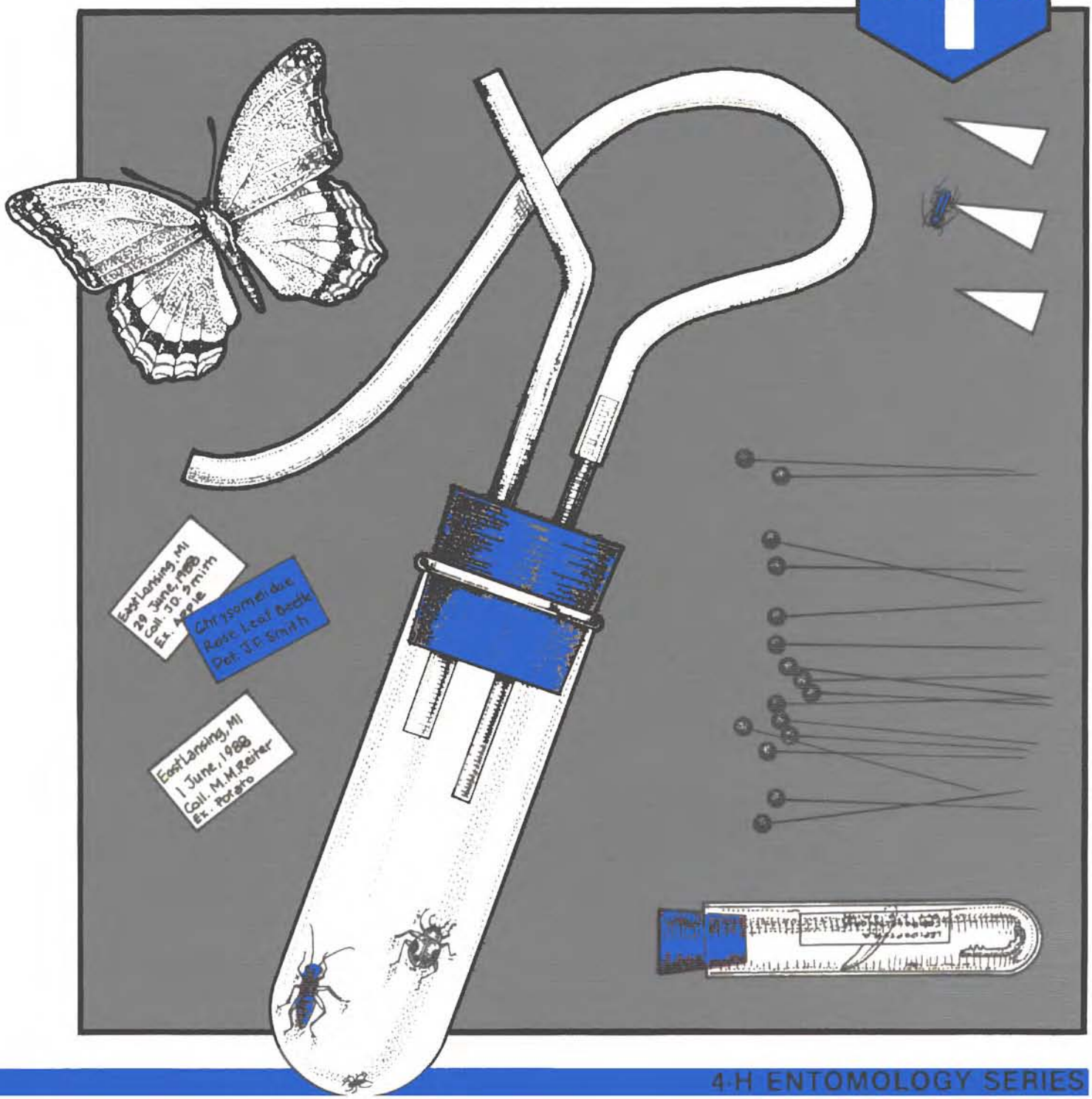
4-H 1335

BASIC ENTOMOLOGY

Manual 1



AUTHOR

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ACKNOWLEDGMENT

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Welcome to 4-H Entomology

Welcome to the 4-H entomology project area. It will introduce you to many new and exciting experiences. As well as being fun, it will help you learn how important insects are in the lives of everyone. It may even help you prepare for the study of insects as your life's work or an educational hobby.

This manual gives general instructions for the beginning level activities only. It is designed to acquaint you with the insect world. Specifically, it discusses what insects are, how they live and develop, and how to make an insect collection. There are additional 4-H entomology publications for intermediate- and advanced-level members. Information on how to obtain these other publications is given at the back of this manual.

In your first year, you should become familiar with several of the common and showy insects in your community by studying them out-of-doors and by collecting, mounting, and identifying specimens. This manual does not designate specific requirements for numbers of specimens for first-, second-, or third-year 4-H insect collections. Your county, however, may have specific requirements set up by your 4-H county fair committee. Your leaders will know more about this.

Be a detective and watch insects go about their daily activities. Watch what they eat, and how. Do they eat by chewing up plant parts or by sucking plant juices or animal blood? Find out if various insects have a way to protect themselves from danger. Do they work together as a group or live by themselves? Watch some pest insects in your yard or garden for several days and see how they are controlled by natural means such as birds, toads, and other insects.

Living insects are much more interesting than dead ones. Learn to observe the behavior of these small animals. Refer to *4-H Entomology Series Manual 3: Insect Life Cycle Studies* (4-H 1406) for instructions on insect rearing and observing insects in the outdoors.

Keep an accurate, up-to-date record of your project and club activities. You can use the *Member's Personal 4-H Record Book* (4-H 1192) to record your accomplishments. Volunteer to appear in local 4-H programs. Whenever possible, give talks and demonstrations on entomology. Exhibit your project results at your school and at the county fair.

Enjoy your adventures in 4-H entomology. You will learn many new things and have a good time doing it. Good luck!

Introduction

Entomology (en-toe-mol-o-gee) is from the Greek word **entomo,** meaning insect. Entomology is the science dealing with the study of insects. The scientist who specializes in studying insect life is called an entomologist. However, you do not need to be an entomologist to learn something about the important and fascinating world of insects.

The principal objectives of *4-H Entomology Series Manual 1: Basic Entomology* are to acquaint you with the insect world and give you a better understanding of the importance of insects and how they fit into the living landscape.

What Is an Insect?

Insects are among the most successful of the animals. They have been on the earth for a very long time. Fossil records show that insects existed 250 million years ago.

There are more insects in the world than all other animals combined; three-fourths of all animal species are insects. Nearly 1 million different kinds (species) have already been identified and given names by entomologists. New species of insects are being discovered every day, and some entomologists estimate there may actually be as many as 10 million different species! In North America alone, there are an estimated 85,000 different kinds of insects. Over 17,000 species are known just from Michigan — enough to occupy your interest for a long time!

Insects are found throughout the world, with the possible exception of the Arctic and Antarctic areas, the ocean depths, and the tops of high mountain peaks. Some are so small, a microscope is needed to see them; others are several inches long. They are so widespread that they can be studied practically everywhere — in cities or on farms, in the backyard or garden, in the home, or in a park. And insects are so varied that you can begin an insect project almost any time of the year, regardless of where you live.

INSECTS ARE IMPORTANT

Can you imagine a world without insects? It would be very different from the world we know today. Because insects pollinate many flowering plants, fewer kinds of plants would grow, resulting in a more monotonous landscape and a smaller variety of foods to eat. Since many birds eat insects, fewer kinds of birds would exist. Fish, frogs, toads, skunks, and moles would also be less abundant because they feed on insects.

Many insects help nature with its housecleaning. For example, wood-boring beetles, termites, and ants help speed up the decay of a fallen tree, returning material to the soil for support of new plant growth.

Insects have provided people with honey, silk, shellac, and other products of commercial value. Many discoveries in heredity, medicine, and nutrition have been possible because insects were used in laboratory experiments.

However, some insects are harmful. They can truly be regarded as people's major competitors for food on this earth. They destroy crops by eating the roots, seeds, stems, leaves, or fruit of plants. They attack livestock, weakening or sometimes killing it. They even get into processed food, forcing you to discard it.

Some insects annoy you and your pets. They spread plant diseases such as Dutch elm disease, a fungus, and cucumber wilt, a virus. In some parts of the world, they spread human sicknesses such as malaria, sleeping sickness, bubonic plague, yellow fever, and encephalitis.

Yet, it is impossible to measure in dollars the enjoyment or aesthetic value of watching beautiful butterflies flitting over fields of flowers or the chirp of crickets on a warm summer evening.

INSECT CHARACTERISTICS

If you are going to study insects, one of the first requirements is that you be able to distinguish insects from similar animals. No one will mistake a bird or a mammal or a fish for an insect — but how about a tick or a centipede or a spider?

The animal kingdom is divided into many large groups called phyla (fi-la). The phylum (singular) to which insects belong is called Arthropoda. All arthropods have jointed legs and an external skeleton or exoskeleton (somewhat like a suit of armor). In addition to insects, spiders, mites, ticks, scorpions, centipedes, millipedes, crayfish, shrimp, and sowbugs belong to this phylum.

The phylum, Arthropoda, is further divided into smaller categories called classes. Insects belong to the class INSECTA (or HEXAPODA, which means six feet, as all insects have six legs or feet). To distinguish insects from all other arthropods, use the following insect characteristics, described in the next column and illustrated in figure 1:

1. Three pairs of legs (all other arthropods have four or more pairs).
2. Three body regions — head, thorax, and abdomen. The head holds the eyes, mouthparts, and antennae. The thorax is the middle part with the legs and wings attached. One pair of legs is attached to each segment of the thorax. The abdomen, behind the thorax, contains the organs of digestion and reproduction.
3. One pair of antennae (sometimes called "feelers"). Located on the front of the head, they serve as organs of touch, and sometimes taste, smell, and hearing.
4. Two compound eyes (in most insects).
5. Wings (usually present) when in the adult stage. Most winged insects have two pairs; some, such as flies, only have one pair. A few insects, such as lice, fleas, and worker ants, are wingless as adults.

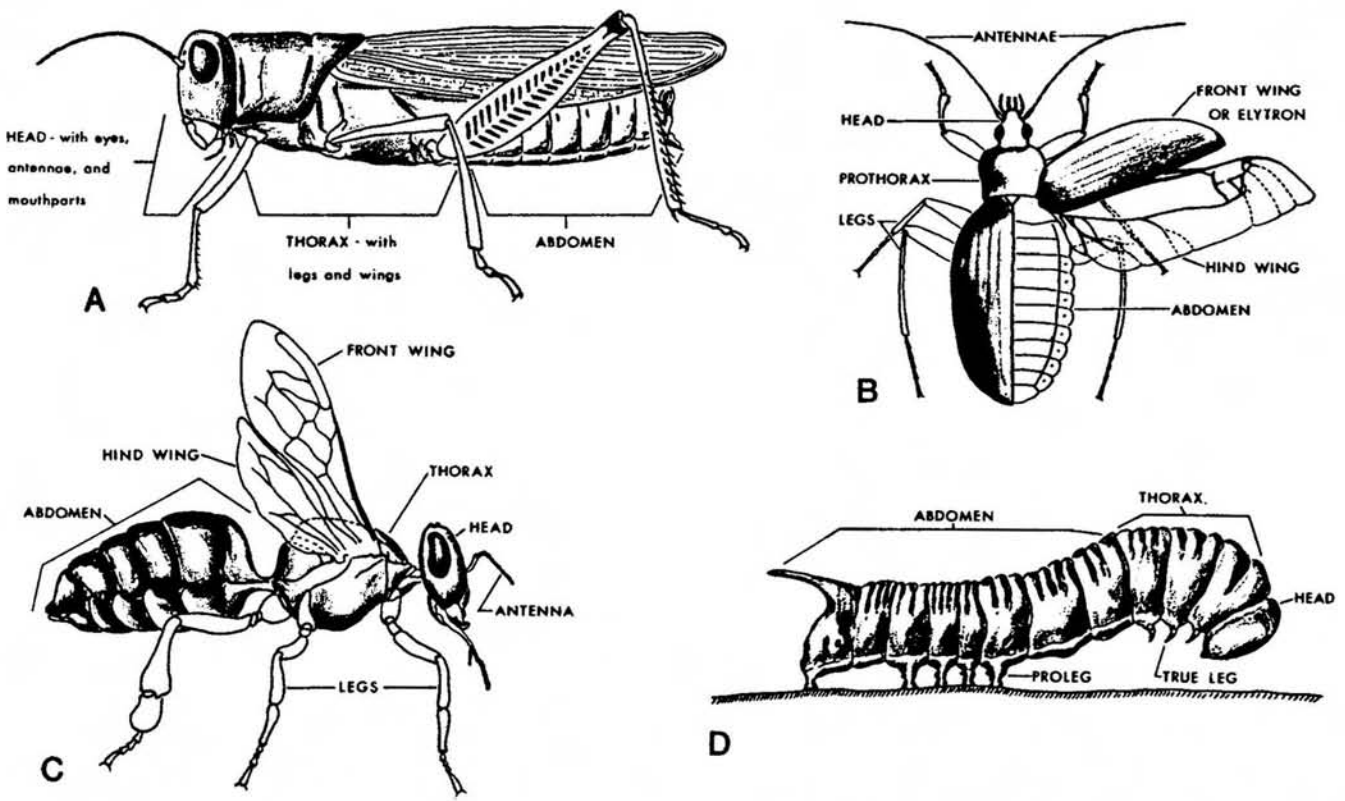


Figure 1. Some of the characteristics of insects make them different from all other kinds of animals: (A) grasshopper, (B) beetle, (C) honeybee, and (D) caterpillar.

Insect Growth and Development

INSECT GROWTH

Insects vary in their growth patterns. All begin as eggs and end up as adults (imagoes). But between the egg and the imago (adult) stage there is an intermediate growth form called the immature stage. It is during this stage, which differs in different groups of insects, that growth takes place. Insect growth is accompanied by a series of **molts** (periodic shedding of the exoskeleton). Molting is necessary because the exoskeleton is incapable of expanding. The number of molts varies in different groups of insects. Usually the number is between four and eight, but there are exceptions. The stage of the insect between molts is called an **instar.** Thus, the immature stage consists of several (usually four to eight) instars.

It is the adult insect that reproduces so that the species can continue to live from year to year. Sometimes, there is only one adult stage per year (one generation per year), such as grasshoppers. But many insects have several adult stages (and hence several generations) per year — for example, houseflies. Other insects, such as June beetles, need several years to complete one generation.

INSECT DEVELOPMENT

The immature or growth stage differs in different groups of insects. These immature stages of different insects are called by many different names, such as: maggots, grubs, nymphs, naiads, wrigglers, worms, caterpillars, crawlers, hellgrammites, etc. However, there are only four different basic types of immature insects, each distinguished according to the degree of similarity to the imago (adult) form. They are as follows:

1. **Young** — an immature stage that is identical to the adult in shape and form. It is only smaller in size (and lacks mature reproductive organs). Only a few primitive, wingless insect groups (orders) have this type of immature stage.
2. **Nymph** — an immature stage that looks like an adult (which is usually winged), but is smaller and has no wings. It has the same food habits and lives in the same habitat as the adult.
3. **Naiad** — an immature stage which is always aquatic (lives in the water), yet the adult is terrestrial (lives on land), and it only slightly resembles the adult form. However, like young and nymphs, the last instar naiad transforms directly into an adult, without passing first into a resting (pupa) stage.
4. **Larva** — an immature stage which may be of many forms (maggot, grub, wriggler, caterpillar, etc.), but usually wormlike and never similar to the adult. Also, the last instar larva always transforms into a pupa (resting) stage before becoming an adult (imago).

Considering the above discussion of egg, immature, and adult stages in insect development, notice that most insects change to some degree in form during development. This change is called **metamorphosis.** There are four basic types of metamorphosis, each associated with one of the four immature stages discussed above. They are:

Type of Metamorphosis	Active Immature Stage
Without Metamorphosis	Young
Gradual Metamorphosis	Nymph
Incomplete Metamorphosis	Naiad
Complete Metamorphosis	Larva

Proceeding from the first to the last, the immature is less and less like the adult. Refer to figure 2 for illustrated examples of the four types as well as a list of major insect groups which exhibit each type.

Knowing the type of metamorphosis for each group (order) of insects is very important for the entomologist. Through this knowledge he/she is able to find the "weakest link" in the insect's life cycle. This will aid in planning a successful program to control an insect pest.

It is generally true that during the insect life cycle, it is the immature stage that consumes the most food. Many of our worst pests are thus most destructive in the immature stage.

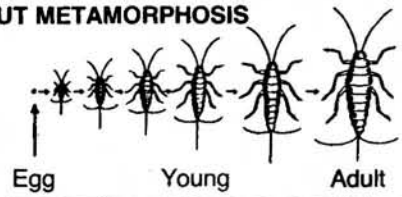
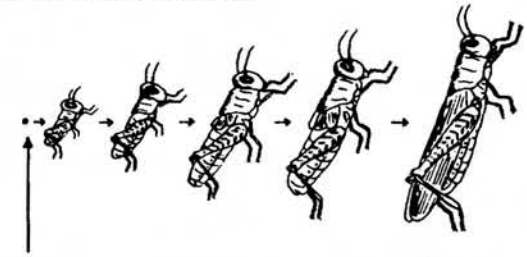
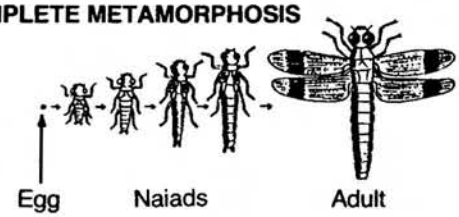
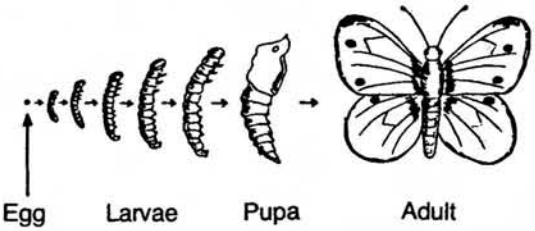
EXAMPLES	ORDERS	WITHOUT METAMORPHOSIS
silverfish	Thysanura	
springtails	Collembola	Egg Young Adult
EXAMPLES	**ORDERS**	**GRADUAL METAMORPHOSIS**
grasshoppers	Orthoptera	
termites	Isoptera	
booklice	Psocoptera	
thrips	Thysanoptera	
true bugs	Hemiptera	
aphids	Homoptera	
earwigs	Dermaptera	
chewing lice	Mallophaga	
sucking lice	Anoplura	Egg Nymphs Adult
EXAMPLES	**ORDERS**	**INCOMPLETE METAMORPHOSIS**
mayflies	Ephemerida	
dragonflies	Odonata	
stoneflies	Plecoptera	Egg Naiads Adult
EXAMPLES	**ORDERS**	**COMPLETE METAMORPHOSIS**
lacewing	Neuroptera	
beetles	Coleoptera	
scorpionflies	Mecoptera	
caddisflies	Trichoptera	
moths, butterflies	Lepidoptera	
flies	Diptera	
fleas	Siphonaptera	
wasps, bees	Hymenoptera	Egg Larvae Pupa Adult

Figure 2. Metamorphosis of various insects.

Insect Mouthparts

Insects feed on plants and other animals, living or dead. Because insects as a group have such diverse food requirements, different insects have different kinds of mouthparts. Basically, the food is taken into their bodies in either liquid or solid form.

Although there is a tremendous variety of insect mouthparts designed for ingestion of liquid and/or solid food, for the purposes of beginning 4-H entomology all insects can be categorized as having one of two basic mouthpart types: chewing or piercing-sucking.

The type of mouthparts is an important characteristic used in identifying the major group (order) to which a particular insect belongs. Reference will be made to mouthparts in the Key to Orders on pages 26-27. The more common types are also illustrated in figure 3.

In addition, the entomologist must recognize the two major types of mouthparts in prescribing control measures. This helps to determine the kind of insect that caused the damage as well as the type of insecticide that will be necessary to control this insect. If a pest has chewing mouthparts, it could pick up an applied layer of insecticide by "chewing" the leaf and ingesting some of the poison. However, if it has piercing-sucking mouthparts, an application of insecticide to the leaf surface would be worthless unless the insecticide had contact action and killed the insect just by coming in contact with its feet. Another alternative would be to use a systematic insecticide which circulates within the vascular system of the stems and leaves and is sucked up along with the plant juices by the insect.

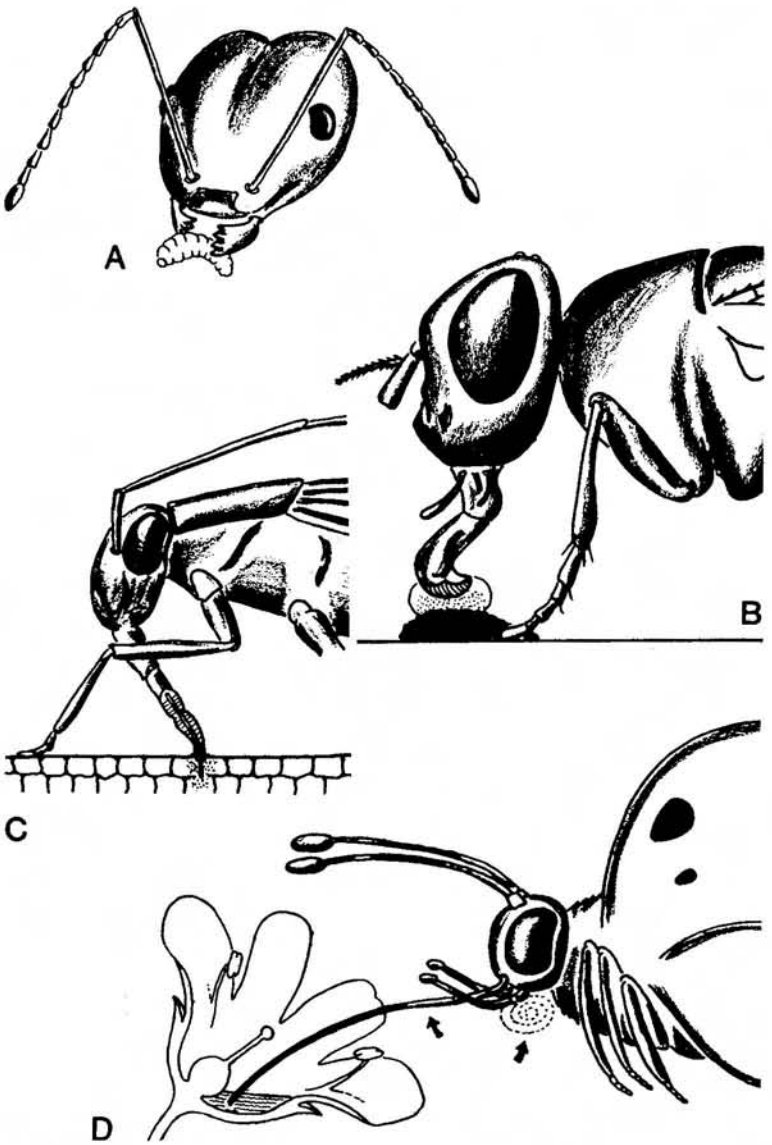


Figure 3. Types of insect mouthparts: **(A)** chewing mouthparts showing mandibles, **(B)** sponging mouthparts of certain kinds of flies, **(C)** piercing-sucking mouthparts, and **(D)** siphoning mouth tube of butterflies (arrows point to extended and retracted proboscis).

Insect Legs and Wings

The legs of adult insects are usually easy to distinguish. One pair of legs is attached to each of the three segments of the thorax, and each leg is composed of five jointed segments.

Though locomotion is their primary function, insect legs have actually evolved for many different types of movement, such as walking, running, jumping, swimming, grasping, and digging. In addition to the true legs attached to the thorax, caterpillars and sawfly larvae have fleshy, nonjointed **prolegs** on the abdomen. Prolegs have primarily a clinging function. Some immature insects, such as the larvae of flies and certain beetles, lack legs altogether.

As mentioned earlier, some insects are wingless. Included in this category are both primitive insects — groups which have never had wings — and more advanced groups which have actually evolved from winged ancestors. Included in the former groups are springtails and silverfish. In the latter category are lice and fleas.

Those insects with wings have either one or two pairs, usually two. In most wings there are thickened lines that run from the base to the tip called **veins.** The pattern formed by the veins, called **venation,** is distinctive for many groups of insects. Individual wing veins have names, but any detailed study of veins is beyond the scope of this introductory manual.

There are many types of wings, several of which are characteristic of major insect groups. The most common type is the **membranous** wing, clear and cellophane-like, which is found on flies, bees, and wasps as well as many smaller groups (orders) of insects such as dragonflies and mayflies. Beetles have a pair of membranous hind wings, but they also have a pair of hard, **armor-like** front wings (called wing covers or elytra). The wings of true bugs, such as stink bugs and plant bugs, have **membranous tips and hard, leathery bases** (and are called hemelytra). Moths and butterflies have **scaly** wings, and caddisflies have **hairy** wings. Thrips have **feathery** wings. Members of the Orthoptera (grasshoppers, crickets, mantids, and their relatives) have **leathery** wings. Many of these wing types are illustrated in figure 4.

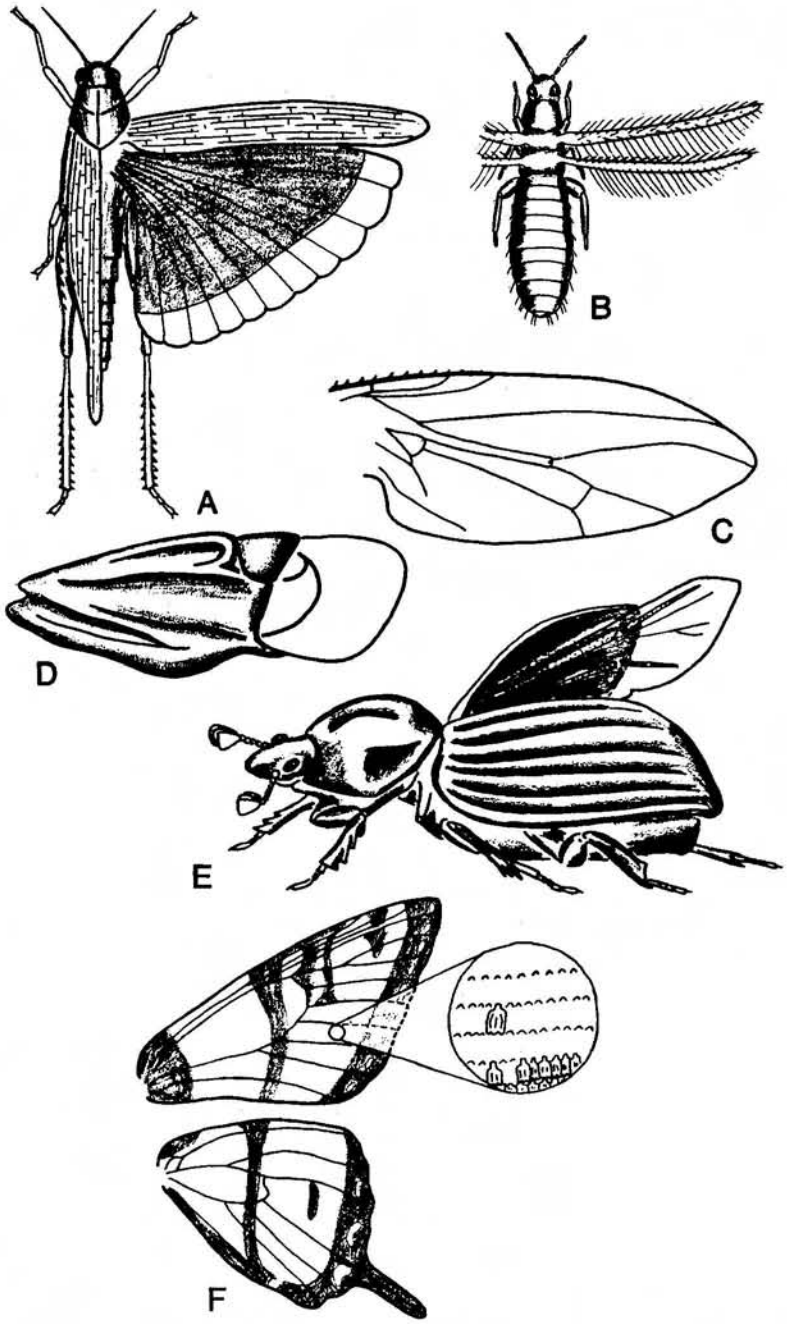


Figure 4. Types of insect wings: **(A)** leathery wings of grasshoppers, **(B)** feathery wings of thrips, **(C)** membranous wing of a fly, **(D)** half-leathery/half-membranous wing (hemelytron) of true bugs, **(E)** armor-like (elytron) and membranous wings of beetles, and **(F)** scaly wing of moths and butterflies.

Insect Classification

Insects are classified or divided into groups. The classification starts with **orders,** which are the largest insect groups. A little later in this manual, you will learn to identify insect specimens to the correct order with the aid of a key.

Classification is an aid to identification. In our society individual people are classified in numerous ways. A good example is the use of a person's mailing address in order to identify and separate that person from other individuals. Determining where insects fit into the animal kingdom is much like your mail carrier determining who you are from a well-addressed letter. Let's compare the two. A complete address would include your name (which really has two parts — a surname and a first name), street number and street, city, and state. But, when a mail carrier sorts mail, he/she reads the address from bottom to top, looking first for the state, then the city, street and so on, ending with delivery to a single individual.

Similarly, an entomologist classifies insects by the process of elimination, ending with the identity of one species. In classifying an insect, an entomologist gets clues from its structure and thus assigns it an "address." The categories of the scientific "address" are **kingdom, phylum, class, order, family, genus,** and **species.** Let's compare postal classification with insect classification, using two examples.

Postal Classification

Country	United States
State	Michigan
City	Lansing
Street	Main St.
Number	1000
Surname	Smith
First Name	Richard

Insect Classification

Kingdom	Animalia
Phylum	Arthropoda
Class	Insecta
Order	Diptera
Family	Muscidae
Genus	*Musca*
Species	*domestica*

In both postal and insect identification, the last two categories give us the name of the individual — Richard Smith and *Musca domestica.* In the case of the insect, we have used the scientific name. The common name in this case is house fly. Note that scientific names are italicized (or underlined).

Making an Insect Collection

Insect collecting can be an interesting and educational experience. By studying live insects you can learn an insect's life stages and habits, but you will not realize the vast number of species that live all around you until you start your own collection — with well-preserved and labeled specimens. The starting point of project work in 4-H entomology is usually the collection and identification of insects. Many people have made this a fascinating hobby, or even a life's work.

The best kind of insect collection to make first is one of every kind of insect you are able to catch anywhere you happen to be, whether near your home or far away. By making such a collection, you get to know and recognize many different kinds of insects. However, keep in mind that when you make such a general collection, you will end up with more of certain kinds of insects than others because some kinds are hard to find, or hard to catch, or may be difficult to pin and mount properly. For example, some people might not like collecting butterflies or moths because they take more work and patience to pin nicely.

After you have assembled a good general collection, there are other types of collections to consider. For example, you may wish to specialize by collecting only one kind of insect, such as only butterflies or only beetles.

Another type of collection would be one consisting of insects from a single habitat, such as ponds, fields, or fallen logs. Or perhaps you wish to make one from a single locality, such as your backyard, a farm, or a city park.

A very interesting type of collection is a life-history collection. In this type, you collect all life stages of particular insects and examples of what they feed on or what damage they do.

Finally, alcohol collections are important. The nymphs, naiads, and larvae of insects are often difficult to preserve other than in bottles or vials of alcohol. Alcohol collections are quite important for immature stages and small, soft-bodied insects such as aphids, as well as for related animals such as spiders.

For details on making these types of specialized collections, refer to *4-H Entomology Series Manual 2: Advanced Entomological Techniques.*

The following information will give you some ideas of where and how to look for insects. You will need a minimal amount of equipment, such as a killing jar and net. Directions for making and using these are given on pages 13-15. After you have been collecting for a while, you may want to use some of the special techniques and equipment in *Advanced Entomological Techniques.*

WHERE, WHEN, AND HOW TO COLLECT

Insects, in terms of kinds or species, are the most numerous group of animals on earth. They are all about us and can be found quite easily. However, a few hints on where and how to collect may make your hunting more rewarding.

Insects, like other animals, need food to survive. Their food is almost as diversified as the kinds of insects themselves. The key to making a large and varied collection of insects is to know something of their food habits and where and how they live. Thus, seek out insects in their natural habitats in as many varied places as you can — a meadow, a pasture, in a sand bank, in the soil, in dense woods, along the margins of streams and lakes, etc.

The following information will give you some ideas of where and how to look for insects.

IN THE AIR — The net is an especially handy tool, so learn to use it to its fullest advantage. You may use it for collecting single specimens in flight by swooping it

through the air, or by quickly clamping it over an insect resting on the ground. Another method of using the net (if made from muslin rather than a mesh) is known as "sweeping." This is done by sweeping the net back and forth through vegetation and accumulating the insects in the bottom of the net bag. You may pick out the insects singly by hand, by running the bottle inside the net and forcing the insects into it, or by dumping the entire contents (including leaves and debris) into the killing jar. If the latter is done, the insects can be sorted from the debris after they are dead. Insects collected by sweeping frequently include bees and other stinging insects, so play it safe and handle the bag with caution. One good technique is to insert the end of the bag along with the captured insect into the killing jar. Place the lid over the mouth of the jar as tightly as possible for a minute or so until the insect becomes motionless. Then remove the end of the net from the jar and put the stunned insect back into the killing jar.

IN THE WATER — All too often beginning entomologists use only an insect net and thus miss collecting many important and even common kinds of insects. For example, many insects are aquatic and spend all or at least a portion of their lives in water—some in stagnant ponds and others in cold, highly-oxygenated water. An aquatic screen, like the one in figure 5, is easy to construct. It works best when used by two people who walk upstream against the current, dislodging rocks in front of it. Also, biological supply houses sell many kinds of aquatic insect nets, or you could use an ordinary kitchen strainer.

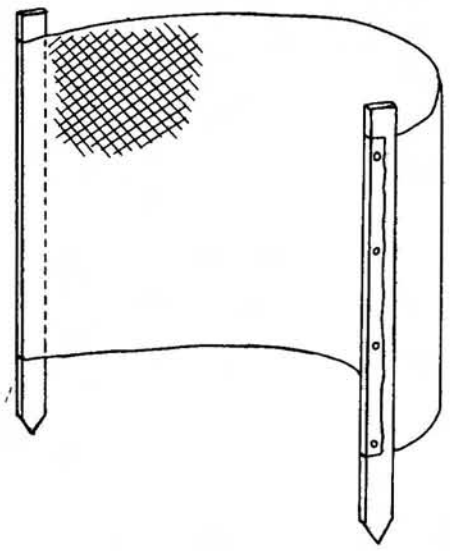


Figure 5. Aquatic screen.

ON LAND — Many insects, both large and small, are common on the soil surface. Some are very active; others live under leaves and other debris and wander very little. The best way to collect terrestrial insects is to look under rocks, logs, boards, and other objects. Also, pry off the dead bark of fallen trees. Remember that the courteous insect collector returns these objects to their original position after searching for insects. Use forceps to pick up insects from cracks or crevices where your fingers can't reach. Forceps are also useful if you don't like to pick up insects with your fingers, especially if the specimen looks like it is capable of biting or stinging.

A good tool for collecting the more active insect forms is a pitfall (or tumble-in) trap. The trap (a jar, can, or other container) should be buried in the soil so that the top edge is just below the soil surface. It sometimes helps to provide a cover, such as a board supported by stones. The trap can be left empty or baited with sliced fruit or vegetables or chicken bones. It should be checked frequently as some trapped insects consume others and some also may fly out. A variation is to add an inch or so of 70 percent ethylene glycol (automotive antifreeze) to the bottom. This fluid kills and temporarily preserves any insects which fall into it, and you need check the trap only about once a week (unless heavy rains add a lot of water to the trap).

IN TREES — Many insects sit perched rather securely on the branches of trees and shrubs. A good technique for collecting many of them is to use a beating sheet. The beating sheet somewhat resembles a kite, constructed from canvas (or bed sheeting) and wooden sticks (see figure 6). Grasp the wooden sticks where they cross, hold the sheet out under a branch, and beat sharply

on the branch with a strong stick such as a wooden ax handle. The beating will dislodge large numbers of insects which will drop onto the canvas and can be easily seen. They can then be picked up and transferred to vials or a killing jar.

AT NIGHT — Many insects are nocturnal (active only at night). Curiously, while they shun the light of day, they are attracted to a light placed in your yard or on your porch. You will find that by replacing the incandescent bulb with a blacklight bulb (available in gift and party stores) greater diversity will be produced. However, by visiting street lights and lighted signs in the summer, you will often find large numbers of insects. You can also try searching the ground with a flashlight to capture those insects (and spiders) which are active at night but do not come to light.

While the methods referred to above will suffice to attract some types of insects, other lighting setups are more efficient. Refer to *Advanced Entomological Techniques* for details.

Another method of collecting night-flying moths and beetles is called baiting or sugaring. A standard bait mixture consists of 6 fluid ounces of stale beer and 8 ounces of dark molasses. Some collectors add to this mixture a small amount of mashed, overripe fruit, such as bananas or peaches. However, the pulpy material should be held to a minimum to avoid making the mixture too thick. This bait can be mixed in the morning and left out in the sun to ferment, adding to its effectiveness.

The mixture is painted on a selected row of trees at a convenient height before it gets dark. At this time, any dried twigs should be cleared away so that your approach to the insects at the bait is as noiseless as possible. If the bait is left on the trees for 20 to 30 minutes after dark, the feeding specimens are less cautious and more easily collected. Patrol the baited trees cautiously with a dim flashlight and a killing jar. Desirable specimens are collected by placing the opened killing jar over the feeding insect and holding it in place until fluttering is slowed down. The jar is then quickly removed and capped.

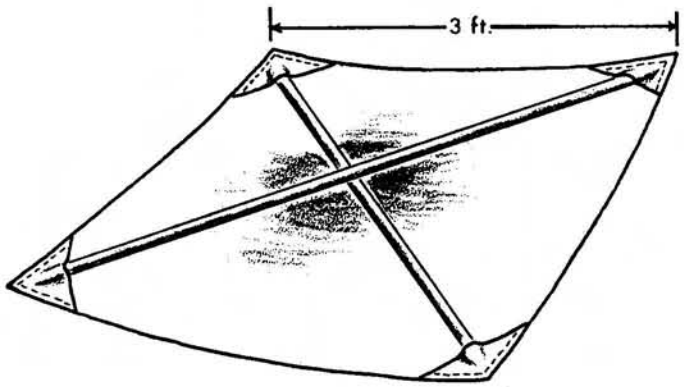


Figure 6. Beating sheet.

The fall months are most productive for underwing moths and other desirable species. Many butterflies and other insects are attracted to the bait mixture during the daytime.

SUMMARY: LOOKING FOR INSECTS

Aquatic Habitats

- Around marshes, ponds, lakes, and streams — mayflies, dragonflies, damselflies, stoneflies, caddisflies, aquatic bugs, and beetles

Terrestrial Habitats

- Under boards, rocks, etc. — ants, crickets, termites, and beetles
- Under loose bark (logs and stumps) — ants, crickets, and bark beetles
- Dumps and refuse piles — cockroaches, earwigs, and flies
- Manure piles — flies and beetles

Arboreal Habitats

- On flowers and foliage — bees, flies, aphids, mantids, leaf beetles, thrips, wasps, ants, walking sticks, insect galls, butterflies, and moths
- On crop plants — grasshoppers, beetles, true bugs, flies, aphids, leafhoppers, spittlebugs, and moths

Aerial Insects

- In the air — butterflies, flies, bees, wasps, beetles, leafhoppers, spittlebugs, and moths

Special Habitats

- Cellars and basements — crickets, beetles, ants, and bristletails
- In buildings — crickets, beetles, ants, flies, mosquitoes, moths, termites, and silverfish
- Store products (fabrics and food) — clothes moths, carpet beetles, flour beetles, grain weevils, and bean weevils
- At lights — beetles, moths, true bugs, flies, wasps, leafhoppers, mayflies, and stoneflies
- On livestock, poultry, and pets — fleas, lice, and flies

Record-Keeping

You shouldn't rely on your memory alone for an accurate accounting of all your entomological endeavors. Instead, take the time to record your accomplishments as they happen. The recording method you choose will depend on the nature and complexity of your project, activity or event.

You may wish to use the *4-H Entomology Record and Report* (4-H 1393) to record some of your accomplishments. You could also use a looseleaf notebook to record your more complicated experiments or field observations. A scrapbook can hold news clippings, photographs, illustrations or other mementos of special events and activities. The scrapbook can be an important record of your achievements, especially when there isn't any other tangible evidence of your involvement in an event or activity.

Accurate, timely record-keeping is a useful life skill to develop, especially if you plan a career in science. Scientists are expected to keep concise, accurate records of all their activities, observations and investigations in the laboratory and the field. You'll find many other uses for your record-keeping and writing skills as well. One good example is that keeping accurate and up-to-date records can greatly simplify the process of applying for 4-H awards and other recognition.

Equipment for Collecting

The equipment needed to start collecting and mounting insects is fairly simple and costs very little. Much of the basic equipment can be quite suitably improvised. Essential equipment includes a collecting net, killing jar, insect pins, pinning block, forceps or tweezers, scissors, spreading board, insect labels (locality and identification), specimen boxes, and a fine-pointed pen. The following will tell you how to make some of these things and how to use them properly.

THE COLLECTING NET

The collecting net consists basically of a handle, a metal ring, and a cloth bag. The handle may be made from a ¾-inch piece of dowel stock which is 3- to 4-feet long. A discarded broom or dust mop handle will also do nicely. The handle should be drilled with angled holes (fig. 7A) or grooved on both sides (fig. 7B). If the latter method is followed, the groove should be 2 inches long on one side and 3 inches long on the other, and deep enough to permit the hoop wire to fit snugly in place. Each groove should end in a hole large enough to receive the end of the wire.

The hoop is made from a 4-foot piece of heavy wire, about ⅛ inch in diameter (a heavy coat hanger will do), and bent as shown in figure 7A or 7B. Make sure that the bent ends fit exactly into the holes in the handles. This will prevent the hoop from twisting on the completed net. To hold the hoop in place, the handle can be bound with tape, wire, nylon cord, or a metal collar which just fits over the handle can be used (method B only).

The bag of the net may be made from a variety of cloth materials. If you are making an aerial net for collecting flying insects such as butterflies and dragonflies, marquisette or scrim is the best material. It is light and durable, and will withstand a lot of hard use. The mesh should be coarse enough to allow air to pass through easily as it is swung through the air. Still, the mesh needs to be fine enough to prevent the escape of small, captured insects.

To collect insects out of trees, shrubs, and grasses, use a sweeping net. This should be made of a heavier material such as unbleached muslin, feed sacks, sheeting, or some other similar nonmesh material to prevent ripping.

The bag for both nets should be cone shaped with a rounded tip, and twice as

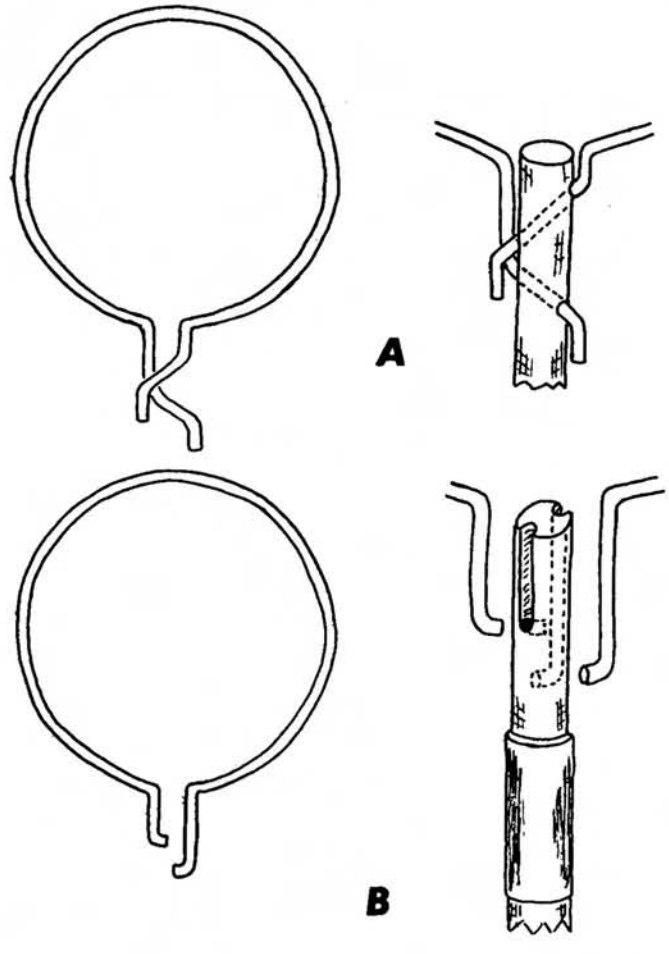


Figure 7. Net bag construction; two alternative ways of attaching hoop to handle.

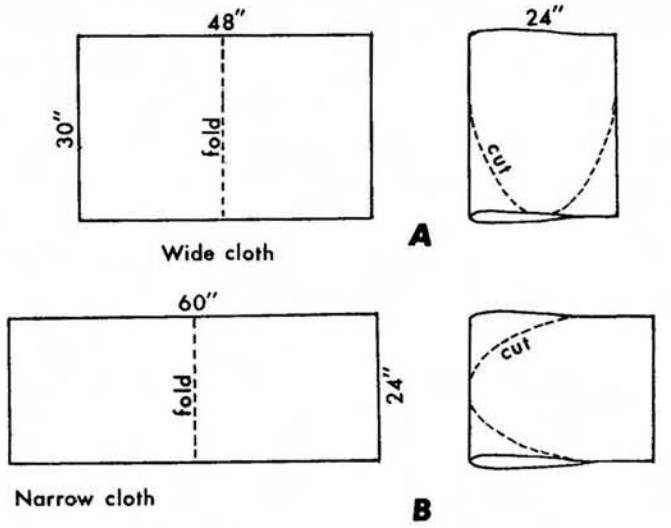


Figure 8. Construction of cloth net bag.

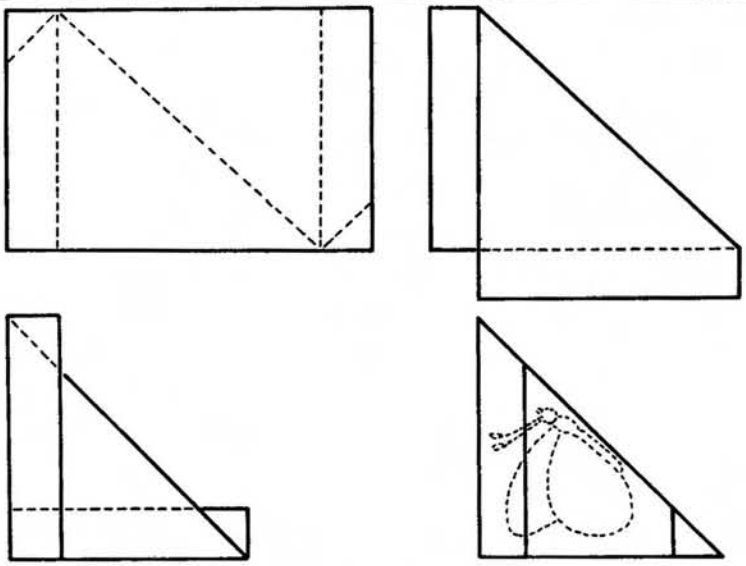


Figure 9. How to fold a paper triangle.

long as the diameter of the metal hoop. For example, if the diameter of the hoop is 15 inches, then the dimensions of the cloth should be as shown in figure 8. Cut the cloth to shape and pin the cut edges together to hold them while you sew. Fasten the open end of the bag to the wire loop by folding it over the wire and sewing with heavy thread.

Additional suggestions for collecting butterflies and moths — Once a specimen has been netted, it is wise to "pinch" it. This is done by firmly applying pressure to the thorax between your thumb and forefinger. This technique immobilizes the specimen so you can put it into the killing jar without it damaging its wings before it dies. After the specimen is dead, it can be pinned and spread. If you are not going to mount it immediately, store the specimen in a paper triangle (figure 9) or place it in the freezer. If stored for very long in the triangle, it will have to be relaxed before mounting. To avoid breaking legs and antennae, specimens in paper triangles should not even be removed until they have been relaxed for at least 12 hours.

THE KILLING JAR

A killing jar is one of your most essential items. Start with a wide-mouthed jar with an easy to remove twist-off lid. Mix plaster of paris and water to a consistency suitable for pouring. Pour the mixture to a depth of 1 to 1½ inches in the jar and let it stand overnight. Do not replace the lid until the plaster is dry, at which time the jar is ready to use.

When ready to collect, place a teaspoon of killing agent in the jar. The best and safest killing agent is ethyl acetate, also called acetic ether, which is sold at biological supply houses. It is safe to use, kills insects quickly, and keeps the insects flexible until they are removed from the jar to be pinned. Carbon tetrachloride is not recommended because it makes the insects dry and brittle and can be absorbed through the skin. Sodium cyanide should not be used because it is too dangerous.

It is best to keep your supply of ethyl acetate in a dropper bottle. Then, the jar can be recharged as needed by adding a few drops to the plaster of paris and waiting until it is soaked up. Always keep the jar tightly covered except when placing insects in it,

as the killing agent evaporates very rapidly. Also, place a crumpled piece of tissue paper or paper toweling in the jar. This provides something for the insects to crawl on until they die, instead of becoming tangled up with each other.

As an alternative, many insects can be killed without the use of dangerous chemical killing agents. You may wish to kill some insects by placing them directly in a bottle filled with either 70 percent ethyl or 35 percent isopropyl (rubbing) alcohol. This method works well for beetles, bugs, hoppers, most flies, and many other insects; however, this method should **not** be used for killing bees, butterflies, and moths because it will ruin the specimens. If it's all right with your parents, you may want to kill your insects by placing them in the freezer (for several hours to overnight, depending on the type of insect). Always place the insects in a closed container, as this prevents moisture from ruining the specimens when you take them out of the freezer. After the container and specimens reach room temperature, you can easily and safely prepare the specimens for your collection.

OTHER EQUIPMENT

INSECT PINS — Pins may be obtained from most college or university bookstores and by mail order. Your 4-H leader or 4-H - Youth agent may know the best source. Do not use common pins, since they will rust and soon ruin what may be valuable specimens. Insect pins come in several sizes; the larger the number, the larger the pin. Numbers 2, 3, and 4 are most useful.

THE PINNING BLOCK — Medium- and larger-sized insects should be pinned vertically through the body, using a pinning block to set the height on the pin. The specimens should be pinned with about one-third of the pin above the upper surface of the insect. This is important, both for neatness and ease in handling. A wooden pinning block, constructed to the dimensions given in figure 10, will permit uniformity in pinning heights.

FORCEPS AND SCISSORS — A small pair of scissors is handy for cutting out insect labels and stiff pieces of smooth paper or pieces of wax paper when spreading moths and butterflies on spreading boards. A pair of fairly large, fine-pointed forceps, and a pair of flat-pointed forceps are very useful for handling smaller insects, moths, and butterflies.

THE SPREADING BOARD — Every insect collector needs at least one spreading board for moths, butterflies, and other insects that should have their wings spread when pinned. You can purchase a spreading board at a biological supply house, such as the professional one shown in figure 11, or you can make one. To make one, obtain

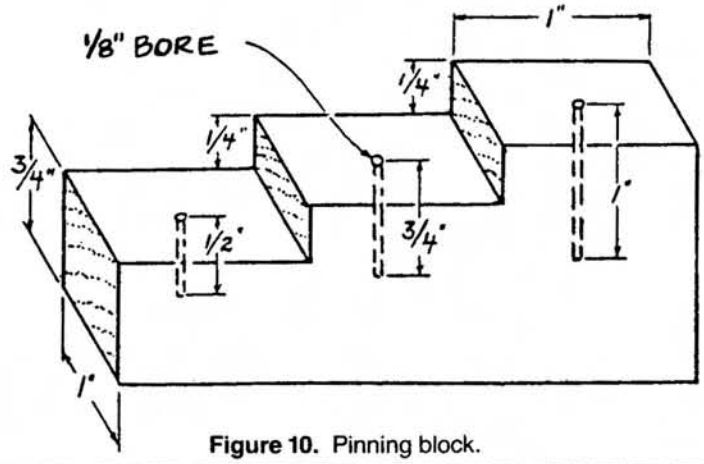


Figure 10. Pinning block.

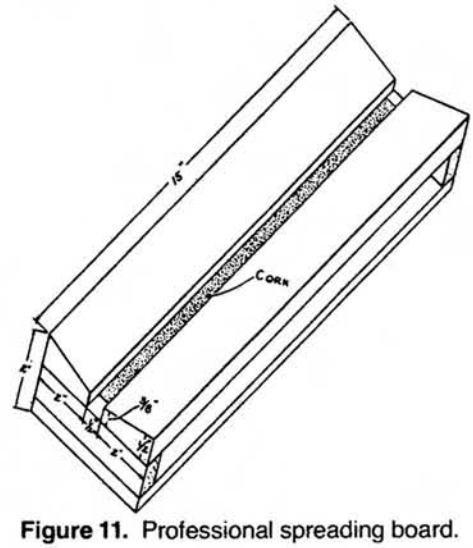


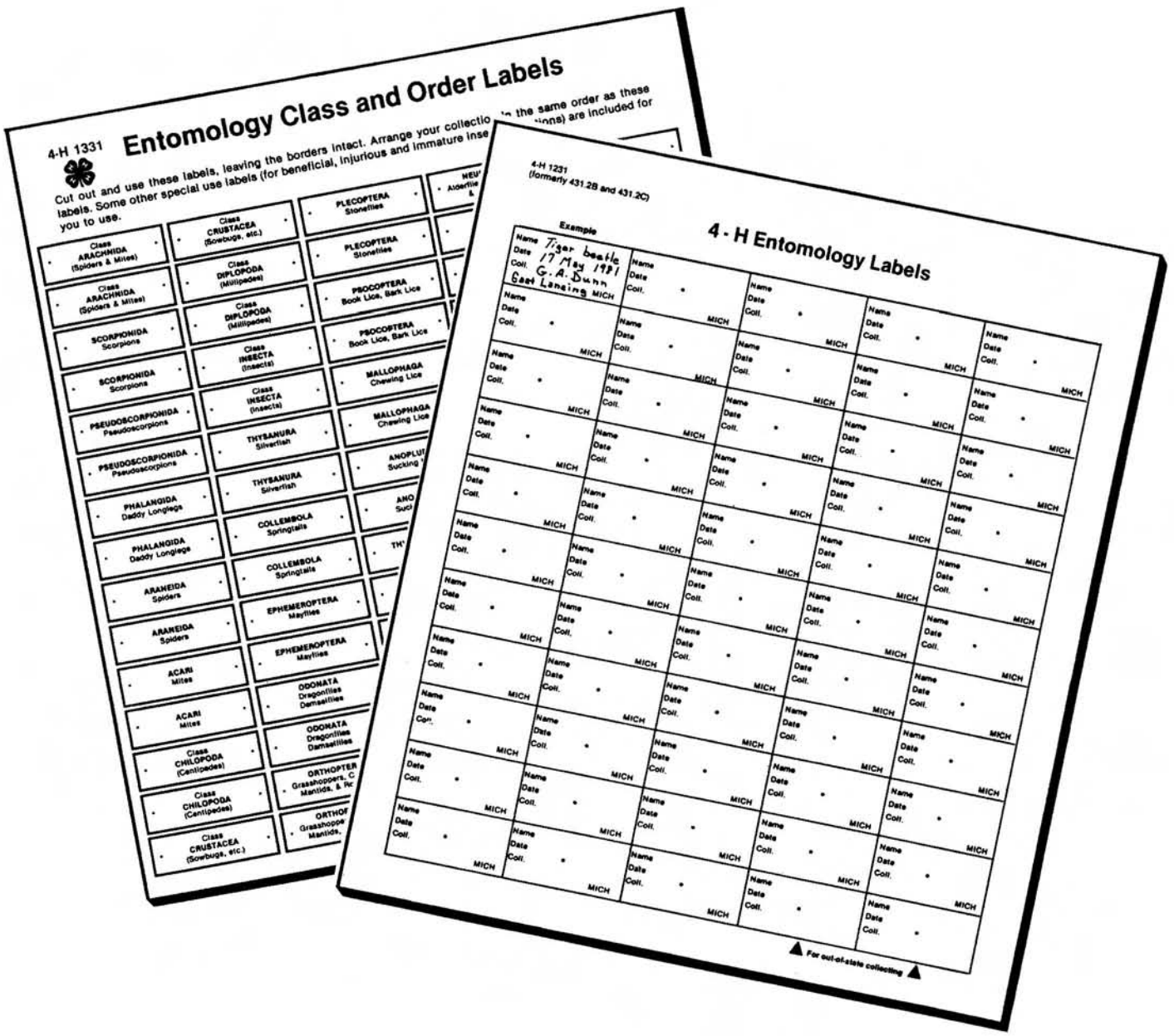
Figure 11. Professional spreading board.

a piece of plastic packing foam with at least one smooth surface. Make a longitudinal groove in it large enough to handle the bodies of the butterflies and moths you wish to pin. Two boards would be even better — one for butterflies and small moths, and another, with a larger groove, for large moths. Some professional spreading boards are made so the gap between the two wooden slats is adjustable.

INSECT LABELS — Labels on pinned insects are essential. Without a label, an insect in a collection is just a pretty (or ugly) dead thing. With a label it becomes something important — it is a piece of scientific information. Whenever you catch and kill an insect, and add it to your collection, be sure you have labeled it properly so that it will have some value.

A locality label tells where the insect was caught, when it was caught, and who caught it. It goes on the pin directly beneath the specimen.

Printed 4-H labels are available through your leader. However, you will still need a fine-pointed pen to complete them. More information about labeling is included on page 21.



Preserving Your Insects

Once insects have dried, they are very fragile. For this reason, they should be mounted when fresh.

Insects are pinned through the thorax (the middle section of the body). A good rule of thumb is to pin the insect slightly to the right of the midline, in the region where the second pair of legs are attached. Figure 12 illustrates a completed mount.

Some variation occurs in the many groups of insects as to where they should be pinned. For example, beetles are best pinned through the right wing cover. Refer to figure 13 for the correct place to pin representatives of each of the major orders of insects.

The height at which specimens are pinned should be uniform, with about one-third of the pin exposed above the upper surface of the insect (figure 14). Also, the insect should be horizontal on the pin when viewed from both the front and the side. This is important both for neatness and ease in handling. The pinning block (figure 10) will permit uniformity in pinning heights. Slide the specimen upward on the pin using the deepest hole in the pinning block.

Figure 12. Correctly pinned insect.

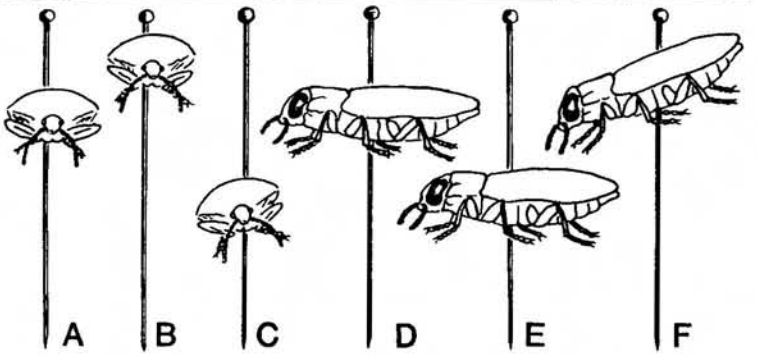


Figure 14. Correctly and incorrectly pinned insects: **(A)** correct, **(B)** too high, **(C)** too low and tilted, **(D)** correct, **(E)** too low, **(F)** too high and tilted.

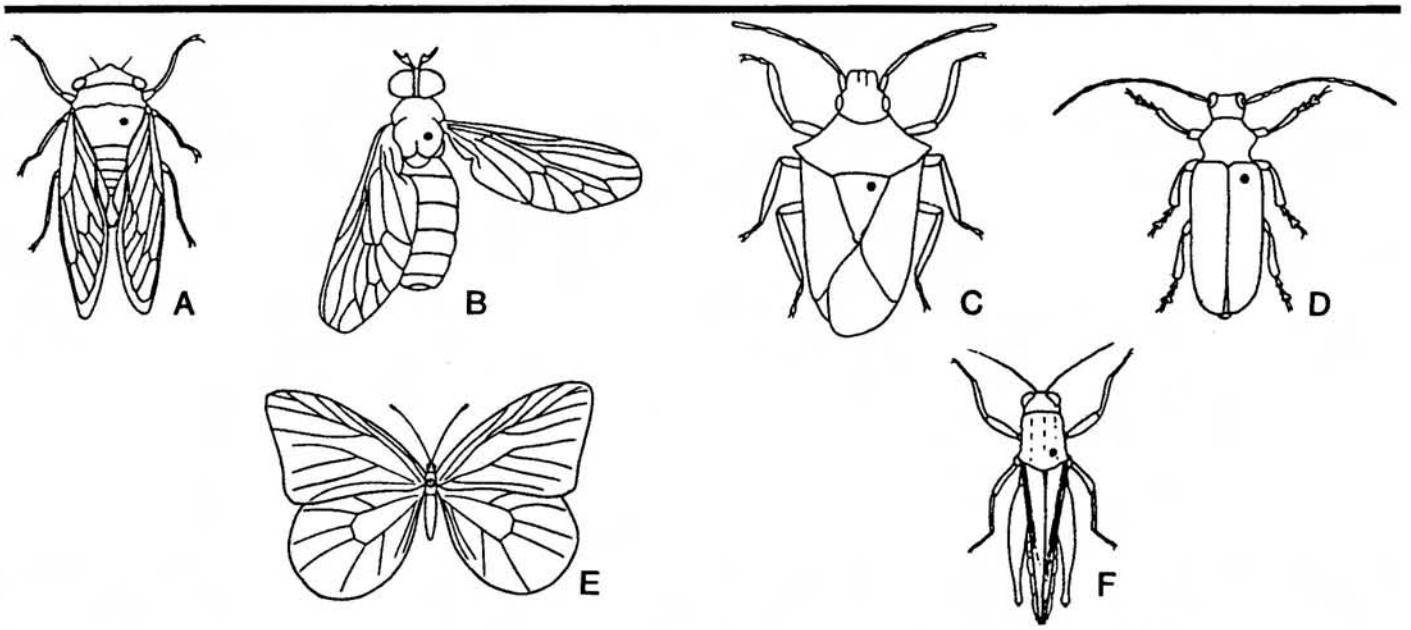


Figure 13. Correct place to pin in several orders of insects. The small, round dot in the thorax indicates the position of the pin. **(A)** the cicada or dog-day harvestman, Homoptera; **(B)** horsefly, Diptera; **(C)** stink bug, Hemiptera; **(D)** long-horned beetle, Coleoptera; **(E)** butterfly, Lepidoptera; **(F)** grasshopper, Orthoptera.

All butterflies and moths should have their wings spread. Orthoptera, such as grasshoppers and mantids, should have only their left wings spread. Dragonflies and damselflies can be pinned through their side with the wings folded up over their back or through the back with their wings spread (preferred way).

SPREADING LEPIDOPTERA

One of the most difficult tasks for young collectors to learn is the proper mounting of moths, butterflies, and skippers. In this group of insects, small overlapping scales on the wings produce a variety of colored patterns, many of which are very beautiful. Color patterns are used in identifying species; to see these patterns, the wings must be spread correctly. Use either a homemade spreading board or one purchased at a biological supply house. Starting with a freshly killed specimen or one that has been in the freezer and thawed, follow these steps:

1. Pin the specimen through the thorax in the usual manner (fig. 13E).
2. Push the pin down through the center slot of the spreading board until the wings are even with the side pieces (fig. 15A).
3. Move the front wings forward with the aid of an insect pin or a pair of blunt-ended tweezers.* (Don't handle the specimen with your fingers because the delicate scales rub off very easily.)
   a. Place the pin behind the heavily veined portion on the front margin of the wing.
   b. Pull the front wings forward until the hind margin is perpendicular or forms a right angle to the length of the body (figs. 15B and 15C).
4. The pin holding the front wing may then be temporarily anchored into the wood or foam.
5. Pull each hind wing forward in a similar manner until the front margin of the hind wing is hidden beneath the front wing and a small notch or "V" remains between the two wings at the outer margin (fig. 15D).
6. Hind wings can also be temporarily anchored with insect pins.
7. Strips of smooth finished paper (waxed paper or pieces of index cards) may then be placed over the wings and anchored securely with common pins. Since a common pin will leave a considerable hole if punched through the wing, the paper strips should be pinned just off the wing margins. The insect pins used for

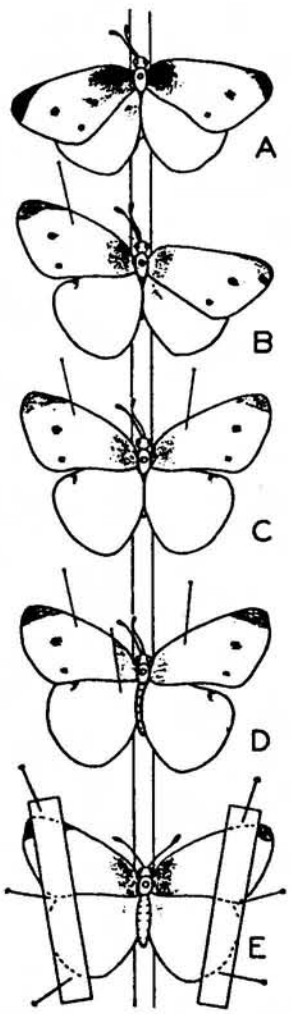


Figure 15. Steps in the proper spreading of the wings of moths and butterflies.

*If using tweezers, place the waxed paper strips over the wings before moving the wings. Once the wing is held in place by the tweezers, the waxed paper can be anchored tightly with the pins. This method eliminates making a pin hole in the wing.

temporarily anchoring the wings in position may then be removed by gently rotating and withdrawing (fig. 15E). If pulled straight out, the wing is often torn.

8. Antennae should be positioned as in figure 15E. Pins may be used to hold them in place until they dry.

If several specimens are spread on the same spreading board and the collection data is not the same for all of them, you should pin a locality label to the board alongside each specimen. The spreading board is then ready to set aside for the insect to dry — out of reach of younger brothers and sisters, pets, mice, and ants. Do not set it in the sun as some specimens will fade. The drying period lasts about a week but varies to some extent with the size of the insect. It may take as long as two weeks for certain large moths to dry properly.

After the specimen has thoroughly dried, remove it carefully from the spreading board, label, and place it in your collection.

RELAXING DRY SPECIMENS

It is often some time before you can get around to pinning or spreading your dead insects. Freshly killed specimens can be adequately stored for 3 to 4 weeks by placing them in the freezer compartment of your refrigerator. They can be mounted immediately when thawed.

However, specimens sometimes become dry and brittle before they can be frozen or if they are frozen too long. If you try to pin or spread an insect that is dry, it will crumble or the legs will fall off. To overcome this, the insect should be relaxed.

To relax an insect, place it in a very damp atmosphere for a few days. Most relaxing containers are made of tin (cookie tins are excellent) with a tight-fitting lid. Large jars will also work. Damp paper towels or about one inch of damp white sand in the bottom of the container will provide the humid atmosphere. The water used to dampen the paper towels or sand should contain a few drops of carbolic acid to prevent the growth of mold, or a small amount of mothball flakes will also discourage mold formation. The insect specimens should be laid in a flat, open dish rather than directly in contact with the wet paper toweling. Check the specimens daily until they are flexible enough to mount. Do not leave them in the relaxer any longer than necessary.

An alternative method is to carefully place the dry specimens (except for moths, butterflies, bees, caddisflies, and some flies) into **very hot** (not quite boiling) water for about 5 minutes.

PRESERVING SMALL AND FRAGILE INSECTS

Specimens too small to be pinned, such as small flies, beetles, and wasps, should be mounted on triangular paper points. The paper points should be cut from heavy paper, such as index cards. Make them no more than ⅜-inch long and ⅛-inch wide. Paper point punches are available from biological supply houses but they are quite expensive. A punch will allow you to obtain points of much more uniform size.

Push a pin through the base of the card point and push the point up on the pin by using a pinning block, just as you do with a pinned insect (see fig. 16A). With a pair of tweezers or forceps, bend down the tip of the point (as in fig. 16B). Put a tiny drop of fingernail polish or white glue on the bent-down part of the point and press it gently to the right side of the insect (fig. 16C). Generally, you should point any insect which you feel would be damaged by trying to pin it.

Some soft-bodied insects, such as aphids, springtails, silverfish, and mayflies, should not be pinned at all but can be preserved in small vials of alcohol. These small bottles or vials may be purchased from biological supply houses or sometimes from local drugstores. Lice and fleas, as well

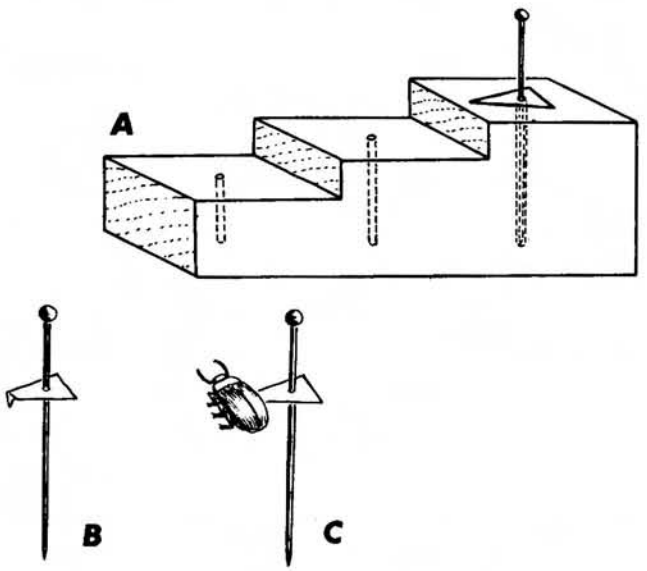


Figure 16. Pointing an insect: **(A)** setting height of point on pin, **(B)** tip of point bent down, and **(C)** insect correctly mounted on point.

as very fragile insects such as craneflies and mosquitoes, are also best preserved in alcohol. Professional entomologists use 70 to 80 percent ethyl (grain) alcohol. However, rubbing alcohol, available from any drugstore, will do nicely. Use a 35 percent concentration. To reach this concentration, mix store-bought rubbing alcohol with an equal amount of water. The same information that is written on the label which goes on a pin is then written on a small piece of paper with a pencil or waterproof ink (not ball point). These labels are placed inside the bottle or vial with the specimens.

Labeling Specimens

Printed labels are furnished for your 4-H entomology project. All necessary information should be filled in with ink using a fine-pointed pen. The locality label (fig. 17A) should accompany each insect specimen. The label should contain the following information: location (state and nearest town), date of collection, name of collector, and name of insect. The label goes on the pin immediately beneath the specimen (fig. 17B). The middle hole in the pinning block is used to set the label height on the pin. Notice that the pinned specimen in figure 17B faces the left as you read the label.

For pointed insects, the label is placed on the pin in the same manner. Again, notice the orientation of the pointed specimen, with the point directed to the left (fig. 17C). Also notice that the pin passes through the right half of the label in pointed specimens, whereas it passes through the center of the label in pinned specimens.

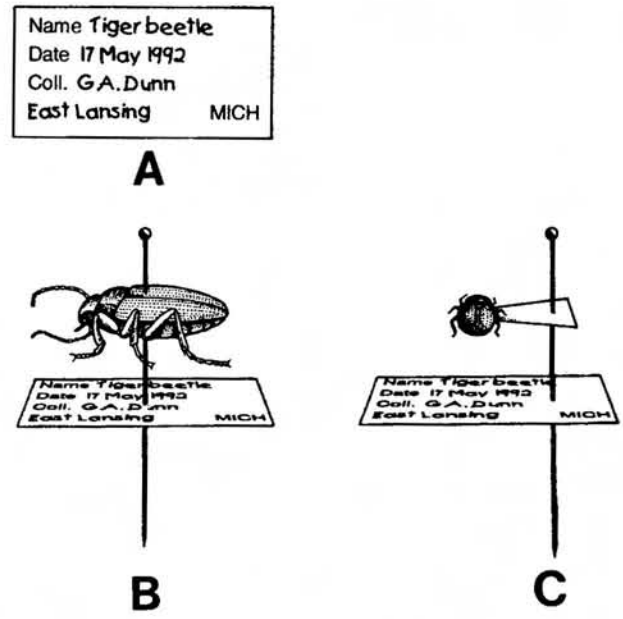


Figure 17. Labeling insects: **(A)** locality label, **(B)** correct position of locality label on pin, and **(C)** proper orientation of label for a pointed insect.

Storing and Displaying Your Collection

A collection of pinned insects must be properly stored in order to protect it from dust, damage, and infestations of carpet beetles and other museum pests. The beginner who wishes to use the collection for study purposes only may find that cigar boxes are satisfactory. If a cigar box is used, a piece of corrugated cardboard, soft fiberboard, balsa, or cork should be glued to the bottom to provide a pinning surface. However, if you wish to display your insects or maintain the collection for a number of years, a more elaborate, tight-fitting box is highly desirable.

The standard museum display case, measuring 18 x 24 x 3½ inches, may be constructed from white pine, a masonite bottom, a pinning cushion, and a glass top. Measurements and details of construction are included in figure 18. To ensure that your collection box seals tightly, glue the joints. Also seal the glass top with tape whenever you are not working with your collection. The pinning cushion can be Styrofoam or Celotex. If a plastic foam is used, make sure that it does not react with moth balls or moth ball crystals. To test this, seal up a moth ball or some moth crystals with a piece of foam in an airtight container for several days and check for any chemical reaction.

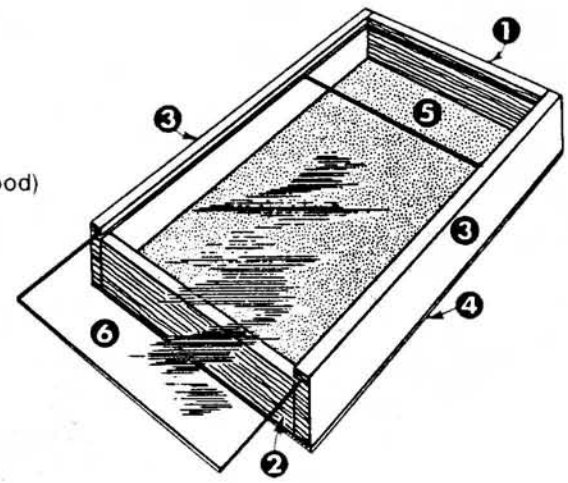
Regardless of the type of box you use, your dried insect specimens are perfect food for certain dermestid beetles, commonly

called carpet beetles. Precautions must be taken to prevent their entrance. Moth crystals (paradichlorobenzene or PDB) are good for preventing infestations. They may be placed in a small box in one corner of the collection box and replenished when necessary.

An ordinary mothball also works well. The head of a common pin heated with a lighted match (by holding the point of the pin with a pair of pliers) can be applied directly to the mothball. The mothball will melt around the pinhead and then harden again. It may then be pinned into the corner of your collection box.

Place only pinned and labeled specimens in the box. Orders should be placed in neat rows beneath the order label. Neatness in pinning and displaying insects is important at county and state fairs. Printed order labels are available through the 4-H entomology program.

Piece No.	Quantity Needed	Size (inches)	Material
1 end	1	¾ x 3½ x 16½	white pine
2 end	1	¾ x 3 x 16½	white pine
3 sides	2	¾ x 3½ x 24	white pine
4 bottom	1	⅛ x 18 x 24	masonite (or ¼" plywood)
5 cushion	1	½ x 16½ x 22½	Styrofoam
6 top	1	⅛ x 17 x 23	glass



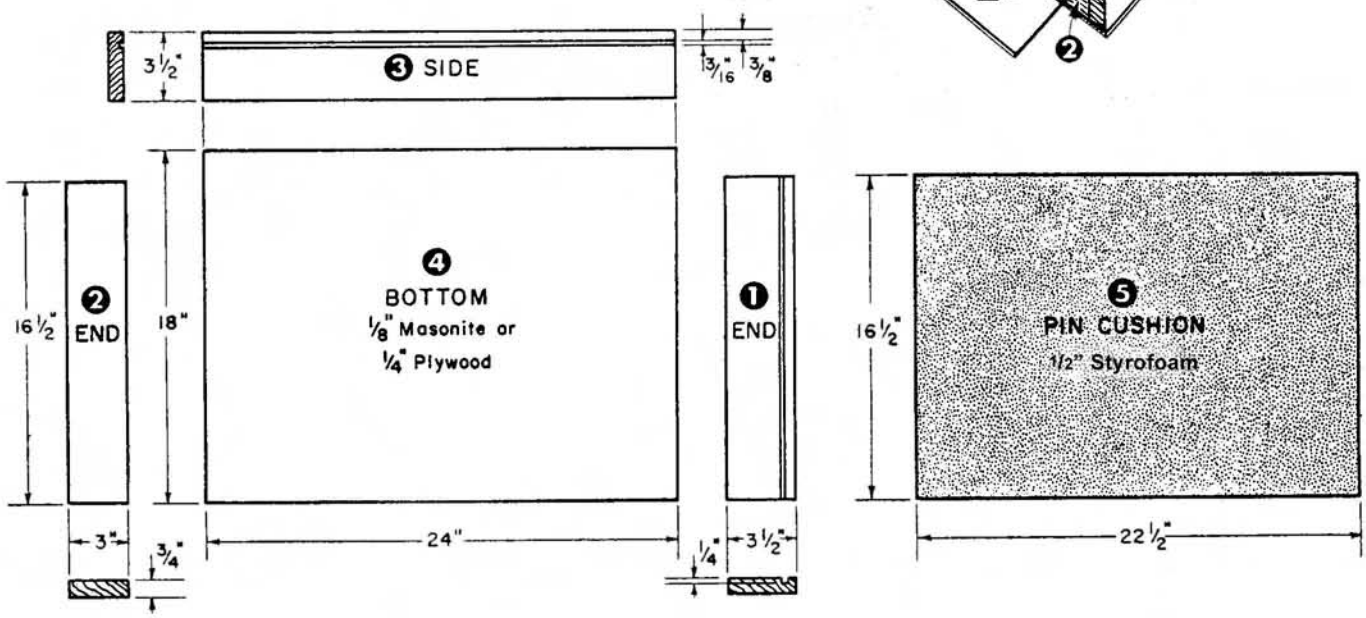


Figure 18. Insect display box and materials needed for its construction.

Identifying Your Insects

KEYING TO ORDER

From structural and other characteristics, the biologist sorts out common features and prepares a classifying tool called a key. Each step in the key requires you to make a choice between contrasting characteristics. In the keys that follow, your first choice is: Is the insect wingless or does it have wings (figs. 19 and 20)? Follow the keys as you would a road map. In most instances you will come to a correct identification. However, no key is perfect, for there are always specimens that don't seem to fit the generalizations that make up the key. And note that these keys apply only to **adult** insects.

As you look through other entomology books (like those listed in the next section), you may notice some difference in insect classification and order names. As an example, you may see cockroaches, walking sticks, and mantids placed in the orders Blattodea, Phasmatodea, and Mantodea, rather than as Orthoptera. This is merely a difference of opinion among entomologists. See the list below for the orders that are subject to inconsistencies. The **preferred** names are given in bold type.

Variation in Order Names

Common name	Alternate name	Preferred name
Mayflies	Ephemerida	**Ephemeroptera**
Cockroaches	Blattodea	**Orthoptera**
Walking sticks	Phasmatodea	**Orthoptera**
Mantids	Mantodea	**Orthoptera**
Book lice	Corrodentia	**Psocoptera**
Aphids, hoppers, etc	Heteroptera	**Homoptera**
True bugs	Heteroptera	**Hemiptera**
Sucking lice	Phthiraptera	**Anoplura**
Chewing lice	Phthiraptera	**Mallophaga**
Alderflies, dobsonflies	Megaloptera	**Neuroptera**

DETERMINING THE COMMON NAME

Many useful reference books exist that will allow you to determine the common names of your insects and learn something about them. Your leader may have copies of some of these books. The list below contains books that past 4-H'ers in entomology have found useful in identifying their insects, as well as some books that professional entomologists think are suitable for beginners. Some of the books listed here are out of print, but may be available from your local library.

Arnett, R.H., and Jacques, R.L., 1981. *Guide to Insects.* Simon and Schuster, N.Y., 511 p. Illustrated with color photos. Insects are categorized by structure and habitat.

Bland, R.G., and Jacques, H., 1978. *How to Know the Insects.* W.C. Brown Co., Dubuque, Iowa, 409 p., paper with spiral binding. An illustrated key to common families and species of insects.

Borror, Donald J., and White, R.E., 1970. *A Field Guide to the Insects of America North of Mexico.* Houghton Mifflin, Boston, Mass., 404 p. A comprehensive, up-to-date, pocket guide to North American insects, with the emphasis on family identification. More than 1,300 drawings and 142 color plates. User should have some experience in insect identification.

Carter, David, and Kindersley, Dorling, 1992. *Butterflies and Moths.* Eyewitness Handbooks, N.Y., 304 p.

Chu, H.D., 1949. *How to Know the Immature Insects.* W.C. Brown Co., Dubuque, Iowa, 140 p., paper with spiral binding. An illustrated key to orders and families of immature insects.

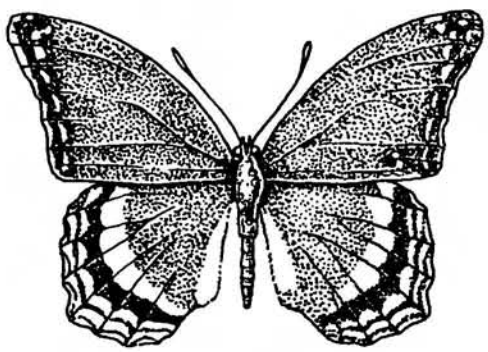
Covell, Charles V., Jr., 1984. *A Field Guide to the Moths of Eastern North America.* Houghton Mifflin Co., Boston, Mass., 496 p. The best identification guide to the moths of eastern North America. More than 1,300 species are described, with most species illustrated (many in color).

Dillon, E.S., and Dillon, L.S., 1972. *A Manual of Common Beatles of Eastern*

North America. Dover Publications, Inc., N.Y., 894 p. (2 parts). A paper-bound reproduction of the original 1961 publication. Descriptions, keys, and illustrations of many common eastern beetles.

Feltwell, John, 1993. The *Encyclopedia of Butterflies.* Prentice Hall, N.Y., 288 p.

Fichter, G.S., and Zim, H.S., 1966. *Insect Pests.* The Golden Press, Inc., N.Y. 166 p., paper. Describes biologies, damages, and controls of more than 350 common insect pests of middle North America. All insects and many damages are illustrated with color drawings.



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Klots, Alexander B., and Klots, Elsie B., 1961. *1001 Questions Answered About Insects.* Dodd, Meade & Co., N.Y., 260 p. Answers to questions that are hard to find in other entomology books.

McDaniel, B., 1979. *How to Know the Mites and Ticks.* W.C. Brown Co., Dubuque, Iowa, 350 p., paper with spiral binding. An illustrated key to the Acarina (mites and ticks).

McGavin, George, 1992. *Insects.* American Nature Guides, Smithmark Publishers, N.Y., 208 p.

Milne, L.J., and Milne, M.M., 1980. *The Audubon Society Field Guide to Insects and Spiders.* A.A. Knopf Publishing Co., N.Y., 989 p. Beautifully illustrated with 702 color photos.

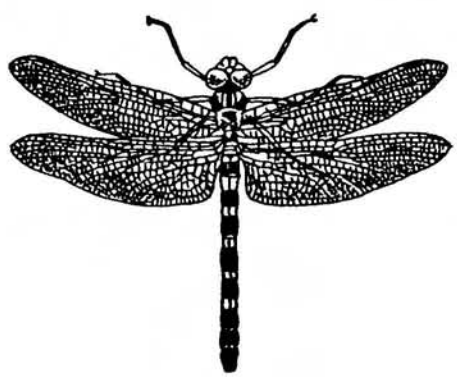
Opler, Paul A., and Malikul, Vischai, 1992. *A Field Guide to the Eastern Butterflies.* Houghton Mifflin Co., Boston, Mass., 396 p. A complete revision of the 1951 *Field Guide to the Butterflies of North America,* by Alexander B. Klots.

Pyle, R.M., 1981. *The Audubon Society Field Guide to North American Butterflies.* A.A. Knopf Publishing Co., N.Y., 916 p. Beautifully illustrated with 759 color photos.

Reid, G.K., Zim, H.S., and Fichter, G.S., 1967. *Pond Life.* The Golden Press, Inc., N.Y., 160 p. A guide to common plants and animals of North American ponds and lakes. Contains much useful information on aquatic insects and their relatives.

Slater, J.A., and Baranowski, R.M., 1978. *How to Know the True Bugs.* W.C. Brown Co., Dubuque, Iowa, 300 p., paper with spiral binding. An illustrated key to the true bugs (Hemiptera).

Stanek, V.J., 1969. *The Pictorial Encyclopedia of Insects.* The Hamlyn Publishing Group Limited, London, England, 544 p. Containing more than 1,000 black-and-



white and color photographs, this book details feeding habits, life cycles, colors, and sizes of a large variety of insects from Europe, Africa, and Asia.

White, Richard E., 1983. *A Field Guide to the Beetles of North America.* Houghton Mifflin Co., Boston, Mass., 368 p. An excellent general guide to beetles with keys and generous illustrations.

Wigglesworth, V.B., 1968. *The Life of Insects. Mentor Books,* New American Library, Inc., N.Y., 383 p., paper. Ways in which insects live and function, including relatively simple explanations of the physiology involved.

Zim, H.S., and Cottam, C., 1951. *Insects.* The Golden Press, Inc., N.Y., 160 p., paper. A pocket-sized identification guide to North American insects. Color drawing of each insect, its growth stages, and development. Notes on habits, life histories, and habitats.

Zim, H.S., and Mitchell, R.T., 1964. *Butterflies and Moths.* The Golden Press, Inc., N.Y., 160 p., paper. A guide to the more common North American species, with a color drawing and notes for each one.

Entomology Resources

The *Guide to Michigan 4-H Youth Programs* contains up-to-date listings of new entomology materials and resources from the 4-H Youth Programs of Michigan State University Extension. A copy of the Guide is available for inspection in your county MSU Extension office.

Contact Gary Dunn, Director of Education, Young Entomologists Society, Inc., 1915 Peggy Place, Lansing, MI 48910-2553, phone (517) 887-0499, for more information.

4-H ENTOMOLOGY MANUALS

The following 4-H entomology manuals are available from your county MSU Extension office:

- *4-H Entomology Series Manual 2: Advanced Entomological Techniques* (4-H 1336)
- *4-H Entomology Series Manual 3: Insect Life Cycle Studies* (4-H 1406)
- *4-H Entomology Leader's Guide* (4-H 1479)
- *4-H Entomology Labels* (4-H 1331)
- *4-H Entomology Record and Report* (4-H 1393)

Figure 19. A key to winged insect orders.

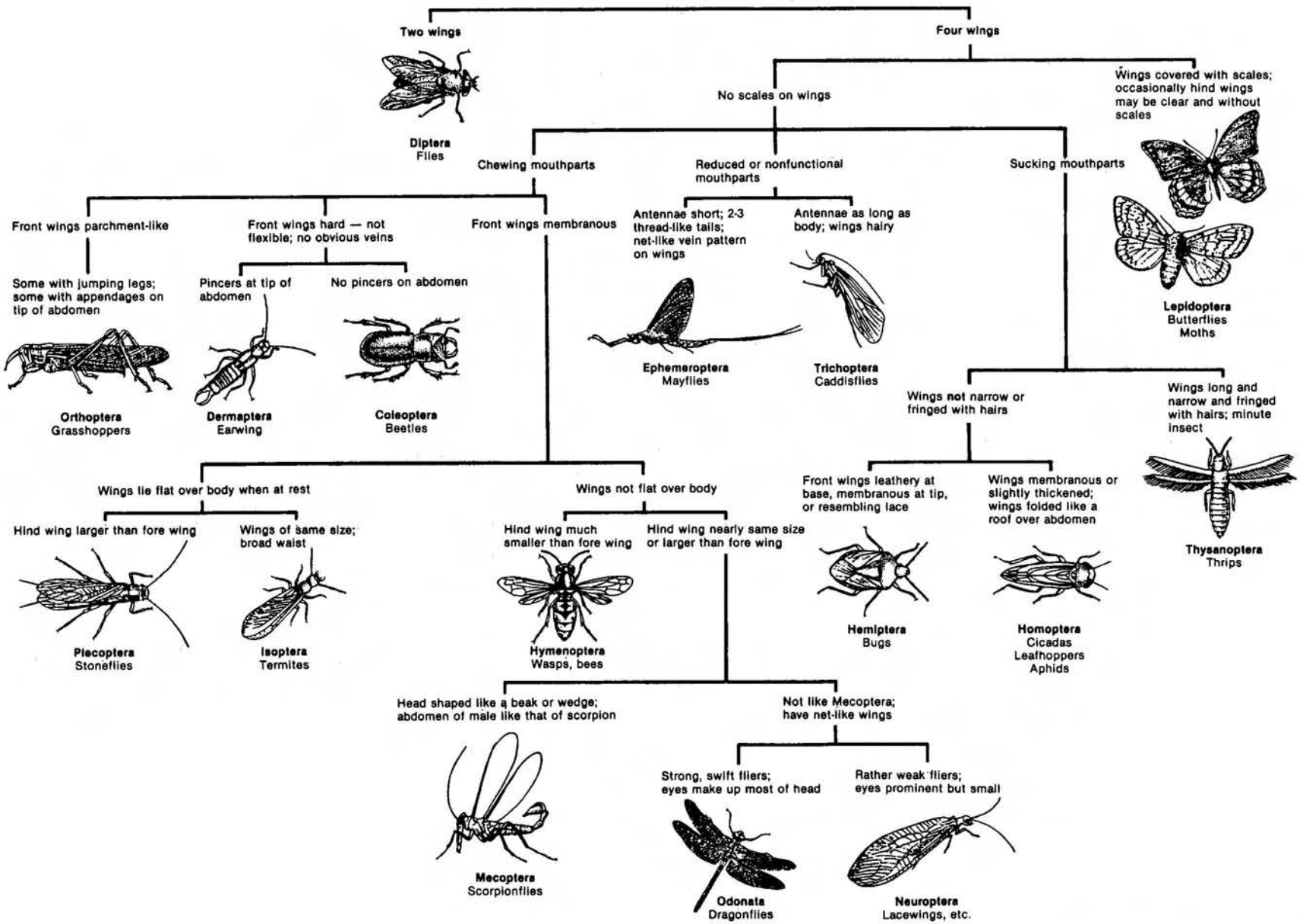
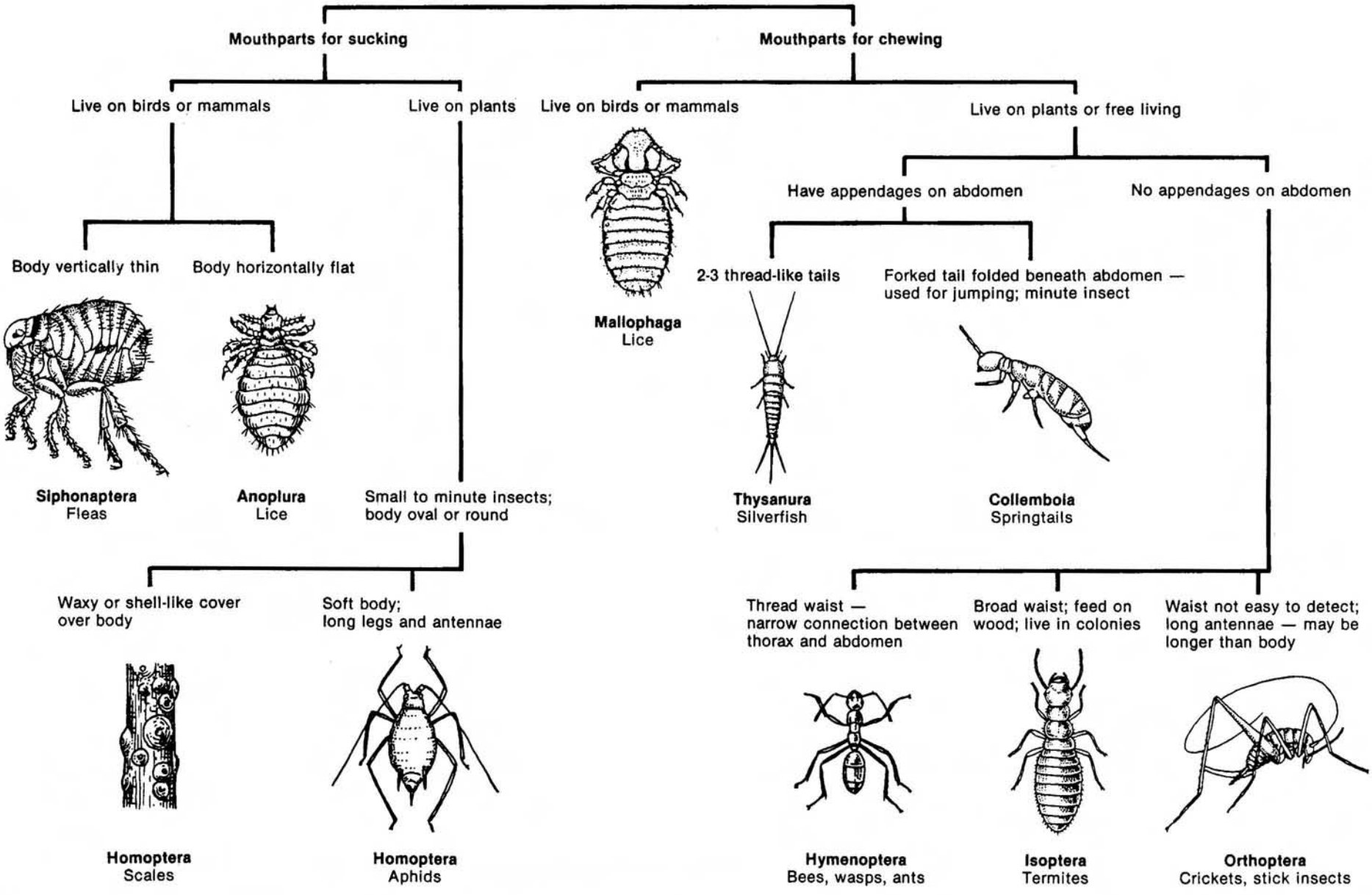


Figure 20. A key to wingless insect orders.



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