of these insects fed on. It’s much more efficient to produce only a few pollen grains that an insect carries to the next plant, than to produce a lot of pollen hoping the wind will carry at least one or two of them to a mate. Today certain kinds of flowers are only attractive to specific pollinators. Bees, for example, are generally attracted to flowers that are bright blue or purple. Moths are attracted to flowers that open at dusk and are a pale color so they are easy to see in the dim twilight. Flowers that attract butterflies often have a landing platform for these insects to stand on as they feed on the nectar.

Read textbook pages 264-288 and 294.
Answer the questions on your study guide.

Mutualism

People generally view insects only as pests that destroy agricultural crops. However, there are many beneficial insects that help protect and propagate plants. Interestingly, as the insect helps the plant, the insect is benefited as well. This is called a mutualistic relationship which means that both organisms involved in the relationship benefit. For example, bees get nectar from a plant, but carry the pollen to the next plant they land on. The bee gets fed, and the plant is helped in reproduction. Besides helping plants spread pollen, there are many other mutualistic relationships between insects and plants.

Some insects help protect the plant from predators or spread the plant’s seeds (besides pollen). Some of these relationships have become so interwoven, that the plant cannot survive without the insect and the insect without the plant--like the yucca plant and yucca moth which you will read about. We will first discuss some examples of mutualism. How many of plant/insect mutualistic relationships can you think of?

Mutualism Examples

There are three types of insect/plant mutualistic relationships we will discuss. Seed dispersal, protection, and reproduction/pollination.

Seed dispersal Ants pick up seeds off the forest floor to carry back to the nest. Once inside the nest, the ants chew ends off the seeds for food. This action promotes germination in the seeds at a later date.

Protection The cecropia plant provides shelter and food for the ant, and the ant protects the plant from herbivore predators.

Reproduction/Pollination In order for most plants to make seeds, pollen from one plant must be transferred to another plant. Butterflies, bees and other insects often suck sweet nectar from flowers for food and pick up pollen as they do so.

Video – Ants in North America

Video – Cecropia Plants and Azteca Ants

Video – Butterfly Landing Platforms
Video – Hover Fly

IMPORTANT NOTE:
Throughout the course units, you will be asked to view short video clips. Please understand that many of these video clips are copyrighted and are NOT to be used outside of this class and only may be used for this semester. Please do not copy or distribute these clips.

More Examples

Some fig trees can only be pollinated by the fig wasp. Read how in your text on page 284.

Bees are sometimes commercially used to pollinate plants. Read about it at this website: http://www.ars.usda.gov/is/AR/archive/oct97/pollen1097.htm

More Examples Continued

The yucca plant and moth cannot survive without each other.

The state flower of Mexico owes its existence to insects. The yucca plant, which Native Americans used to make baskets, has a mutualistic relationship with the yucca moth. These moths are specific pollinators for the plant and the plant cannot survive without them. The male and female yucca moths emerge from their cocoons under the soil in the early spring and congregate on flowering plants where they mate. The female yucca moth uses her maxillary palps to place a small bundle of pollen into the bowl shaped stigma of the plant’s flower. This pollination is important because the moth only lays eggs during this time so the larvae can feed on the newly formed seeds. The males do not have these prehensile appendages, therefore only the female yucca moth can pollinate the delicate flower. This relationship is absolute for the survival of both yucca and yucca moth. In fact, yucca plants in the old world will only produce seeds by hand pollination because the moth has virtually gone extinct.

Insect Galls

Galls occur on a wide variety of plants. These growths may be the result of fungi, bacteria, nematodes, or mites, but insects are the prime cause. Gall-forming insects include aphids, phyloxerans, psyllids, midges (gall gnats) and cynipid wasps (gall wasps). Of the more than 2000 gall-producing insects in the United States, 1500 are either gall gnats or gall wasps. About 80 percent of the gall wasps produce galls specifically on oak trees. In fact, 60 percent of all known insect galls occur in the oak family, and 30 percent occur in the daisy, rose and willow families. These growths are called galls because they contain large amounts of tannin, which has a very bitter taste. Long ago, they were known as “gallnuts” because they tasted as bitter as gall.

Gall Locations

Galls are found most commonly on the stems and leaves but also occur on trunks, flowers, fruit, leaf-shoot terminals, petals and roots. Each gall-forming insect produces a gall that is characteristic of that particular insect. Some galls may be two inches in diameter while others are so small they are barely noticed. Gall production is believed to result from the reaction of the cambium and other meristematic tissues to stimuli produced by the larvae to cause the abnormal growths. The immature insects can often be found in a cell or cells within the developing gall. After a brief period of cell growth, all development stops. The insect becomes enclosed by the gall and feeds only on gall tissue during its development. Small holes on the outside of the gall indicate that the adult insects have emerged.

Insect Galls Continued

Plant galls are abnormal growths of plant cells formed as a response to a stimulus. Insect stimuli include egg laying, or larvae or nymphs feeding. In the spring, before the leaves are fully developed, eggs are laid in the leaf or stem. Gall production is believed to result from the reaction of the cambium and other meristematic tissues to stimuli produced by the larvae to cause the abnormal growths. The immature insects can often be found in a cell or cells within the developing gall. After a brief period of cell growth, all development stops. The insect becomes enclosed by the gall and feeds only on gall tissue during its development. Small holes on the outside of the gall indicate that the adult insects have emerged.

Gall wasp inside oak apple gall

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Insecticidal control is usually not practical because:

- Damage is not significant most of the time. Parasites normally build up and suppress populations of gall-makers before serious injury occurs.
- Correct timing of application is essential to control the adult pests before the gall is formed.
- Environmental contamination and expense are involved, especially on larger trees. Some galls that occur on the stems and limbs may be handpicked and destroyed.

Gall Gallery

For more information on insect galls refer to pages 273-278 in your textbook.

Plant Defenses

During the previous sections you have learned about beneficial insect/plant relationships. But we are all too familiar with insect pests that are not beneficial and plague farmers. Grasshoppers, caterpillars, locusts, and many others in outbreak conditions, can defoliate a plant or an entire field crop causing severe financial loss to the farmer.

About 20% of crops are lost annually to insects. During this section you will learn about how plants defend themselves against these insect predators. Some plants have evolved tough bark, slippery leaves, or noxious/distasteful chemicals contained within the plant body. These methods of defense can be grouped under two categories: physical and chemical. Tough bark and slippery leaves are examples of physical defenses which relate to structures on the plant that deter insects. Noxious/distasteful chemicals are chemical defenses which plants produce.

To complete this section read text pages 265-267 and answer the questions in your study guide.

Conclusion

You have seen how insects and plants have evolved together through time. Plants colonized land first, and then insects followed. It didn’t take long for the insects to begin eating the plants, and the plants had to find ways to adapt to this. They developed physical and chemical defenses to ward off insect predators. But insects then developed ways to get around these defenses. Bark beetles can bore through tough bark, for example. Some plants contain chemicals called protease inhibitors that mess up an insect’s digestive system once ingested. And the war between insects and plants continue.

However, there are several beneficial insect/plant relationships. Ants eat fleshy portions of wildflower seeds, and this prepares the seed to germinate. Azteca ants eat starchy nodules secreted by the Cecropia plant, and in return, the ants fight off any of the plant’s predators. The fig wasp uses the fig fruit as an incubator for its larval stage and the fig tree is pollinated. Bees, beetles, hover flies, and other insects are also pollinators of various plants. Pollination is a more efficient way to spread pollen rather than using the wind. It’s quite fascinating to learn about all these specialized relationships. Orchids even have adapted evolved platforms for butterflies to use when sucking nectar out of these flowers.

References