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4-H Honey Bee Leaders Guide Book I

The Buzz About Bees: Honey Bee Biology and Behavior

Virginia Cooperative Extension

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Virginia Tech
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Virginia State University

To the 4-H Leader: The honey bee project (Books 1 - 4) is intended to teach young people the basic biology and behavior of honey bees in addition to hands-on beekeeping management skills. The honey bee project books begin with basic honey bee and insect information (junior level) and advance to instruction on how to rear honey bee colonies and extract honey (senior level). These project books are intended to provide in-depth information related to honey bee management, yet they are written for the amateur beekeeper, who may or may not have previous experience in rearing honey bees.

Caution:

If anyone in your club is known to have severe allergic reactions to bee stings, they should not participate in this project.

The honey bee project meets the following Virginia State Standards of Learning (SOLs) for the fourth, fifth, and sixth grades:

Grade 4

Life Processes 4.4

The student will investigate and understand basic plant anatomy and life processes. Key concepts include:

- processes and structures involved in reproduction (pollination)

Living Systems 4.5

The student will investigate how plants and animals in an ecosystem interact with one another and the nonliving environment. Key concepts include:

- organization of communities
- life cycles
- influence of human activity on ecosystems

Living Systems 4.8

The student will investigate and understand important Virginia resources. Key concepts include:

- animals and plants

Grade 5

Living Systems 5.5

The student will investigate and understand that organisms are made up of cells and have distinguishing characteristics. Key concepts include:

- vertebrates and invertebrates

Grade 6

Life Science 5

The student will investigate and understand how organisms can be classified. Key concepts include:

- characteristics of the species

Life Science 8

The student will investigate and understand that interactions exist among members of a population. Key concepts include:

- competition, cooperation, social hierarchy, and territorial imperative

Acknowledgments

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Introduction

Honey bees are complex, fascinating insects. Managing honey bees can be fun and profitable for the 4-H member who has an understanding of their colony structure and behavior. The Honey bee Project Books are intended to train the 4-H member in the art of beekeeping. We begin by introducing honey bee biology and foraging behavior then advance into the dynamics of the honey bee colony. Our ultimate goal is to initiate the 4-H'er into the world of honey bee management.

Life Skills Objectives:

- Learning through observation, problem solving, and critical thinking.
- Working together by cooperating and communicating.

Learning Objectives:

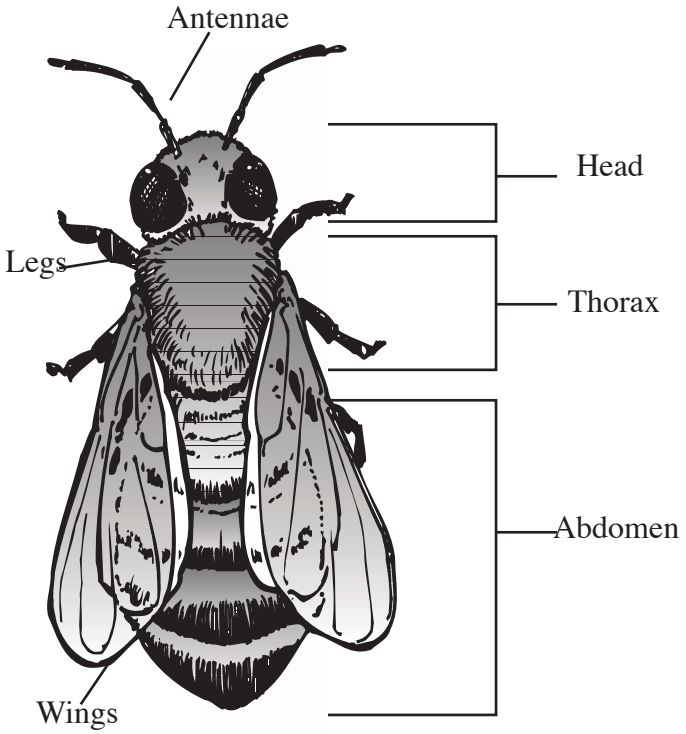
1. To become familiar with the body parts of the honey bee and how they function.
2. To understand the social nature of the honey bee.
3. To become familiar with the operations of the beehive.

Why are we interested in honey bees?

Throughout this unit it is important to understand the significance of honey bees in our agricultural system. Honey bees produce honey, which is a valuable commodity. However, the production of honey is by no means the honey bee's most important function. The value of honey bees comes from their ability to enhance agricultural crop production. Honey bees are the farmer's favorite insects. Honey bees travel throughout the flowering fields moving from blossom to blossom, carrying pollen from one flower to the next. This transport of pollen from flower to flower is called pollination. Pollination is what causes plants to bear fruit. Without the work of honey bees our agricultural crops would suffer huge losses, as the plants would produce considerably less fruit and seed. Therefore, the honey bee's commercial value comes from the role it plays in the pollination of crops.

What is a honey bee?

Like the praying mantis, cockroach, and butterfly, the honey bee is an insect. Insects are a group of animals that have a hard skeleton on the outside of their bodies. This skeleton covers the three insect body regions, the head, thorax, and abdomen. Insects have several characteristic features that are attached to these body regions. An insect has six legs and four wings connected to its thorax and a pair of antennae on its head. The antennae are used to detect odors and vibrations.



Insects are further divided into groups that share similar qualities. Bees, wasps, and ants share many common qualities. One of these qualities is their cooperative behavior. You have probably seen honey bees or ants working together in large numbers either foraging for food or building a nest. Well, honey bees, ants, and wasps belong to an order of insects called Hymenoptera. Many members of the Hymenoptera live in large, extended family groups called colonies. Honey bees live exclusively in family colonies. Honey bees and several other members of the Hymenoptera are termed social insects. This is because different members of the colony have specific jobs that help the colony function as a whole. However, not all members of the Hymenoptera are social insects; many bees and wasps live and work alone.

Honey bees and other members of the insect order **Hymenoptera** have the following physical characteristics:

1. Two pairs of thin, veined wings with the forewings much larger than the hindwings. The bee's wings are adapted for swift flight and also for sustaining the bee's weight and a load of pollen and nectar.
2. Chewing-lapping mouth parts with a long tongue or proboscis to suck nectar out of flowers and mandibles (jaws) to manipulate wax or other materials.
3. Complete metamorphosis during development. This means that the immature (worm-like) insect looks and behaves very differently from the adult. Similar to the butterfly, the honey bee has four developmental stages: egg, larva, pupa, and adult.
4. Three major body regions: the head, thorax, and abdomen. The head contains the antennae, mouthparts, and the "brain," which is the center for learning and receiving sensory information. The thorax is the body region specialized for locomotion (walking and flight). The legs and wings are located on the bee's thorax. The last body region is the abdomen. This region contains the digestive system, the honey stomach (a pouch inside the bee's gut where it can store and carry nectar), the reproductive organs, and the sting.
5. A constriction or "thin waist" separating the thorax and abdomen. The honey bee however, has dense yellow and black hairs covering its body. The hairs tend to make the bee's "waist" less obvious.

Where do bees live?

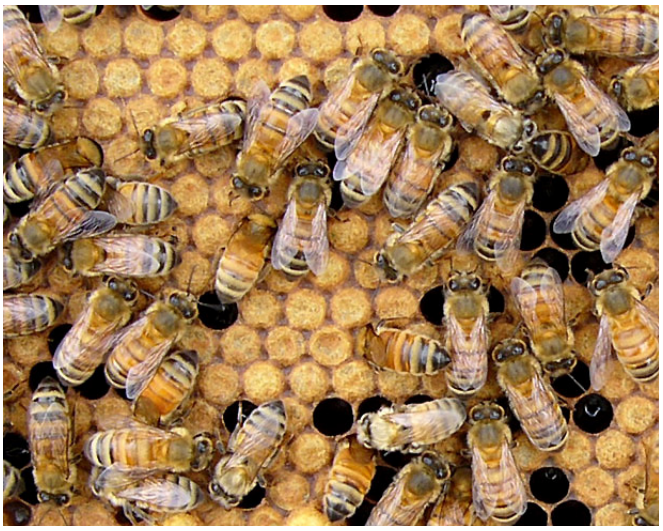
In nature, bees live in hollow trees or small caves. The beekeeper keeps bees in boxes called "hives." Hives are made up of interchangeable parts, so the inside can be examined by the beekeeper, and the various parts can be moved from one hive to another.

Members of the bee colony

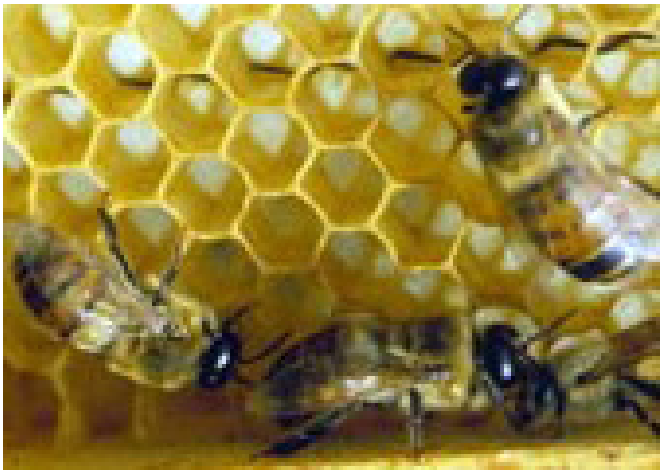
There are three kinds of bees in a colony: the worker, queen, and drone. In the summertime, a good colony of bees will have from 50,000 to 60,000 workers, 1,000 or more drones, and one queen.

The **worker bee** is a female with undeveloped reproductive organs so she does not normally lay eggs. She has pollen baskets on her hind legs and antennal cleaners on her forelegs. She has several specialized glands for the secretion of scent, wax, and food for larval bees. Her tongue is very long for lapping up nectar. Her jaws (mandibles) are flat and designed to manipulate wax for building the honeycomb. Her sting is straight and barbed. Worker bees do all of the foraging for the hive and are, therefore, the agents of pollination.

- Workers are the smallest bees in the colony, but most of the colony is made up of workers.
- In a colony of 30,000 bees more than 29,000 would be workers, depending on the time of year, colony health, etc.
- Workers do not lay eggs, but they carry on all the other duties in the colony, including comb building, brood care, and colony protection.
- Workers secrete wax from specialized glands on the underside of their abdomens to build honeycomb. They also collect materials to use in hive construction.
- Workers convert nectar into honey and store it in the hive as food for the members of the colony.
- It is the responsibility of certain workers to keep the hive clean while other workers



Workers



Drones

Queen bee

are responsible for air conditioning. The air conditioners fan their wings to keep the hive cool. The fanning also helps the watery nectar condense.

- Some workers feed and care for the queen. Other workers feed drones or the larvae confined in the comb cells.
- Workers guard the hive against intruders. They have a "sting" on the tip of their last abdominal segment. The sting is connected to a gland that produces a poison. This is why a bee sting is so painful.
- The honey bee sting is barbed. When a worker stings an animal, the sting gets caught in the animal's hide and is ripped out of the bee's body. Parts of the bee's internal organs are ripped out with the sting. This causes the bee to die after stinging but insures that the sting is effective. Drones cannot sting.
- Workers normally live for only four to five weeks if they emerge in the summer (working season). However, they may live as long as six months to a year if they emerge from the pupa in the fall or winter.

A **queen bee** has well developed ovaries and lays all the eggs in the colony. She lacks many of the specialized glands and pollen baskets of the worker and her jaws are too small for manipulating wax. Her sting is not barbed but smooth and curved.

Workers nursing larvae in comb

- She is the largest bee in the colony, and has a long, pointed abdomen designed for egg laying.
- Her primary function is to lay eggs so that the colony can continue to exist.
- She can lay both fertilized and unfertilized eggs. The type of egg she lays is determined by the size of the comb cell in which it will be deposited. The worker bees that construct the cell determine the cell size.
- Fertilized eggs develop into workers (females). Unfertilized eggs develop into males. The males are called drones.
- The queen is fertilized by as many as 18 drones (male bees) during the mating period early in her adult life. She receives several million sperm cells, which she stores in a special organ inside her body. She will use these sperm the rest of her life to fertilize her eggs.
- There is usually only one queen bee in the honey bee colony.
- The queen is fed and groomed by the worker bees. However, they will cease to care for her if she fails to produce enough eggs.
- The queen does not rule the colony, but she regulates it. She releases chemicals (odors) from her body that maintain the social order in the colony. Without her, the bees become excited and disorganized. The colony will die soon without a new queen.
- The queen only leaves the hive to mate or to swarm (start a new colony).
- Queen bees usually live for two or three years, although some have been known to live for ten years. Beekeepers usually replace the queen after one or two years.
- New queens develop from larvae that are fed a special diet (See "Food Fit for a Queen" below). Usually the larvae from the fertilized eggs are reared as workers. New queens are only reared under special conditions, such as, to replace a lost or failing queen or before a swarm (colony division).

Queen surrounded by workers

Food Fit for a Queen?

Honey bees use pollen as a source of protein and nectar as a source of carbohydrate (honey). However, there is another very special food consumed by honey bees. This is royal jelly. Royal jelly is a white, jelly-like substance produced from specialized glands in the head of the worker bee. This jelly has an important purpose. It is used to feed larvae that are destined to be queens. The royal larvae are fed this substance during their entire five-day larval period. A similar substance is fed to worker and drone larvae but for only half of their larval period. The 5-day feeding of royal jelly is what causes otherwise normal larvae to develop into queens. Royal jelly is also fed to the adult queen when she is laying eggs. Some authorities believe that the queen is fed royal jelly throughout her life but this has not been proven.

Drones are male bees. They have large eyes that meet in the front of their heads. Their eyes and large heavy bodies make them appear different from the workers and the queen. Their jaws are smaller, and they have no sting.

- Drones are slightly smaller than the queen bee, but larger than the workers.
- Drones have heavy bodies and powerful wings.
- Drone mouthparts are not long enough to suck up nectar, so they must be fed by the workers or they must feed from honey cells in the hive.
- Drones have no pollen baskets or specialized glands. The drones do no work in the hive; their only function in life is to mate with a virgin queen. Mating takes place outside the hive while the queen and drones are flying high in the air. The drones will die immediately after mating.
- Colonies only produce drones during the spring and summer. Drones will die at the end of their first summer season. Sometimes, workers can be seen dragging lingering drones away from the hive in the fall.

Drone bee

What goes on in the beehive?

There are a variety of activities taking place in the beehive, depending on the season. Workers perform almost all of the activities. Most of the time workers are collecting materials that will be used as food or for building the hive and comb. Workers collect four kinds of material for use in the hive: propolis, pollen, water, and nectar.

1. Propolis is a kind of bee glue or varnish; it is usually a brownish colored material collected from the sticky leaf buds of certain plants. The workers use propolis to coat the walls of the hive, patch holes and cracks in the hive, and to strengthen the comb at the attachment point.
2. Pollen is the male sex cell of plants and is the source of protein and other nutrients for the growing bees. Pollen is collected from the flowers and carried back to the colony in pollen baskets on the workers' hind legs. In the colony, the pollen will be used to feed the brood (immature bees). Pollen is stored in cells around the brood cells where young larvae are developing. Stored pollen is sometimes called beebread.
3. Water is used to dilute the honey that is fed to larvae and adult bees. Water is also used to cool and humidify the hive interior and to dissolve crystallized honey. Water is not stored in the hive and must be collected when needed.
4. Nectar is a sweet liquid secreted by the flowers of various plants and collected by bees to make honey. Nectar is a source of carbohydrate that the bees need for energy and flight.

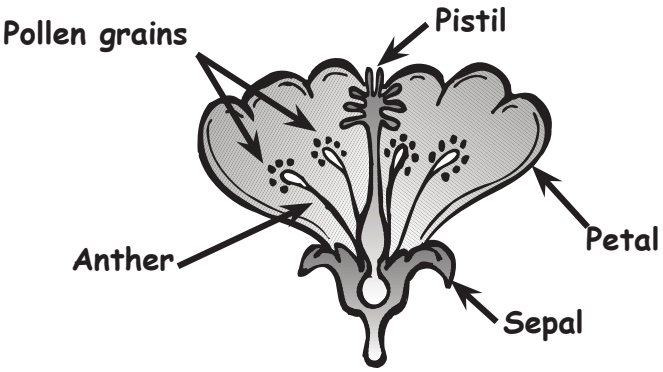
Workers collect pollen and nectar from flowers. The nectar is used to make honey to provision the hive for the winter months.

- Worker mouth parts form a long tube, or tongue, that makes it possible for the bee to suck up nectar from blooming flowers.
- The nectar is drawn into the bee's honey stomach, or crop, where it is stored until the bee returns to the hive and uses it as food.
- The nectar is made into honey and is one of the major food sources for the colony (carbohydrate). In a single summer season a strong colony of bees may collect enough nectar to make several hundred pounds of honey.

Worker bee collecting water

What is pollination?

Pollination is the transfer of pollen from a flower's anther to a flower's pistil. It is the act of transferring pollen that makes the honey bee such a great pollinator of agricultural crops. As the bee moves within the flower to collect nectar, the dusty pollen (located on the anthers or the male parts of the flower) will stick to the hairy legs and body of the bee. When the bee leaves one flower and flies to another of the same species, the pollen on its body will inadvertently brush onto the female part (pistil) of the new flower. The male pollen on the female pistil allows the flower to bear fruit. Bee-aided pollination greatly increases the yield of many crops that would have to rely on accidental pollination by the wind if there were no bees.



What exactly is honey?

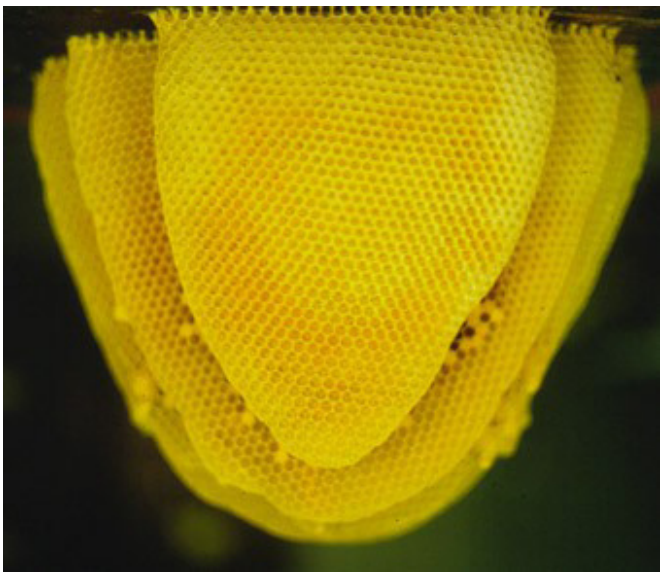
Honey is made from the nectar of flowers. The bees collect the nectar and transport it back to the hive in their honey stomachs or crops.

- The bees that forage for nectar in the field (field bees) bring the nectar to the hive and give it to the bees working in the hive (house bees). The house bees will store the nectar in the wax comb cells where it will be made into honey.
- The nectar is watery at first, but becomes thick as the water in the nectar is allowed to evaporate. Workers, by fanning their wings, help the water evaporate from the nectar more quickly.
- Once the nectar is thick enough, it can now be considered honey. The workers will then seal (cap) the cells for long-term storage.

What is beeswax?

Beeswax is secreted from four pairs of glands on the underside of the worker bee's abdomen. Estimates vary widely as to the number of pounds of honey that bees must consume to make one pound of wax. Some authorities say two to four pounds; others say eight to ten pounds. Worker bees use wax for building honeycomb.

- Wax is usually produced after the worker has eaten a lot of honey.
- The workers take the wax that is secreted onto their abdomens, chew it to make it soft, and then use it in the construction of the comb.
- The wax is also used to seal the cells of the honeycomb when they contain food or pupated larvae.



Natural honeycomb

What is the honeycomb and how is it used?

The honeycomb forms the interior structure of the hive, is made up of six-sided cells, and is made of beeswax. It is used for storing food, both honey and a special food called beebread, which is made of glandular secretions that are added when bees work pollen, as is some honey or nectar. Microorganisms play an important role in the final product as well. When honey is stored in a cell of the honeycomb, it is sealed in with beeswax.

Another function of the honeycomb is as a place for rearing immature bees. The queen lays eggs, one to a cell, in the honeycomb. This area is called the brood nest. When an egg hatches inside the cell, the workers care for the young larva. This is the reason you will find the bees densely clustered in the brood nest; they are rearing the brood. In an artificial beehive, the brood will be confined to specific sections called the brood chambers or hive bodies. When a larva pupates, worker bees seal its cell with beeswax.

Eggs in cells

Bee swarm on a tree branch

How do bees increase their colony numbers?

Swarming is the natural method bees use to create new colonies. Each swarm contains several thousand worker bees, a queen, and several hundred drones. When the brood nest becomes crowded, the bees build "swarm cells" (new queen cells), and the old queen leaves with a swarm. The bees that leave with the swarm cluster congregate at a nearby site. They then seek out a new nest site to start a new hive.

Beekeepers try to prevent swarming in their hives by giving the bees more room and ensuring that the colony has a productive queen. Beekeepers may decide to increase their number of colonies by dividing the strongest colonies or buying packages of bees (wire-screened boxes that contain bees and a queen), or nucs (small nucleus colonies in a small hive that includes frames, comb, etc.). These methods are called "artificial" or "controlled" swarming. Some beekeepers collect "wild" swarms from trees or buildings. Or they may get them from other apiaries (groups of bee hives tended by beekeepers).

Summary

A honey bee is a social insect that lives in colonies. The queen and drone bees are responsible for reproduction. The workers bees take care of all of the hive functions. Workers bees collect nectar from the blossoms of plants and convert it into honey for food and into wax for comb construction. Bees both rear the larvae and store honey inside the honeycomb cells. Bees gather pollen to feed the larvae. In the process of collecting pollen from flowers the honey bee worker performs a priceless service to farmers — the pollination of agricultural crops.

Suggested Club Activities:

1. Compare several bugs (cockroach, butterfly, sow bug, praying mantis, and honey bee) and identify those characteristics that make all of them insects. Are any of these bugs not insects? Which ones? Why?
2. At your local library, check out books and/or videos on honey bees or beekeeping. List two resources used with titles and authors or directors. Review the sections that deal with pollination and how bees make honey. Describe what you learned about pollination. Draw a four-frame cartoon how a honey bee pollinates flowers.
3. Locate flowering plants near your home that are being visited by honey bees. Using a field guide for flowering plants, identify these plants and record when they are supposed to bloom (bloom times). If you were to start a bee colony of your own next May, list which of the flowers would be available as sources of nectar and pollen for your bees. Draw two of the flowers that would be available. Include their pistil and anthers.
4. Call your local county Extension agent (the number for your county extension office is in the telephone book) and ask him or her to send you any circulars or bulletins that deal with beginning beekeeping. Which of the circulars or bulletins were the most helpful for the beginner? Share these with your 4-H group.
5. Find five to six beekeeping sites on the Internet. Record their web addresses. Which of these sites were the most interesting and why? Visit a site from a foreign county. Are the beekeeping practices the same or different? Share these sites with other 4-H members.
6. Find a site on the Internet that talks about the Africanized bee. Record your source. Make a chart to compare the differences and similarities between the Africanized bee and the European honey bee. Will the Africanized bee ever make it to Virginia? Why? Why not?
7. Draw a diagram of the social honey bee colony including the queen surrounded by workers and a drone. Include a drawing of honey bee development inside the honeycomb cell.
8. Make a table or chart that compares the characteristics of queen, drone, and worker bees. Include their sex, relative numbers in the hive, how long they live, and what their job is in the hive.
9. Create your own Honey bee Biology and Behavior crossword puzzle and give it to your club members to solve.
10. Honey bees have influenced human art and culture. Find three examples of honey bees in art, music, or poetry.

Activity 2-2 Answers
Group A: 1, 6 (Hemiptera)
Group B: 2, 7 (Odonata)
Group C: 3, 8 (Lepidoptera)
Group D: 4, 5, 11 (Coleoptera)
Group E: 13, 16 (Hymenoptera)
Group F: 9 (Orthoptera)
Group G: 12 (Diptera)
Group H: 14 (Dermaptera)
Group I: 15 (Homoptera)
Group J: 10 (Acari – non-insect)

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