Cooperative Extension, the New York State College of Human Ecology, and the New York State College of Agriculture and Life Sciences, at Cornell University, Ithaca, N.Y., and the U.S. Department of Agriculture, cooperating. In furtherance of Acts of Congress May 8, June 30, 1914, and providing equal opportunities in employment and programs. Lucinda A. Noble, Director. Reprinted 3/79 CP 3M 6165-A

Reprinted from the official magazine of the New York State Conservation Department, *The New York State Conservationist*

4-H Members' Guide M-6-4

Some Architects of the Insect World

by John A. Wilcox, Associate Curator of Entomology, New York State Museum*

INSECTS rank high among the builders in the animal kingdom. Some of them are extremely proficient in constructing shelters for themselves. This is not to say that they are intelligent, but rather, that there is within them the capacity to respond in a very definite, complex way to certain stimuli occurring both within the insect itself and in its environment. The method of inheritance of these responses, sometimes called instincts, is still one of the great mysteries of biology.

Eggs of most insects are deposited on the surface, in cracks or crevices or inserted in the plant or animal which will become host to the hatching young. Immature and adult insects usually live with no specially constructed protection. It is the few which do construct, directly or indirectly, some shelter that will now occupy our attention.

The Paper House Builders

The best known and perhaps most ambitious of the insect architects are the wasps and hornets. They construct paper nests in which to rear their young. These are made with bits of soft wood or bark from twigs, chewed, mixed with a salivary fluid and molded to form the thin, paper-like layers of the nest. *Polistes*, the slender, brown paper wasp, builds a nest consisting only of cells with a thin stalk for support. Its nest hangs from ceilings or eaves of buildings and is shaped like an inverted mushroom. A single egg is laid in each cell. The young larva hatches, adheres to the side of the cell and is fed by the mother wasp. When the larva is fully grown it covers the cell with a cap of silk within which it takes shelter while awaiting transformation to a pupa. After a week or two the final stage is reached and the newly-developed adult cuts its way out.

Hornets, including yellow jackets, are quite close to paper wasps in actions. Their nest is basically the same as that of the paper wasp, but they also construct thin paper walls around the cells and thus form a closed oval structure which may be much more than a foot long. Some kinds of hornets build their nests in trees or bushes, some in the ground and some in enclosed spaces such as hollow trees or within the walls of a building. Not all hornets are industrious. A few species move into the nests of other species and seem to live in harmony with their hosts, rearing their young without offering any assistance in building or enlarging the structure. Interestingly enough, the guest species is nearly identical with its host in size and color pattern although the two may not be closely related.

These paper nests are strictly nurseries and usually the result of the efforts of a single female and her progeny. The hornets leave in autumn to find some other protected niche for the winter hibernation. In spring each female begins the task of building a new nest for her young ones.

The Mud House Builders

Not all of the hornet family are paper makers. Some types work with mud. The potter wasp, for example, makes a delicate little jug, more or less spherical, with a narrow neck and flaring mouth. Although the hornet larvae are given chewed food (usually insects) by the adults of their colony, the young potter wasp is not so pampered. Its mother does provide for it by provisioning the nest with caterpillars before depositing the egg. These caterpillars are stung so that they remain alive but in a dormant state.

The dark metallic blue *Sceliphron* and black and orange *Trypoxylon* are also mud daubers. The former builds its mud cells side by side or piled several cells deep. The finished nest is rather irregular in appearance. The latter, sometimes called the organ-pipe mud dauber, constructs a nest consisting of several rows of cells, the cells in each row placed end to end. Mud is carried from a nearby puddle in the form of a pellet about the size of the wasp's head. Mud daubers provision their cells with paralyzed insects or, more often, with spiders before they deposit the egg and seal the cell.

The Wax House Builders

Although a large number of different insects secrete waxy substances, only the bumble bees and honey bees mold it for their special use. Beeswax, a product of the bee's abdominal glands, is shaped into cells similar to those of wasps. These cells are storage pots for honey and bee bread, a semi-solid mass of pollen and nectar. They are also used to hold the developing larvae.

Bumble bees, like hornets, leave their nest in autumn. A fertilized queen overwinters in some protecting nook. In spring she constructs a new nest, usually in a deserted mouse nest or bird nest and rears her first brood. These are all sterile, female, workers which take over the job of maintaining the nest, collecting food and caring for the young larvae. The queen retires to a life in which her only duty is egg production. Later in summer more queens and males are produced.

The honeybee queen is more helpless. She cannot start a colony alone but must have a retinue of workers to produce wax and construct cells. These sterile workers also construct special, larger cells in which to rear males from unfertilized eggs and still other large cells for future queens. Both worker and queen bees develop from fertilized eggs. The difference in form and function of these adult females is due to the food given to them while in the larval stage.

The Wood House Builders

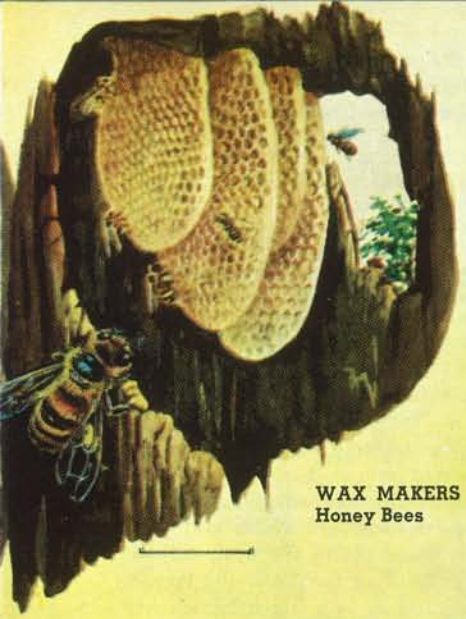
Large carpenter bees look very much like dark, shiny bumble bees, but their nest-building activities are quite different. They excavate galleries in solid wood. The tunnels, which are a half-inch in diameter and may be three feet long, usually are not branched. The bees do not eat wood but do the excavating only to provide protection for the developing larvae. When the excavation is complete the queen bee places a ball of pollen and nectar in the end, deposits an egg on it and seals it in with a cross wall about an inch from the end. The cross wall is made of wood fibers or mud. She then repeats the process until the tunnel is filled with cells.

One other group of bees holds our attention in this tale of insect architecture. These are the leaf-cutter bees. Leaves from which extremely neat, circular pieces have been cut often attract attention. The bees responsible for this feat are rarely recognized. They are medium-sized, fairly stout and usually black or dark colored. They form their nest cells in some natural cavity in wood, under loose bark or in the ground. They line the cells with the circular pieces of leaves, thus producing a nest which looks like a small, poorly rolled cigar. The enclosed larvae feed on pollen and nectar placed there by the mother bee.

*Published by permission of the Assistant Commissioner, New York State Museum and Science Service.

SOME INSECT

(Length of insect indicated

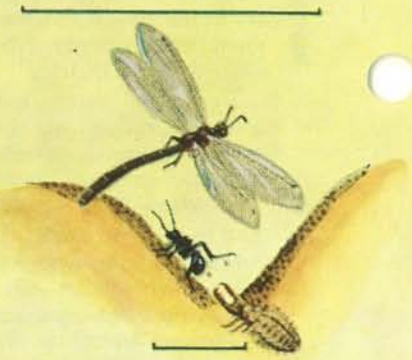


WAX MAKERS
Honey Bees

Mud Dauber Wasp

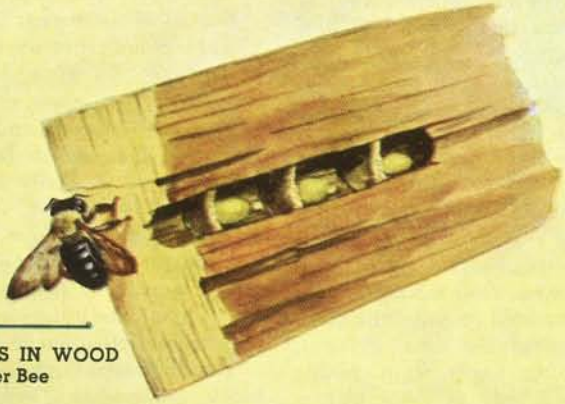
Potter Wasp

HOUSES OF CLAY



TRAP IN SOIL
Ant Lion

HOUSES OF BUBBLES
Spittle Bug



TUNNELS IN WOOD
Carpenter Bee

DECORATED HOUSE OF SILK
Bagworm

HOUSE OF LEAVES
Leaf Cutter Bee

HOUSE OF SILK
Cecropia Moth

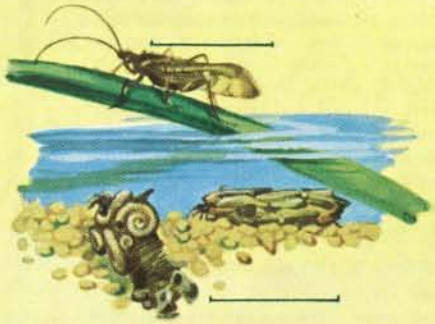
ARCHITECTS

by horizontal black lines)

HOUSE OF PAPER
Bald-faced Hornet

EGG MASS (Spumulin Covered)

SPUMULIN MAKERS
Tent Caterpillar



UNDERWATER DECORATED HOUSE OF SILK
Caddis Fly

GALL OR LIVING HOUSE
Goldenrod Gall Fly

GALL OR LIVING HOUSE
Spruce-Cone Gall (Aphid)

GALL OR LIVING HOUSE
Oak Spangle Gall (Midge)

Wool Sower (Wasp)

GALLS OR LIVING HOUSES
Oak-Apple Gall (Wasp)

HOUSE OF LEAVES
Leaf Roller Moth

Wayne Trimm

The Bubble House Builders

A spittlebug can produce one of the strangest nests of all. These small members of the order Homoptera, which includes cicadas and leafhoppers, are called froghoppers. Adults are strictly dry land creatures but the nymphs spend most of their time surrounded by a mass of moist bubbles. They can travel over dry parts of their host plant and do so until they find a suitable spot. A drop of fluid is then voided from the anus and rapid motion of the abdominal appendages whip the fluid into a froth which completely covers the insect. The fluid is mostly sap sucked from the host plant, but also includes a mucilaginous substance which is excreted from glands near the end of the abdomen. The resulting "spittle" is very persistent, remaining moist in the dry atmosphere and holding its form even when washed with light rain. In addition to providing the necessary moist environment, it probably protects the young hopper from enemies, although predatory wasps have been observed removing nymphs from their nests.

The Silk House Builders

Silk is a fabulous substance used by many different kinds of insects, spiders and mites. It is produced as a liquid, in a gland usually situated below the mouth of the insect. It is ejected and almost immediately hardens to form the tough, durable strand of silk. An insect is able to build a very practical structure by proper placement of these strands. The most frequent use of silk is found in spinning cocoons for the protection of the helpless pupal stage. These enclosures may vary from a very open network, which barely holds the pupa, to intricate double walled cocoons.

Cecropia moths construct the largest cocoons found in eastern North America, but their size is deceptive. The caterpillar begins the task by spinning a thin outer wall, then a sparsely filled middle portion and, finally, a very tightly spun, hard, inner wall. The air spaces between the inner and outer walls provide an excellent insulation against sudden changes in temperature which are so dangerous to an insect.

Eastern tent caterpillars exemplify the larvae which live on a silk carpet. These caterpillars usually select a crotch in the branches of a tree as a base for their activities. They construct a tent of silk in the crotch and remain in it at night and during cloudy and rainy weather. When the weather is favorable they travel to the foliage, spinning a thin path of silk along the way. The tent is enlarged as they grow until it becomes quite large, sometimes two or three feet across.

Ugly nest caterpillars and the hymenopterous webworms draw the leaves or needles of their host plants together in a mass of silk, leaves and debris from their feeding. Since they have incorporated their food in the nest they can remain within the nest. In fact many of them pupate within the nest and need not leave it until they are winged adults.

The caterpillars mentioned above work together, but many of their relatives are not so co-operative. Several families of small moths are called leaf-rollers because their larvae form individual shelters by pulling opposite edges of a leaf together and "sewing" them in place with a few strands of silk. They then feed on the inner surface of the sheltering leaf. Since they are small, they may spend their entire larval life in one leaf. A few, like the trumpet maple skeletonizer, build a silk tube within the leaf as an added protection.

These stationary shelters are a little too confining for some caterpillars. They construct a tighter, more compact tube or case around their body, leaving only the head and legs free. With such a case they need no specific nest but can wander about, hauling their shelter with them. When time for pupation comes, the casebearers have their cocoons already made. They merely anchor the case firmly and cap it with a few more strands of silk.

The bagworm has carried this way of life to an extreme. Its case is built of silk with bits of leaf or sand woven in for effective camouflage. After pupation, the adult male emerges from his cocoon and flies in search of a mate. Females do not leave their cocoons. Mating takes place while the female remains in her cocoon and the eggs are deposited within the bag.

Caddisflies, distant, aquatic relatives of moths, also construct silk cases. Their use of other materials is fascinating. Items from the floor of their watery home are added to the case until it blends with the background. Each species uses its own blue print in case construction. One caddisfly may select small sticks or long pieces of plant material and place them lengthwise along the outer walls. Another may use similar objects but place them perpendicular to the long axis of the case and so build a rough "log cabin." Species living in smoother areas may use only sand or small pebbles. Small snail shells are used in areas where snails are common. Most species make long cylindrical cases but one group builds spiral cases shaped like coiled snail shells.

The Living Plant House Builders

Many insects provide shelter for themselves or their young by producing a plant gall. Certain beetles, moths, wasps, flies and aphids produce galls. A gall is typically an abnormally swollen, hollow portion of a living plant. It is plant tissue stimulated to unusual growth by some secretion of the insect. Gall shape may vary from a slight swelling to a very ornate organ which does not appear to belong to the plant at all. A single gall may contain a single insect larva or dozens of individuals, both adult and immature. Also, a gall may contain not only the insect responsible for its development but also several other species of insects which may feed on the plant or on other insects dwelling in the gall.

One of the most easily found galls is the ball gall of goldenrod. This nearly spherical gall is produced by a fly which is a little larger than a housefly, dark brown with wings mottled with brown. It spends the winter in the larval stage in the gall and can be found as a round, headless, legless maggot throughout the colder months. When warm weather returns the larva changes to a pupa and in a few days emerges from the gall as a winged fly. Eggs are then laid in the stems of young goldenrod and the cycle starts again. A similar but more elongate goldenrod gall is produced by the caterpillar of a small moth.

Not all galls are produced by insects living within the plant tissues. Development of some, like the spruce cone gall is initiated by insect feeding on the surface. The instigator of the cone gall is an aphid which feeds by inserting its mouth parts into outer layers of the young spruce needles. The feeding retards development of the twig, but stimulates growth of the needle base. The result is a rather compact cone-like gall produced by the overdeveloped needles. There is a pocket at the base of each needle in which about a dozen young aphids may be found. The aphids depart in summer as the gall dies.

Damage done by gall insects is usually not serious and many plants can carry a heavy infestation of such insects without apparent injury. However, in some cases, such as on spruce, death of affected parts may make control measures worth while.

For some unknown reason, oak trees are hosts for far more species of gall insects than any other genus of plants. Three diverse types are illustrated. The oak apple is a large spherical gall attached to the leaf. The outer surface is smooth but the space within may be filled with a thick cottony mass or with only a few fine threads. The tiny wasp grub lives in the small, hard central kernel. Some of the small cynipid wasps produce very different galls. The wool sower produces a composite gall made up of a number of hard cells, one for each larva, and an irregular fibrous mass over them all.

Cecidomyid gall midges make up the largest family of gall producing insects.

There are hundreds of species of these minute, fragile, long-legged, dull-colored, two-winged flies. Identification of the adults is very difficult. Identification of larvae is nearly hopeless. But very similar species may produce dissimilar galls.

The Trap Builders

Nearly all of the structures discussed so far provide some form of protection to the insect. The ant lion is one of the few insects which constructs a trap to capture its prey. The flattened, spiny ant lion larva, sometimes called a doodlebug, is found in loose, dry, sandy soil. It digs down into the sand, then flips its head upwards. This action tosses the sand up and eventually forms a funnel-shaped pit which leads down to the insect. Other insects walk into the pit, slide down the sides and find themselves in the jaws of the ant lion.

Caddisflies, mentioned before as case bearers, use their silk in constructing nets. One type forms underwater webs set where the water flows swiftly. These webs are crude models similar in form to those of spiders. They lack the sticky strands found in most spider webs but the force of the flowing water is enough to hold the victims until the caddisfly larva can capture them. Another species of caddisfly constructs a funnel-shaped net on stones in swift-flowing streams. This silk net is placed with its wide mouth facing upstream. The larva waits in the small end for its prey to be washed into its jaws.

Single copies free to residents of New York State; additional copies 30 cents each.