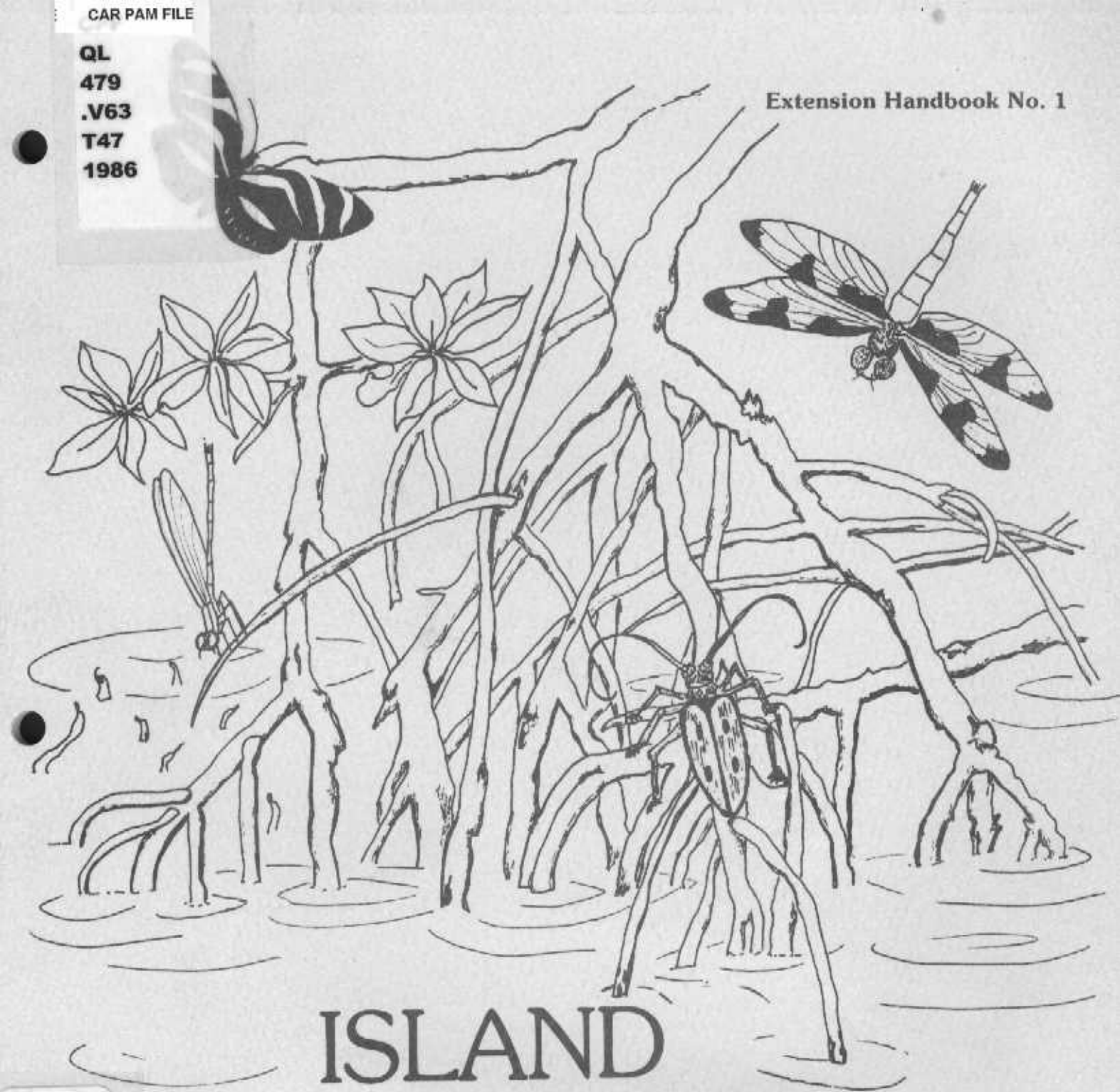
Extension Handbook No. 1



ISLAND INSECTS

Handbook for Insect Study

College of the Virgin Islands • Cooperative Extension Service • Darshan S. Padda, Director • St. Croix, U.S. Virgin Islands

Foreword

"If yo' put yo' ear a mangle root, yo' will hear crab cough. . ."
Virgin Islands Proverb.*

This is a handbook for young people and educators interested in the living world and its natural resources. It is dedicated to the powerful idea expressed by the proverb above, which is that if you can take the time to pay close attention, you are bound to hear, see and learn unexpected things—important things—about life and yourself. Anyone who puts his ear on a mangrove ("mangle") root—literally or figuratively—is bound to gain in his understanding of the interrelationships that exist between different animals, plants and their environment. The theme on the cover symbolizes this thought.

The focus of this booklet, though, is not on just one environment. Rather, it is on a group of animals which spans practically all living spaces on earth. Insects occupy many more environments than any other form of life visible to the naked eye. Of every ten known kinds of animals, at least eight are insects. Well over half of all living things on this planet are insects.

Insects have intrigued, benefited—and irritated—humankind for a very long time. They play a highly significant role in the world of nature. Thus, insects provide an excellent subject with which to build environmental awareness and introduce the scientific approach to learning.

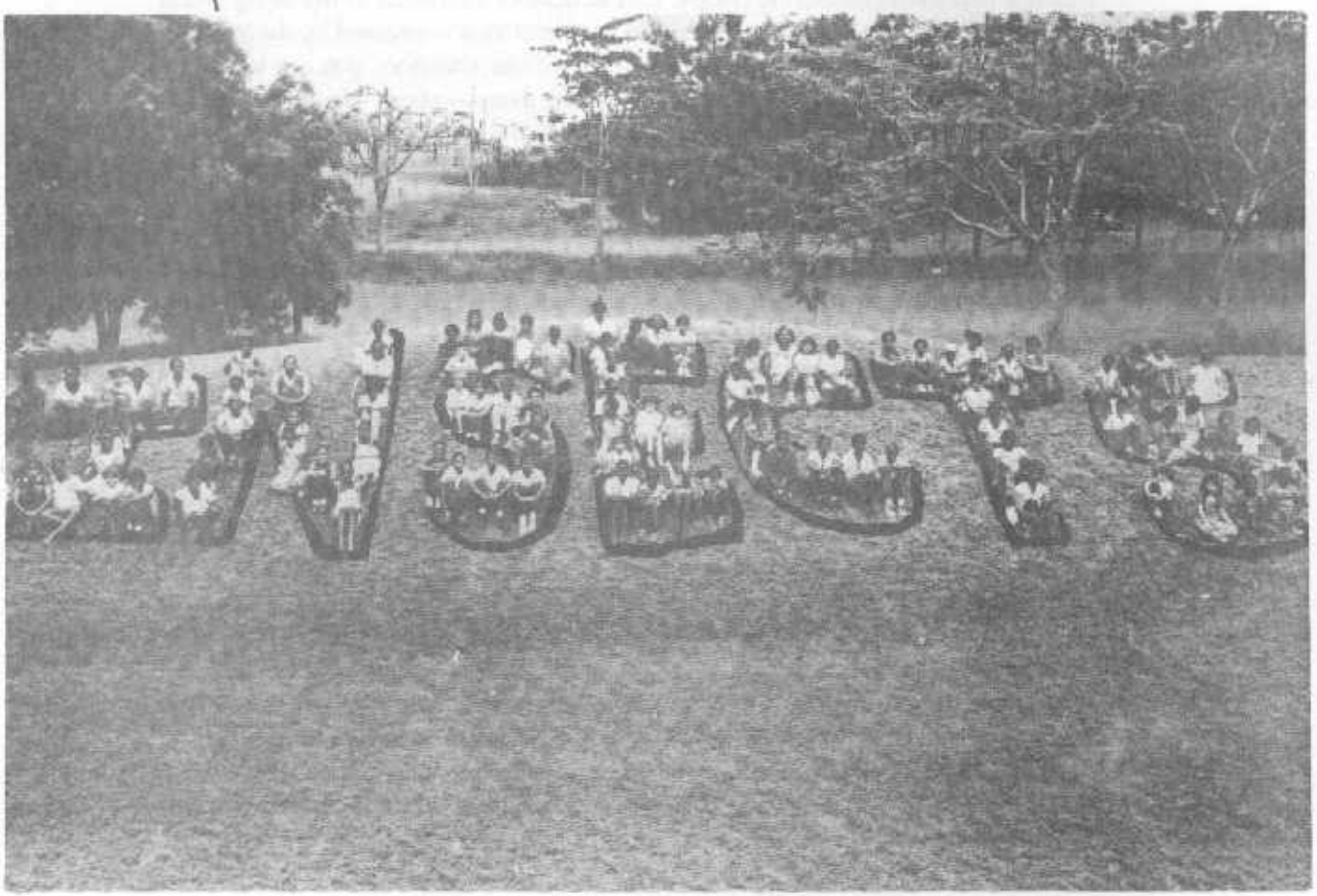
This handbook is an adaptation and blend, with some original material, of several national and state 4-H entomology project guides, but also draws on other sources (see the bibliography). It is intended to fulfill the following objectives:

1. To introduce youth, teachers, parents and other leaders of young people to the principles and practices of insect science.
2. To provide a non-technical "how-to" guide on projects relating to insects.
3. To provide introductory learning experiences for youths in areas such as collecting, mounting, preserving, labeling and displaying insects; identification and classification; insect rearing; studying insect behavior; and career opportunities.
4. To provide a source for educational aids and resource materials, such as books, supplies and visual aids.

The idea for this handbook originated with an insect club started at the Virgin Islands Cooperative Extension Service by the pest management staff, with the assistance of the 4-H Youth Development program of the same agency. Because of the strong response, this special interest activity has broadened considerably to include all types of schools and youth-education programs. Environmental studies programs are enthusiastically received by teachers and students in the Virgin Islands, but few locally-developed resources have been available. The Extension pest management and natural resources programs at the College of the Virgin Islands offers this insect natural history learning resource for students, teachers and volunteer leaders. We hope that as a result of this publication, more people will stop, look, listen and learn about the fascinating world of insects.

Walter I. Knausenberger, Entomologist
Program Leader, Natural Resources

*From George A. Seaman's *Not So Cat Walk: The Philosophy of a People and An Era Expressed by Proverbs*. St. Croix. 64 pp. 1975.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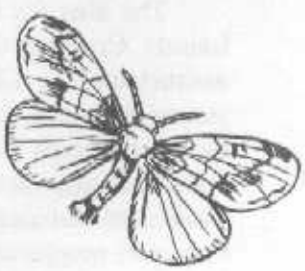

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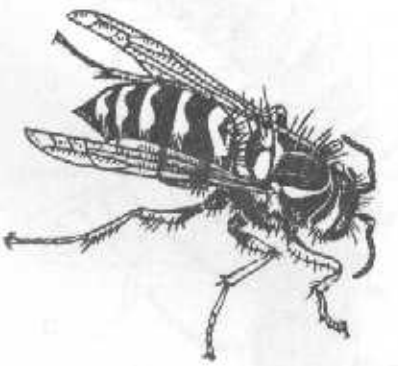
Introduction

In 1980, the Virgin Islands' first program devoted to learning about insects and where they live was started by the CVI Cooperative Extension pest management program. The first members chose to call themselves by the exciting name of "Stingers," and by now thousands of children from 6-20 years old have participated. We welcome you to the wonderful world of insects and their relatives. Not only will you find out how much fun insects can be, but you also will learn how important they are in the lives of everyone. You may even make a career of working with insects.

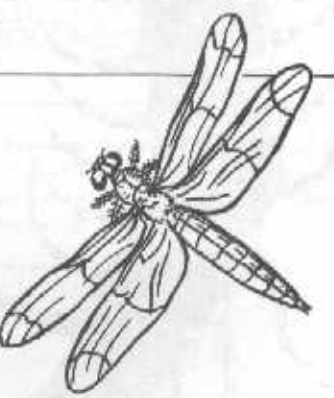
This manual will show you where insects can be found, how to catch them, and how to create your own collection, as well as many projects you can do on your own to learn more about the six-legged world.

The word *entomology* (en-toe-mol'-o-gee) is from the Greek word entomon, meaning insect and the word "insect" itself is from Latin. Both words mean "cut into," based on the fact that insects are "cut into" three body sections. Entomology is the science dealing with the study of insects. The scientist who specializes in studying insect life is called an *entomologist*.

As you use this handbook, watch for words written in *italics*. Look in the glossary in the back for an explanation of these words.



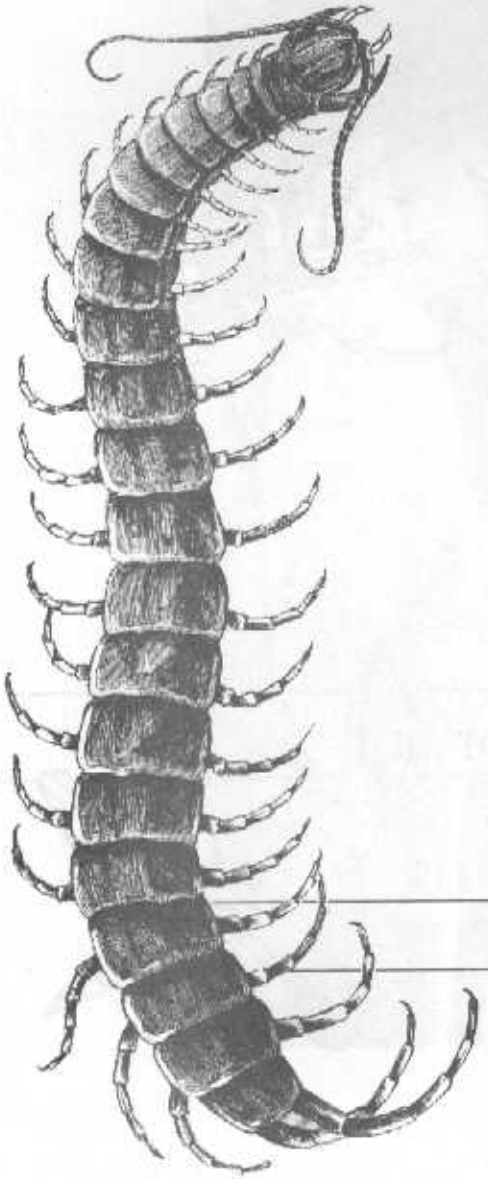
Insects are Important



Insects are very successful organisms. They were on earth long before man and most other living creatures that are alive today. From fossil studies we learn that insects were plentiful 350 million years ago. Cockroaches were among the first air-breathing animals on the earth. Did you know there were dragonflies with three-foot wing spans flying at the time of the dinosaurs?

There are more insects in the world than all other animals combined: 75% of all animal species are insects. Over 1 million different kinds of insect species have been identified and given names. In one square mile of land the number of insects exceeds the human population of the earth. In the Virgin Islands alone there are at least 2,000 species—enough to occupy your interest for a long time.

Insects are found throughout the world, with the exception of the ocean depths. Some, like our "no-see-ums" (or "mampees") are so small they can hardly be seen with the naked eye, while others such as the long-horned wood borer are several inches long. They are so widespread that they can be studied practically *everywhere*—in our towns or on our farms, in our backyards or gardens, in our homes or at the seaside. And insects are so varied that you can begin to study them almost anytime of the year, regardless of where you live.



Can you imagine our islands without insects? The environment would be very different from the place we know today. It is estimated that 95% of all insects are beneficial in one way or another. Bees, wasps, flies, butterflies and other insects pollinate many flowering plants and without them our landscape would not have coconuts, genips, limes or the beautiful pink coralita. Since many island birds eat insects, fewer birds would exist. Frogs, toads, fish, lizards (anoles and geckoes) as well as bats would be less abundant because they feed on insects.

Many insects help nature with housecleaning. For example, woodboring beetles, termites, and ants help speed up the decay of plants, returning material to the soil for support of new plant growth.

Some insects truly can be regarded as man's major competitors for food, fiber, and shelter. Insects destroy 30% of all food grown in the world today. In the Virgin Islands, the banana root borer destroys thousands of dollars worth of bananas, scale insects suck the sap from our citrus trees, and aphids suck the juices from our vegetables. Termites destroy furniture and houses. Stored product insects such as the confused flour beetle get into dry foods and livestock feed, making them unusable. Insects also help spread infection in plants by carrying such diseases as papaya mosaic or cucumber wilt from one host plant to another.

Some insects are harmful or dangerous to man, livestock and wildlife. Fleas, lice and mosquitoes annoy you and your pets. In the Virgin Islands, the yellow fever mosquito has been known to spread sickness such as dengue fever in humans and heartworm in dogs. Insects attack livestock, weakening them. For example, a horse that would eat just one blister beetle could become sick and perhaps die.

Yet is it possible to measure in dollars the enjoyment or value of watching beautiful butterflies flittering over fields of flowers, or the buzzing of bees as they pollinate our plants? Is it possible to calculate the benefits derived from insects?

What is an Insect?

If you are going to study insects, one of the first requirements is that you are able to distinguish insects from similar animals. No one will mistake a bird for 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 the Arthropoda. All arthropods have jointed legs, segmented body parts and an external skeleton or *exoskeleton* (somewhat like a suit of armor). Not only insects, but also spiders, mites, ticks, scorpions, centipedes, millipedes ("gongolos"), crabs, shrimp, and sowbugs belong to this phylum.

The phylum Arthropoda is further divided into smaller categories called *classes*. The class Arachnida includes spiders, ticks, mites and scorpions; the class Chilopoda includes centipedes; and

millipedes make up the class Diplopoda. Insects belong to the Class Insecta (or Hexopoda, which means "six feet," because all insects have six legs or feet). To distinguish insects from all other arthropoda, use the following insect characteristics described below and illustrated in Figure 1.

Insect Characteristics

1. Three pairs of legs in the adult insect. 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. Other arthropods have one, two or more than three body regions.
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 adult insects) and 2-3 single eyes.
5. Wings (usually present) when in the adult stage. Most winged insects have two pairs; some such as lice, fleas and worker ants, are wingless as adults. No other arthropods have wings in any stage.

Insect Life Cycles

Insects vary in their growth patterns, but all begin as eggs and end up as adults. One life cycle consists of the period from egg to adult. Between the egg and the adult stage there is an intermediate growth form called the *immature stage*. It is during this stage, which varies 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 can not expand. The number of molts varies in different groups of insects. Usually the number is between four and eight, but there are exceptions. The stages of the insect between molts are called *instars*. Thus, the immature stage consists of several (usually four to eight) instars. Once the adult stage is reached, no more molting occurs.

It is the adult insect that reproduces so that the species can continue to live from generation to generation and from year to year. Sometimes, there is only one adult stage per year, but in the tropics most insects have several adult stages (and hence several generations) per year—for example, fruit flies, cockroaches and fleas.

Insect Development

The insect starts out as an egg which is laid by the adult. The eggs of different insects vary greatly in appearance: some are round, some are barrel-shaped, some are laid on the undersides of leaves and others are laid under water. But they all hatch into the immature stage where most of the growing takes place. The immature stages or growth stages of different insects take many different forms, such as maggots, grubs, nymphs, naiads, wrigglers, "worms," caterpillars

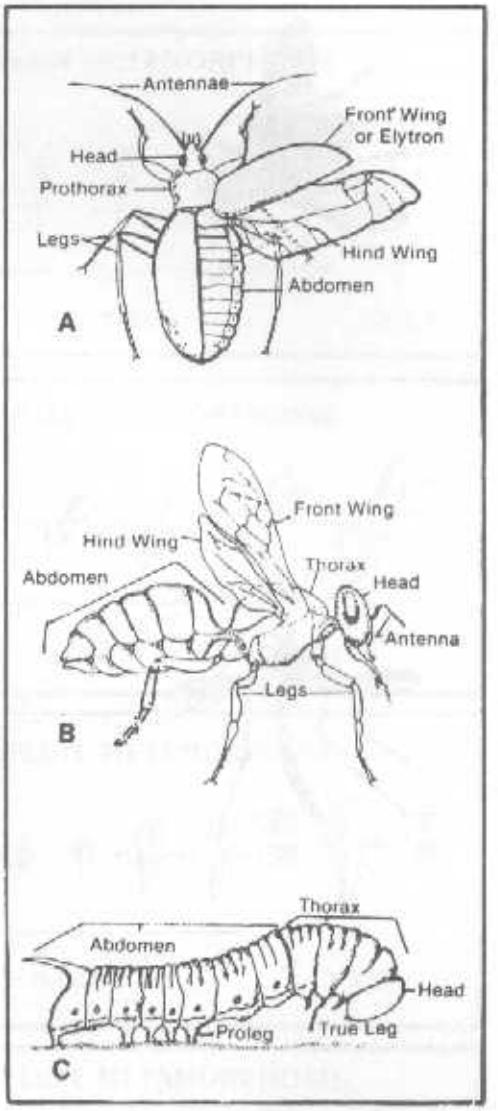
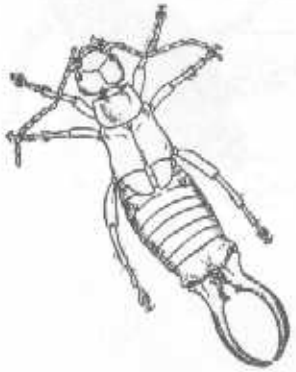


Figure 1. **Some of the characteristics of insects that make them different from all other kinds of animals: (A) beetle, (B) honeybee, and (C) caterpillar.**



and crawlers. There are only four different basic types of immature insects, each distinguished according to the degree of similarity to the 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 the 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 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. The last instar larva can spin a silken structure around itself called a *cocoon* or develop a *chrysalis* which is a hardened outer shell created from the instar skin. Both of these structures serve to protect the pupal stage while it is developing into an adult.

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

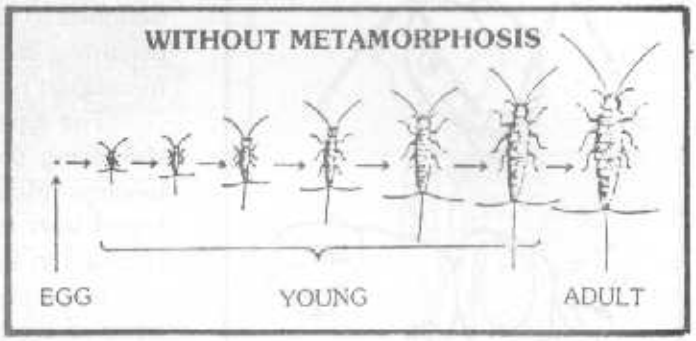
Types of Metamorphosis	***Active Immature Stage***
Without Metamorphosis	Young
Gradual Metamorphosis	Nymph
Incomplete Metamorphosis	Naiad
Complete Metamorphosis	Larva

Proceeding from the first to the last, the immature is less and less like the adult. Refer to Figure 2 for illustrated examples and major insect groups which exhibit each type.

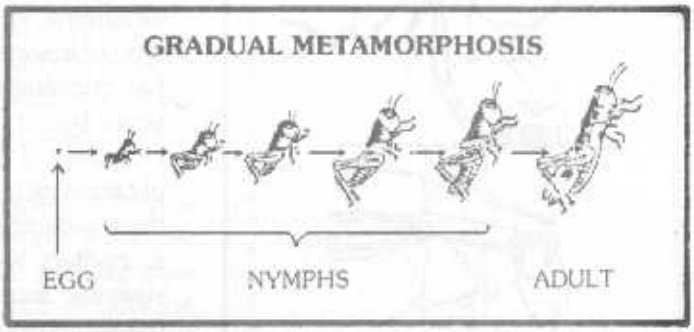
Knowing the type of metamorphosis for each group (order) of insects is very important for the entomologist or pest control operator. Through this knowledge he is able to find the "weakest link" in the insect's life cycle and proceed to destroy the injurious pests through biological, physical, or chemical means.

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

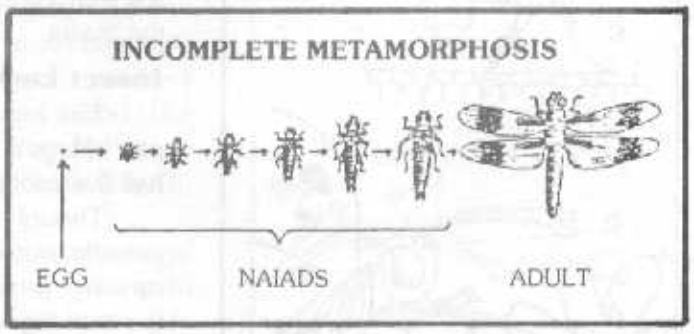
Examples	Orders
silverfish	Thysanura
springtails	Collembola
biting lice	Mallophaga
sucking lice	Anoplura



grasshoppers	Orthoptera
termites	Isoptera
booklice	Psocoptera
thrips	Thysanoptera
true bugs	Hemiptera
aphids	Homoptera
earwigs	Dermaptera



mayflies	Ephemeroptera
dragonflies	Odonata
stoneflies	Plecoptera



lacewing	Neuroptera
beetles	Coleoptera
scorpionflies	Mecoptera
caddisflies	Trichoptera
moths, butterflies	Lepidoptera
flies	Diptera
fleas	Siphonaptera
wasps, bees	Hymenoptera

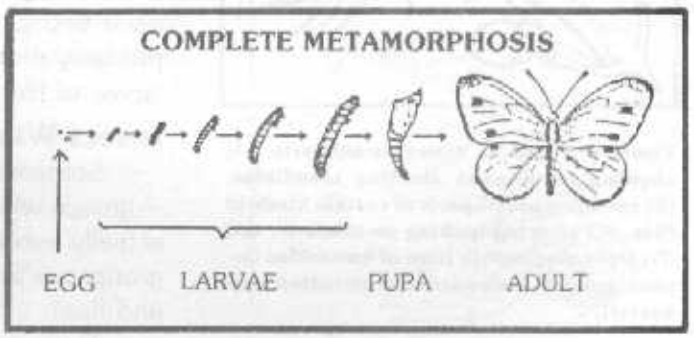


Figure 2 **Metamorphosis of Various Insects**

Insect Mouthparts

Insects feed on plants and on other animals, living and 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.

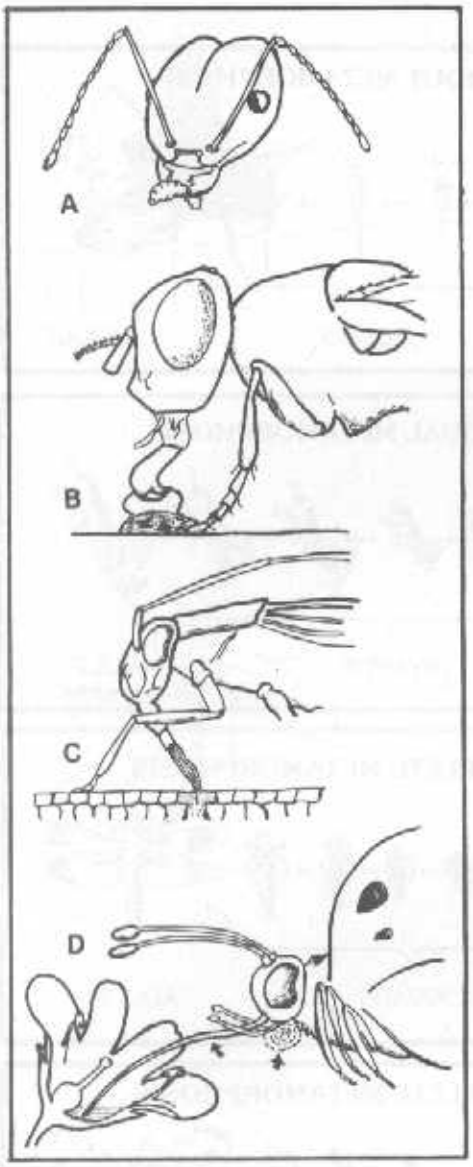


Figure 3 **Types of insect mouthparts: (A) chewing mouthparts showing mandibles, (B) sponging mouthparts of certain kinds of flies, (C) piercing-sucking mouthparts, and (D) siphoning mouth tube of butterflies (arrows point to extended and retracted *proboscis*).**

Although there is a tremendous variety of insect mouthparts designed to take in liquid or solid food or both, for the purposes of beginning entomology we can place all insects into one of two basic mouthpart types: chewing or sucking.

The type of mouthparts is an important characteristic used in identifying the major group (order) to which a particular insect belongs. Mouthparts are referred to in the Key to Insect Orders found later in this manual. 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. It helps him determine the kind of insect that caused the damage as well as the type of insecticide that will be necessary to control the insect. If a pest has chewing mouthparts, it could pick up a surface layer of insecticide by "chewing" the leaf and swallowing some of the poison. However, if the insect pest 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 body. Another alternative would be to use a systemic insecticide which circulates within the vascular system of the stems and leaves and is sucked up along with the plant juices by the insect.

Insect Legs

The legs of adult insects are usually easy to distinguish. One pair of legs is attached to each segment of the thorax, and each leg has five movable parts.

Though locomotion is their primary function, insect legs have actually evolved for many different types of activity, 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, non-jointed *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.

Insect Wings

Some insects are wingless. They may be either primitive insects —groups which never had wings—or more advanced groups which actually evolved from winged ancestors. Included in the primitive groups are springtails and silverfish. In the second category are lice and fleas.

Those insects with wings have either one or two pairs, usually two. In most wings there are thickened lines called *veins* that run in a network from the base to the tip. The pattern formed by the veins, called *venation*, is distinctive for many groups of insects.

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, leathery front wings (called wing covers or *elytra*). The wings of true bugs, such as stink bugs, have membranous tips and hard, leathery bases (and

are called *hemelytra*). Moths and butterflies have scaly or hair wings. Thrips have feathery wings. Members of the Orthoptera (grasshoppers, crickets, and mantids, and their relatives) have parchment-textured wings. Many of these wing types are illustrated in Figure 4.

Insect Classification

Insects must be classified or divided into groups to allow information about the tremendous numbers of insects to be communicated effectively. Classification is done according to similarities and differences, and starts with *orders*, which are the largest insect groups. A little later in this manual, you will learn to identify insect specimens of the correct order with the aid of a so-called "key," once you have determined it *is* an insect.

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 him and separate him from other individuals. Determining where insects fit into the animal kingdom is much like your postman 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 given name), post office box, city and island. But when the postman sorts mail, he reads the address from bottom to top, looking first for the island, then the post office or city 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, he gets clues from its structure and thus assigns it an "address." The categories of the scientific "address" are *phylum, class, order, family, genus* and *species*. Let's compare postal classification with insect classification, using two examples:

Postal Classification

Territory . . . . . U.S. Virgin Islands
Island . . . . . St. Croix
City or Post Office . . . . . Christiansted
Post Office Box . . . . . P.O. Box BUZZ
Surname . . . . . Fly
Given Name . . . . . Felipe

Insect Classification

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—Felipe Fly and *Musca domestica*. In the case of the insect, we used the scientific name. The common name in this case is house fly.

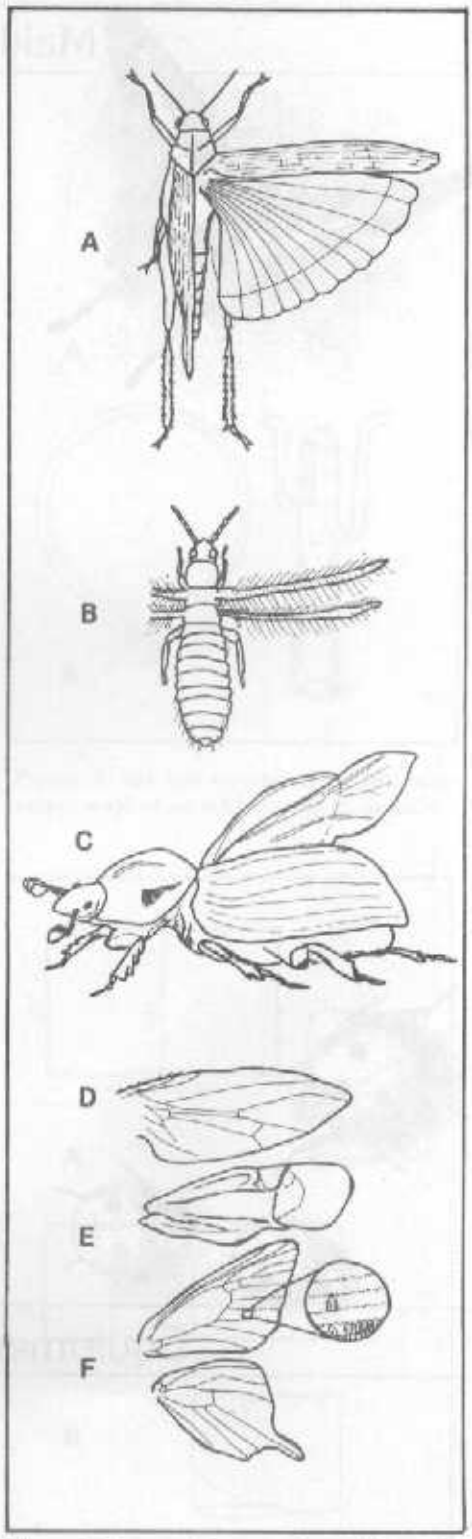
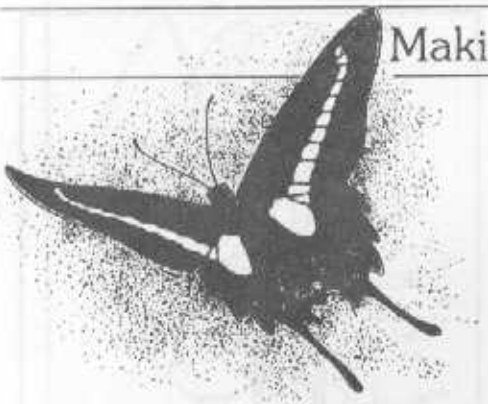


Figure 4 **Types of insect wings: (A) parchment wings of grasshoppers, (B) leathery wings of thrips, (C) leathery (elytron) and membranous wings of beetles, (D) membranous wing of a fly, (E) half-leathery membranous wing (hemelytron) of true bugs, (F) scaly wings of moths and butterflies.**

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 entomology is usually the collection and identification of insects. Many people have made this a fascinating hobby, or even a life's work.

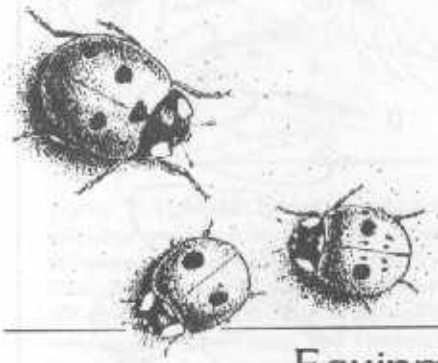
Your first collection should include all the insects you can find, wherever you may be. By making such a collection, you get to know and recognize many different kinds of insects. However, keep in mind that when you make such a general collection, you will end up with more of certain kinds of insects than others because some 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 practice 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 order of insects, such as only butterflies or only beetles.

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

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. See page 18 for information on what kind of alcohol to use.



Equipment for Collecting and Pinning

The equipment needed to start collecting and mounting insects is fairly simple and costs very little. Much of the basic equipment can be suitably improvised. Essential equipment is: 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 or pencil. 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 (or hoop) and a cloth bag. The handle may be made from a ¾-inch

piece of dowel rod which is 3 to 4 feet long. A discarded broom or dust mop handle will also do nicely. There are two ways to drill the holes in the handle of the net. The first is pictured in Figure 5A, where the holes are drilled at an angle. The second way pictured in Figure 5B has a groove drilled on both sides of the rod. The groove should be 2 inches long on one side and 3 inches long on the other, and deep enough to permit the hoop of 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 1/8 inch in diameter (No. 8 gauge) and bent as shown in Figure 5A or 5B. 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, you can bind the handle with tape, wire or cord, or you can use a metal or plastic sleeve (made from PVC pipe) which just fits over the handle (method B only). A small hole should be drilled below the sleeve and a cotter pin placed in the rod to keep the sleeve from dropping off.

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, nylon net is the best material. It is light, durable, and will withstand a lot of hard use. The mesh should be coarse enough to allow air to pass through easily. Still, the mesh needs to be fine enough to prevent the escape of small, captured insects. Look for material with 15 to 30 holes per inch.

To collect insects out of shrubs and grasses, use a sweep net. This should be made of a heavier material, such as unbleached muslin or sheeting material, to prevent ripping. The best net has muslin sides and has the bottom made from a see-through material, so that insects can easily be seen to be put into the killing jar.

The bag for both nets should be cone-shaped with a rounded tip, and twice as 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 would be as in Figure 6. 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. Most of the stress of movement will be where the net covers the wire loop, so reinforce this area with an extra layer of cloth.

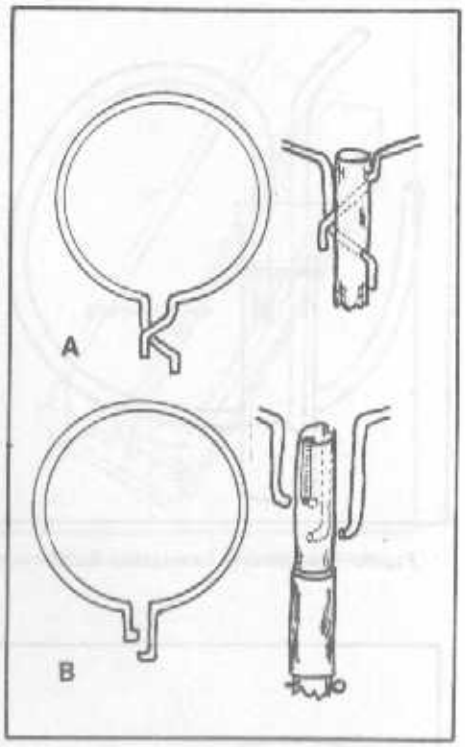


Figure 5 **Net bag construction; two alternative ways of attaching hoop to handle.**

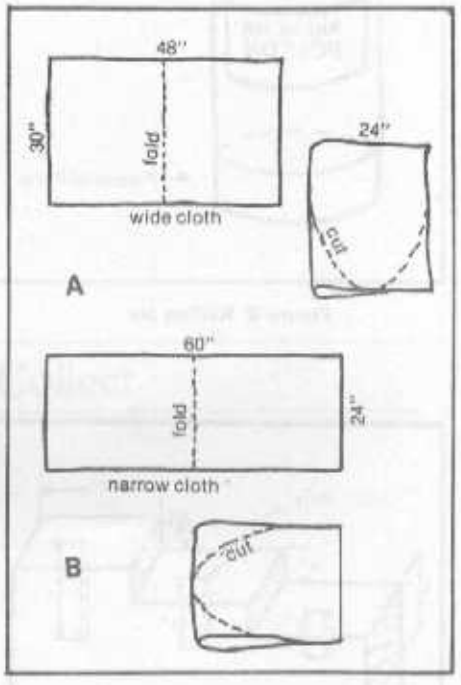


Figure 6 **Construction of cloth net bag; (A) shows how to layout and cut wide cloth and (B) shows how to make net with a narrow piece of cloth.**

Aspirator or Suction Bottle

The aspirator (see Figure 7 on page 10) is a convenient device for collecting small insects, either from the collecting net or from under stones, bark or other debris and can be purchased from supply houses listed in the back of this manual.

The aspirator is used by placing the end of the rubber tubing in the mouth, aiming the longer tube at a small insect and sucking sharply. The air current will pull the insect into the vial. With practice, this method makes it possible to collect small insects more quickly and in better condition than many other ways.

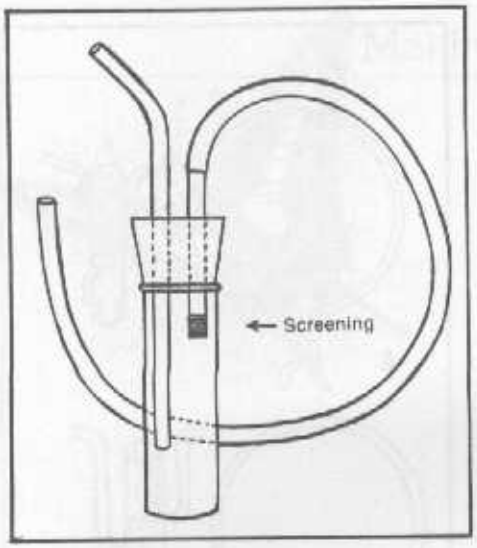


Figure 7 **Aspirator or suction bottle.**

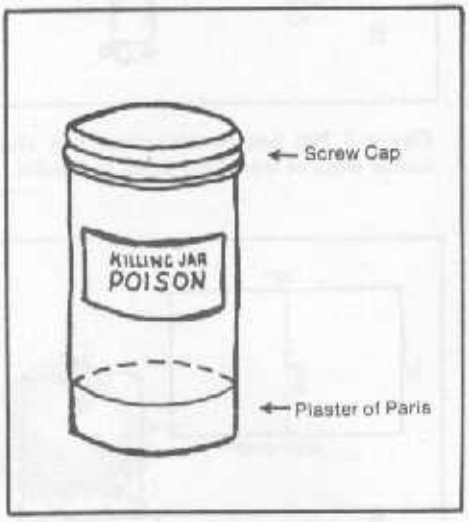


Figure 8 **Killing jar.**

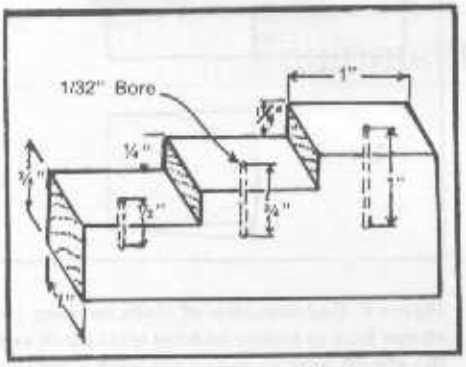


Figure 9 **Pinning block.**

Killing Jar

A killing jar (see Figure 8) is one of your most essential items. Start with a wide-mouthed jar such as an 8 oz. peanut butter jar with a twist-off lid. Mix plaster of Paris and water to a consistency suitable for pouring. Pour the mixture to a depth of ½" to 1" in the jar and let it stand overnight. Do not replace the lid until the plaster is dry. (Caution: do not dispose of leftover plaster of Paris by rinsing down a drain—it will clog the pipes. If possible, mix your plaster batch in a disposable container.)

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 can be purchased from biological supply stores. 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. Insects can also be killed by putting them in a jar and placing the jar in the freezer compartment of your refrigerator for ½ hour.

Insect Pins

Pins may be obtained locally, (see your pest management extension agent) as well as from a biological supply house listed in the back of this manual. It is necessary to buy insect pins (not common pins) made of stainless steel, so they will not rust in your collection box and ruin your specimens. Pins come in several sizes; the larger the number, the thicker and stronger the pin. Numbers 2, 3 and 4 are most useful.

The Pinning Block

Medium and larger size 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-fifth 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 with the dimensions given in Figure 9, will permit uniformity in pinning height. See the section on preserving insects, page 16, for more on pinning and the preparation of specimens.

Forceps and Scissors

A small pair of scissors is handy for cutting out insect labels and stiff pieces of smooth paper. These strips are used for 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 may purchase a spreading board from a biological supply house, such as the professional one shown in Figure 10, or you may make one. To make one, obtain a piece of plastic packing foam with at least one smooth surface. Office supply houses are usually a good free source of this material. 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 larger moths. Some professional spreading boards are made up so the gap between the two wooden slats is adjustable.

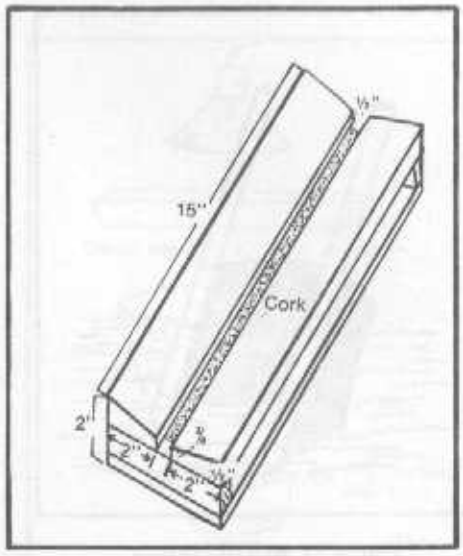


Figure 10 **Professional spreading board.**

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.

The first and most important label is the locality label. It tells where the insect was caught, when it was caught, and who caught it. It goes on the pin directly beneath the specimen.

The second label is the identification label. It contains the family to which the insect belongs, the scientific name (or at least the common name), and the name of the person who identified it. It goes on the pin beneath the locality label.

Labels are available through your extension agent or from biological supply stores listed in the back of this manual. There is a sample to be cut and used on the last page of this handbook. You will need a fine-point pen or pencil to complete the labels. See page 19 for more details on the labeling process.

Where, When, and How to Collect

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

Insect food is a key to where they will be found. Their food is almost as diversified as the kinds of insects themselves. To make a large and varied collection of insects you must know something of their food habits and where and how they live. Try to seek out insects in their natural habitats in as many varied places as you can—a meadow, a pasture, in beach sand, in the soil, in the rain forests, along the sea shore, in ponds, gut pools, on animals, in houses and in your garden.

Listed on the following page are areas where you will find certain types of insects.

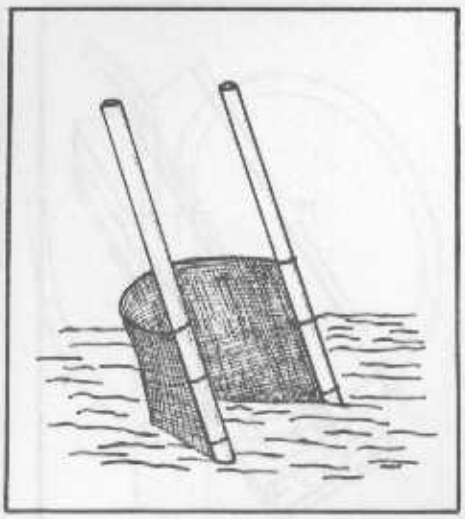


Figure 11 **Aquatic screen**

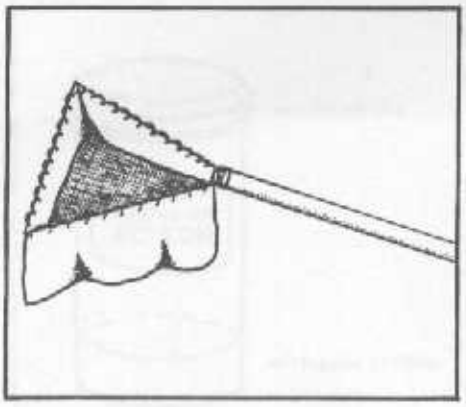


Figure 12 **Water net.**

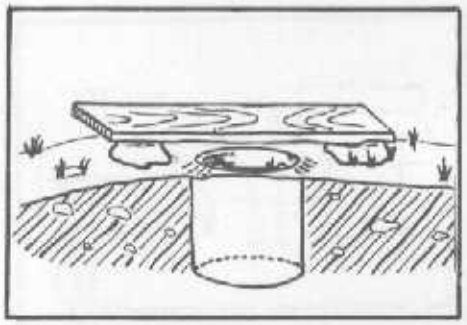


Figure 13 **Pitfall (tumble-in) trap.**

1. Under boards and rocks—ants, crickets, beetles.
2. In or around streams, ponds, lakes—dragonflies (locally called pinchy nannees or matti mamsels), damselflies, aquatic beetles, mosquitoes.
3. Under loose bark, in logs and stumps—termites (or wood lice), ants, bark beetles, tiger beetles, wood borers.
4. On crops—grasshoppers, butterflies, beetles, flies, aphids, leafhoppers, plant bugs, caterpillars.
5. In the air—butterflies, moths, flies, bees, wasps (locally called Jack Spaniards), beetles, leafhoppers, grasshoppers.
6. Crawl-space (under the house)—crickets, beetles, ants, silverfish.
7. On livestock, pets and poultry—fleas, sucking lice, biting lice, flies.
8. In clothes, furniture and store foods—clothes moths, carpet beetles, flour beetles, bean weevils.
9. Around lights—moths, beetles, true bugs, preying mantids (locally called jumbee horses or god horses).
10. Around dumps or piles of refuse—cockroaches, earwigs, beetles, flies.
11. Manure piles—flies, beetles.
12. In, around, or on flowers and ornamental plants— thrips, plant bugs, beetles, bees, wasps, ants, aphids, scale insects, walking sticks, insect galls, butterflies, moths.
13. In houses—crickets, beetles, ants, flies, mosquitoes, moths, cockroaches, termites, silverfish.

The following paragraphs will discuss collecting devices used in particular insect habitats.

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 a single specimen in flight by sweeping the net through the air, or 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 in 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 aerial 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 moving streams. An aquatic screen, like that in Figure 11, is easy to construct. It works best when used by two people who walk upstream against the current, dislodging rocks in front of it.

You can make your own water net out of wire mesh or buy a net from a pet supply store or a metal or plastic dipper can be attached to the end of a pole to dip insects out of the water. Figure 12 shows a model available from a biological supply store.

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. A good tool for collecting the more active forms is a pitfall (or tumble-in) trap (see Figure 13). The trap should be buried into the soil so that the top edge is just below the 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% ethylene glycol (coolant) 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).

Less active and smaller forms can be collected in another way. Rake up samples of forest litter and place them in plastic bags. Upon returning to your home, place the litter in the tray of a "hidden insect trap" which you can construct after studying Figure 14. Within 20-30 minutes after the light is turned on, insects will begin to fall through the equipment. Larger ones may be caught in the 1/16" mesh. Smaller ones will fall into the jar which may be filled with alcohol so that it will immediately kill and preserve the specimens.

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 15). 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 axe 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

Sixty percent of all 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. While the yardlight will suffice to attract some types, other lighting setups are more efficient. A light trap like that in Figure 16 is easy to construct. Use an extension cord with a light socket. A coat hanger may be used as a support for the light. Cut the end from an old funnel and set it in a

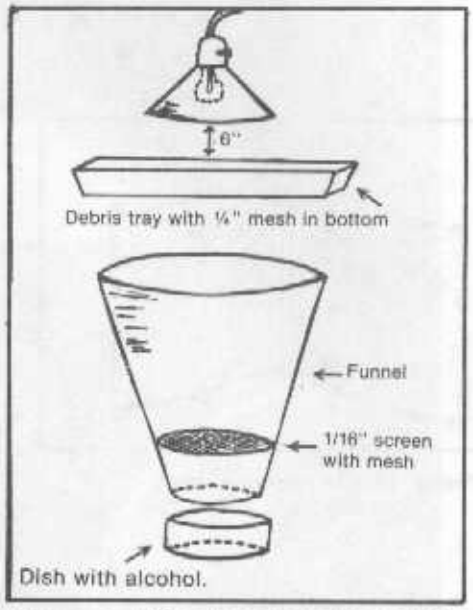


Figure 14 **Hidden insect trap (homemade Berlese funnel).**

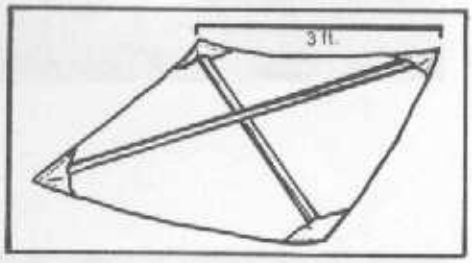


Figure 15 **Beating sheet.**

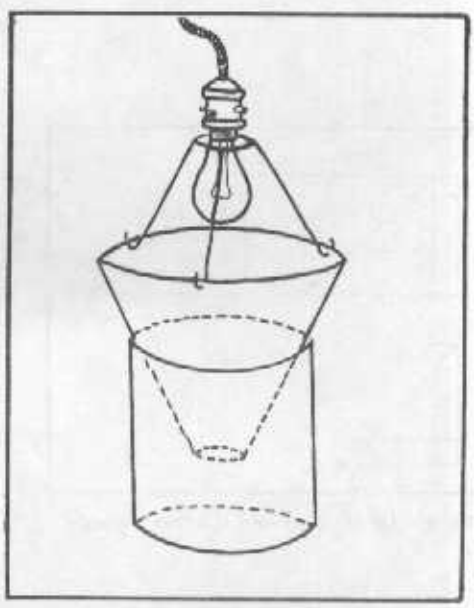


Figure 16 **Homemade light trap.**

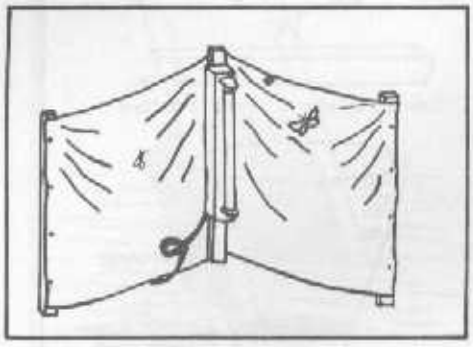


Figure 17 **Blacklighting sheet.**

wide-mouth jar or metal can. Place a small jar containing cotton saturated with a killing agent (such as ethyl acetate) in the bottom of the trap. The light will attract the insects. The fumes of ethyl acetate rising from the bottom will cause them to drop onto the funnel, fall into the can, and die.

Insects are best attracted to light at the near-ultraviolet end of the spectrum. A blacklight (near ultraviolet) fluorescent tube is much more efficient than an incandescent bulb in attracting night-flying insects. An apparatus constructed like that in Figure 17 is very successful. The blacklight requires the same type of fixture on a pole with a white sheet as a reflective surface. Collect the insects as soon as they land on the sheet and place them in a killing jar. This technique is very efficient for moths and night-flying beetles. You should avoid looking directly at the blacklight and limit the time you spend at the light because of danger to your eyes.

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, over-ripe fruit, such as bananas or mangoes. 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. This 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 movement stops. The jar is then quickly removed and capped. Many butterflies are attracted to the bait mixture during the daytime.

Additional Suggestions

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 18) 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. See page 17 for more about relaxing insects.

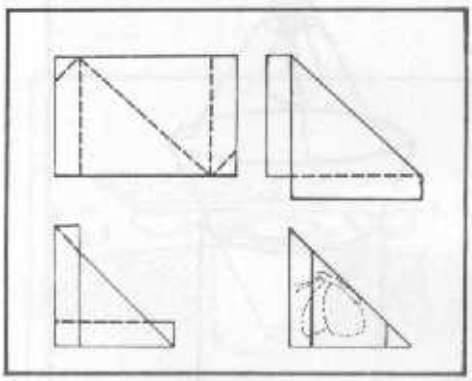


Figure 18 **How to fold a paper triangle.**

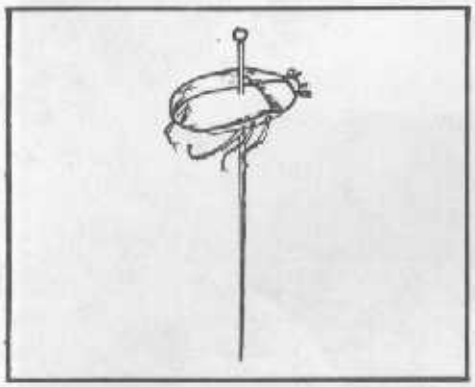


Figure 19 **Correctly pinned insect.**

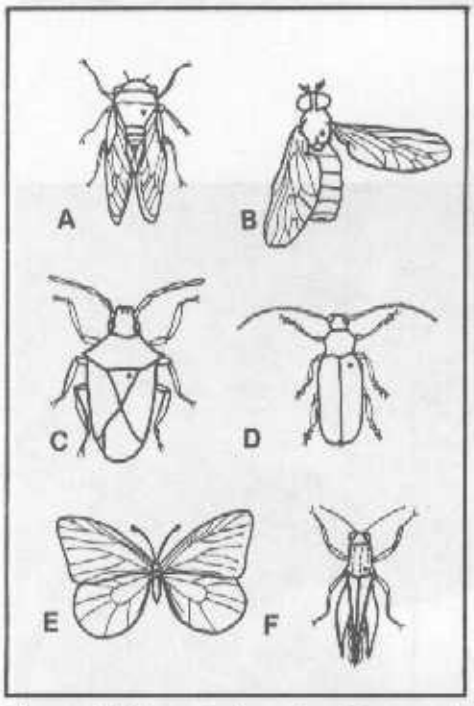


Figure 20 **Correct place to pin several orders of insects. The small, round dot in the thorax indicates the position of the pin. (A) Cicada, Homoptera; (B) horsefly, Diptera; (C) stink bug, Hemiptera; (D) long-horned beetle, Coleoptera; (E) butterfly, Lepidoptera; (F) grasshopper, Orthoptera.**

Once insects have dried, they are very fragile or brittle. For this reason, they should be mounted when fresh. If you find a dead insect or your specimen has become dry before you can pin it, you can relax it by following the procedures on page17.

Insects are often 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 19 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 20 for the correct place to pin representatives of each of the major order of insects.

The height at which specimens are pinned should be uniform, with about one-fifth of the pin exposed above the upper surface of the insect (Figure 21). Also, the insect should be horizontal on the pin when viewed from the front and side. This is important both for neatness and ease in handling. The pinning block, described earlier (Figure 9), will permit uniformity in pinning heights. Slide the specimen upwards on the pin using the deepest hole in the pinning block.

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 of the thorax 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; and 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 relaxed 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. Put insect in pinning block to adjust height on pin.
2. Push the pin through the center slot of the spreading board until the wings are even with the side pieces (Figure 22A).
3. Move the front wings forward with the aid of an insect pin or a pair of blunt-end 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. (Figure 22B).
   b. Pull the front wings forward until the hind margin is perpendicular (forms a right angle) to the length of the body (Figure 22C).
4. The pin holding the front wing may then be temporarily an-

chored into the wood or foam.

5. Pull each hind wing forward in a similar manner until the hind wing is partially hidden beneath the front wing and a small notch or "v" remains between the two wings at the outer margin (Figure 22D).
6. Hind wings can also be temporarily anchored with insect pins.
7. Strips of smooth finish 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 wings, the paper strips should be pinned just off the wing margins. The insect pins used for temporarily anchoring the wings in position may then be removed by gently rotating and withdrawing (Figure 22E). If pulled straight out, the wing is often torn.
8. Antennae should be positioned as in Figure 22E. Pins may be used to hold them in place until 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 insects to dry (out of reach of younger brothers, sisters and pets). Put your board in an air-tight box so that tiny moths or cockroaches will not be able to eat your specimens. If you have no such box, place the pinning board in an oven at very low heat (140° or less) for several hours, or put the specimens under a light bulb for several hours to dry. Do not set the pinning board in the sun as some specimens will fade. The drying period lasts several days but varies to some extent with the size of the insect. It may take as long as a week for certain large moths to dry properly.

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

Keeping Records

Keep records of the insects found, the development stages, the nests they make, and feeding damage they do. This information will become valuable as your collection expands. Forms are provided in the back of the manual for such information.

Relaxing Dry Specimens

Some insects cannot be spread the same day that they are caught and will have to be stored temporarily. Freshly killed specimens can be adequately stored three to four weeks by placing them in the freezing compartment of your refrigerator in an airtight container. They can be mounted immediately when thawed out.

However, specimens sometimes become dry and brittle before they can be frozen or if 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

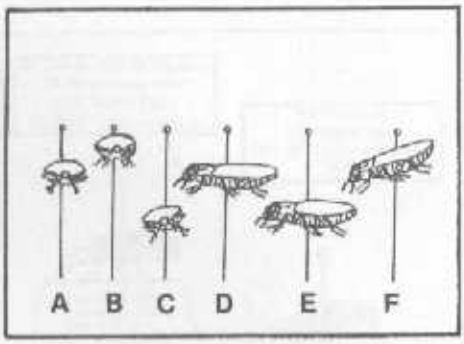


Figure 21 **Examples A and D are correctly pinned.**

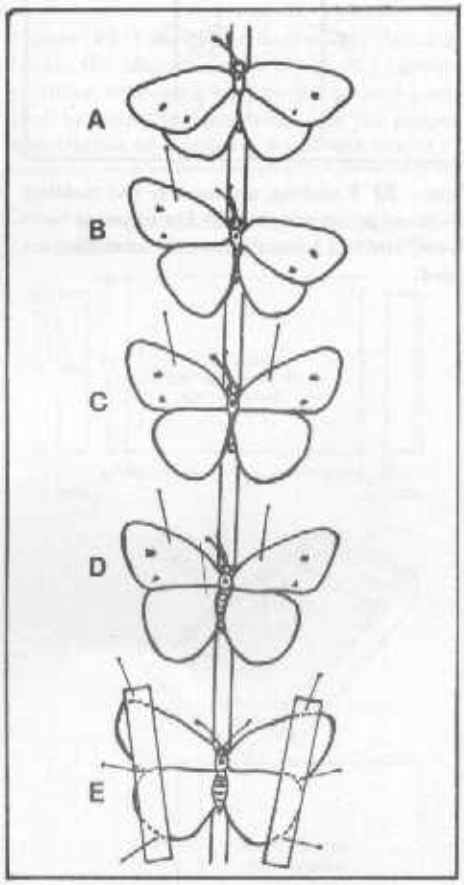


Figure 22 **Steps in the proper spreading of the wings of moths and butterflies.**

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 (phenol) to prevent the growth of mold. This chemical should be used with care. A small amount of mothball flakes will also discourage mold formation. The insect specimens should be laid on metal screen or a piece of cardboard cut to fit the container, rather than directly in contact with the wet paper toweling or sand. Check the specimens daily until they are flexible enough to mount. Do not leave them in the relaxer any longer than necessary.

Preserving Small and Fragile Insects

Specimens too small to be pinned, such as flies, beetles and wasps, should be mounted on triangular paper points. The paper points should be cut or punched from heavy paper, such as filing cards. Make them no more than 3/8-inch long and 1/8-inch wide at the base. Paper point punches are available from biological supply houses but they are quite expensive. You may obtain these points from your CVI-CES Pest Management program or a quantity of points can be purchased from a biological supply house.

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 Figure 23A). With a pair of tweezers or forceps, bend down the tip of the point (as in Figure 23B). 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 (Figure 23C). Generally, you should point any insect you feel would be damaged by trying to pin it.

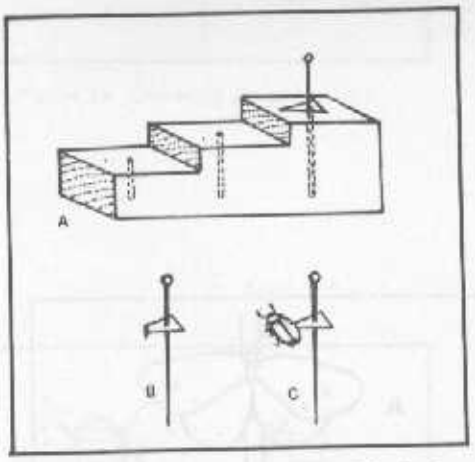


Figure 23 **Pointing an insect: (A) Setting height of point on pin, (B) Tip of point bent down, and (C) Insect correctly mounted on point.**

Preserving Immature or Soft-Bodied Insects

Soft-bodied insects such as aphids, caterpillars, silverfish and some immature insects 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 as very fragile insects such as craneflies and mosquitoes, are best preserved in alcohol. Professional entomologists use 70% to 80% ethyl (grain) alcohol. However, rubbing alcohol, available from any drugstore, will do nicely. Use a 70% concentration. The same information that is written on the two labels which go on a pin is then written on small pieces of paper with a pencil or waterproof ink such as India ink (not ball point). These labels are placed *inside* the bottle or vial with the specimens.

Nymphal insects can be placed directly into 70% alcohol for storage, but insect larvae may shrivel up or lose their color in alcohol unless they are "fixed" first. There are special fixative solutions you can order from biological supply houses, but you can easily fix insect larvae with hot water treatment. To fix insect larvae with hot water, bring a cup of water to boil in a sauce pan. Remove the pan from the heat and wait a half minute. Then pour the hot water onto the larvae you have waiting in a coffee can. The larvae will be killed instantly, but they should be left in the hot water for several minutes until they

are slightly cooked. If the water is too hot when you pour it on the larvae, they may burst open like an overdone wiener. If the water is not hot enough, it may not kill the larvae instantly and they will also be underfixed.

Labeling Specimens

Printed labels are furnished in the back of this manual. The necessary information should be filled in with ink using a fine-pointed pen. Two labels, a locality label (Figure 24A) and an identification label (Figure 24B), should accompany each insect specimen. The locality label should contain the following information: location (island and estate), date of collection and name of collector. It may also contain the host or specific habitat from which the specimen was collected. This label goes on the pin immediately beneath the specimen (Figure 24C). The middle hole in the pinning block is used to set the locality label height in the pin (Figure 23A).

The identification label should contain the following information: family, common name (professional entomologists use scientific name), name of person who identified the specimen (this may be different from the collector),and the year in which it was identified. The identification label goes on the pin beneath the locality label (Figure 24D). Use the shallow hole in the pinning block to set the label height on the pin. Also notice in Figure 24D that the pinned specimen faces left as you read the labels.

For pointed insects, the two labels are placed on the pin in the same manner. Again, notice the orientation of the pointed specimen, with the point directed to the left (Figure 24E). 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.

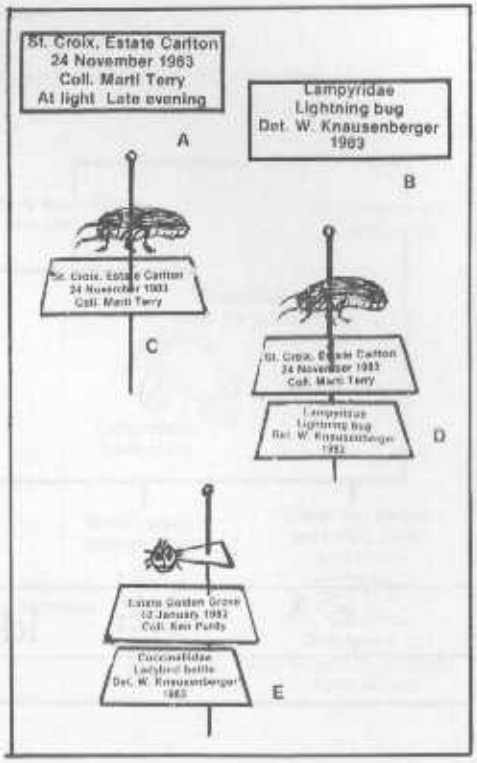


Figure 24 **Labeling insects: (A) locality label, (B) identification label, (C) correct position of locality on pin, (D) correct position of identification label and (E) proper orientation of labels for a pointed insect.**

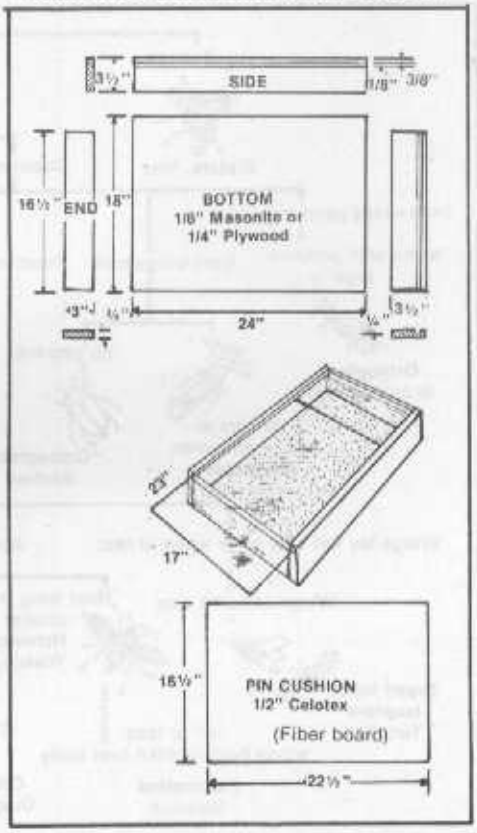


Figure 25 **Insect display box and materials needed for its construction.**

Storing and Displaying Your Collection

A collection of pinned insects must be properly stored in order to protect it from dust, damage, and infestation of carpet beetles or 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.

A standard display case, or Cornell drawer, measuring 18 × 24 × 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 25. The pinning cushion can be celotex, cork or balsa wood. If a plastic foam is used, make sure that it does not react to mothballs or some moth crystals. To test this, seal up a mothball or some moth crystals with a piece of the foam in an airtight container for several days and check for any chemical reaction, such as curling.

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. Most moth crystals, such as napthalene or Paradichlorobenzene (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. Insects should be placed in neat rows beneath their corresponding Order label. Neatness in pinning and displaying insects is important when collections are judged at insect field days or science fairs. Printed Order labels are available in the back of this manual.

Identifying Your Insects

Keying to Order

From structural and other characteristics, the biologist sorts out common features and prepares an identification tool called a *key*. Each step in the key requires you to make a choice between contrasting characteristics. In the key that follows, your first choice is: Does it have wings (Figure 26) or is the insect wingless (Figure 27)?

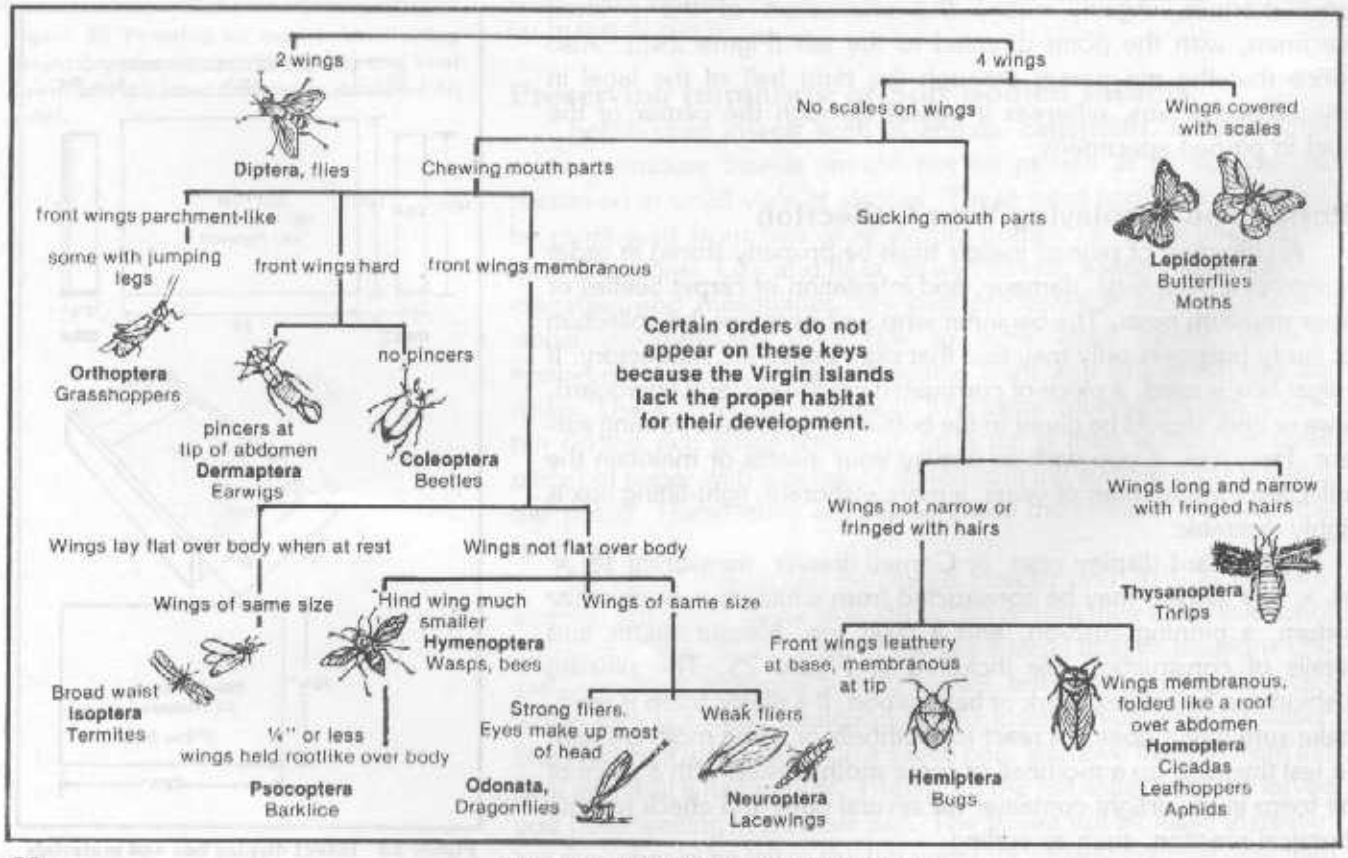


***Figure 26.* A key to winged insect orders.**

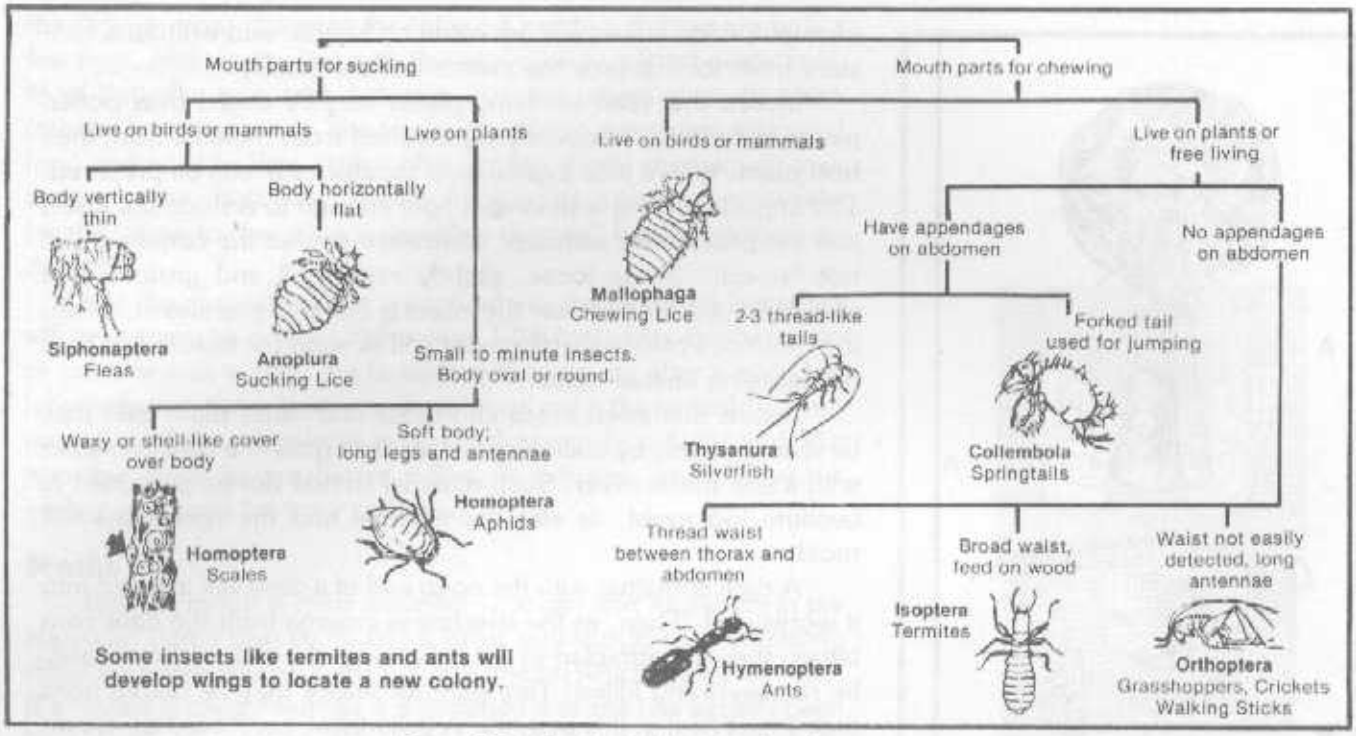


Figure 27. **A key to wingless insect orders.**

Follow the key 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.

Determining the Common Name

Many useful reference books exist which will allow you to determine the common names of your insects and learn something about them. The lists of reference books starting on page 30 contain books which have been found useful in identifying insects as well as some books which professional entomologists feel would be suitable for beginning entomologists.

Rearing Insects

Collecting and observing insects as they change from one stage to another can be a most interesting project. Not only is it the best way to really understand the life cycle of any insect but it is a means of providing you with perfect adult specimens for your collection. Grasshoppers, crickets, mosquitoes, some beetles, bugs and flies, and various moths and butterflies can be studied in this way. The important thing is to try to duplicate the natural conditions for the insect you are rearing, including its preferred food (the plant you find it feeding on) and the proper light, temperature, and humidity conditions.

In order to easily rear insect species, some type of rearing cage or jar is needed. A rearing cage must be constantly tended. For

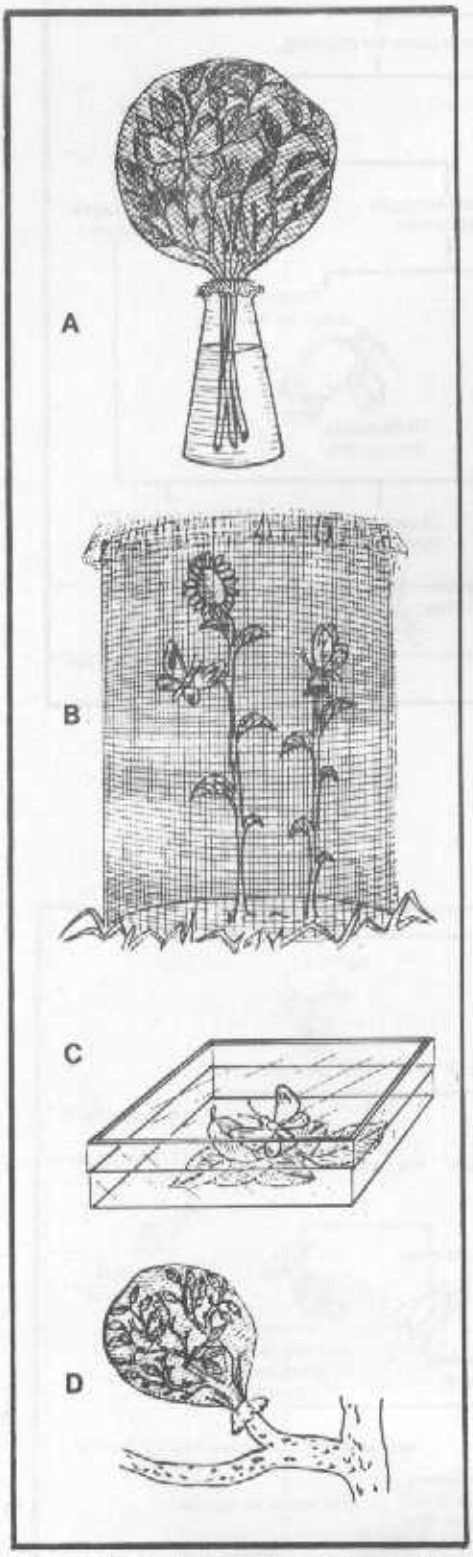


Figure 28 **Techniques in rearing Lepidoptera: (A) bouquet of preferred plant food set in a bottle of water and covered with a nylon net; (B) screen cage with preferred food growing in it; (C) plastic box with picked leaves in it; (D) nylon sack tied over a branch of plant food.**

example, dried leaves are not eaten by insects, and without a constant fresh food source the insects will die quickly.

Insects that feed on living plants may be caged over potted plants or fed with frequently replenished fresh material from their host plant. With a little ingenuity, a suitable cage can be prepared. The important thing is to keep it tight enough to restrain the insect and yet provide for sufficient ventilation so that the container will not "sweat." Some loose, slightly moist soil and ground litter should be provided in case the insect is one that pupates in, or on, the ground. Provide slightly moist soil or sand for insects that feed on decaying animal matter.

Insects that infest seeds and those that cause plant galls may be reared merely by enclosing the seeds or galls in a tight container with a fine mesh cover. Such material should not be permitted to become too moist, or else the material and the specimens will mold.

A dark container with the open end of a glass vial inserted into it works well. Then, as the specimens emerge from the dark container, they are attracted to the light, enter the vial, and can easily be removed and killed. Tiny parasitic wasps may be reared from their insect host in this manner. A cylindrical, cardboard ice cream container is excellent for this type of rearing.

It is interesting to dig larvae and pupae out of rotten logs in the woods and rear them to their adult form. It is not necessary to "feed" these larvae, but you should take along a quantity of rotten wood with the specimens and keep it in a closed jar or metal container to retain the moisture. In this way you can collect some of the largest and least observed beetles.

Another interesting practice is that of collecting cocoons of moths and chrysalises of butterflies. Often you may also find full-grown moth and butterfly larvae (caterpillars) that are just about to transform to the pupae. These can be collected and observed until they pupate and the adults subsequently emerge.

Probably most young people who develop an interest in rearing insects have a desire to raise Lepidoptera (moths and butterflies) through their whole life cycle. This interest justifies devoting some space to the subject here. Knowledge of trees and plants is a big aid in rearing butterflies and moths, and recognition of plants is essential. Adult Lepidoptera are very selective and will lay their eggs only on the plant on which the larvae will feed.

Butterflies

Start by trying to catch a female butterfly (with practice and the use of resource books, the female of the species can be identified by the coloring and size). Place her (1) on a bouquet of preferred plant food set in a bottle of water (Figure 28A), or (2) in a screen cage with preferred plant food growing in it (Figure 28B), or (3) in a plastic box with picked leaves in it (Figure 28C), or (4) in a nylon sack over a branch of the plant food she prefers and tie the bottom (Figure 28D). You will obtain from a few to perhaps a hundred eggs or so. The female may be released after three days.

There are several ways to rear larvae. It is best to leave them in

the sack or cage, changing the foliage if needed. If there are only a few eggs, remove the leaf with the eggs on it to a small plastic box. Most butterfly eggs take between five and seven days to hatch (monarchs take seven). The larvae must have a constant supply of food and must be kept clean. After the first week, cheesecloth over the top of the plastic box is better. It takes about two to three weeks for the larvae to become full size; then they will form chrysalises on the netting.

Put the chrysalises into a cage where the expected butterflies will have room to expand their wings. With butterflies that have two or more broods a year, the butterfly will come out after a period of hibernation; in those having a single brood only, the butterfly will not emerge until the next wet season. Let the butterfly fully expand. Put it in the killing jar just before it flies. In this way you will have a perfect specimen for your collection.

Moths

Rearing moths is quite different. One can start anywhere in the life cycle. Some start by finding a larva; you should plan on raising those for which you have the plant or tree on which the larvae feed. If a female is caught outside it is assumed that she has already been bred. Ordinarily, the female moth does not fly until she is ready to lay eggs. If a female moth emerges in the house, a male must be put in with her or she can be tied outside. The moth should be tied out the evening after she emerges from the coçoon and left all night or put in a cage of ½-inch hardware cloth. Tie the moth with strong thread, around the thorax, crossing and around the abdomen. The thread should be loose enough not to hurt the moth and tight enough so she won't escape. Tie the thread ends through a piece of screen and hang the moth on the screen outside (Figure 29A). Around sunset male moths will mate with her.

It is easy to get eggs. The simplest way is to put the female in a large paper sack, close the top by folding it over, and hold it shut with a paper clip (Figure 29B). Keep her in the sack from one to three days. Some moths such as the Sphinx moths, glue their eggs to the sack; the Tiger moth's eggs, on the other hand, may resemble sugar in the bottom of the sack. If the eggs are glued to the sack, cut around them and put them in a plastic container with proper food and cover. If the eggs are loose, empty them out gently into a container.

The larvae must be kept clean and without too much moisture. If a glass jar is used, only two or three larvae should be put in it. More satisfactory is a netting sack (such as nylon curtain material) over a branch of a tree with twenty or more larvae on it. This will have to be changed from time to time. Cut off the whole branch, put the sack over a fresh branch and put the larvae in it. As they grow larger, they need more space and food.

Sphinx moths pupate in the ground, so after the last molt, place them in a box or large can with two inches or so of slightly damp sand in the bottom. The larvae will crawl down into the sand. They can be left in the sand until they emerge. Most of the other large moths spin cocoons on the branches. The cocoons are

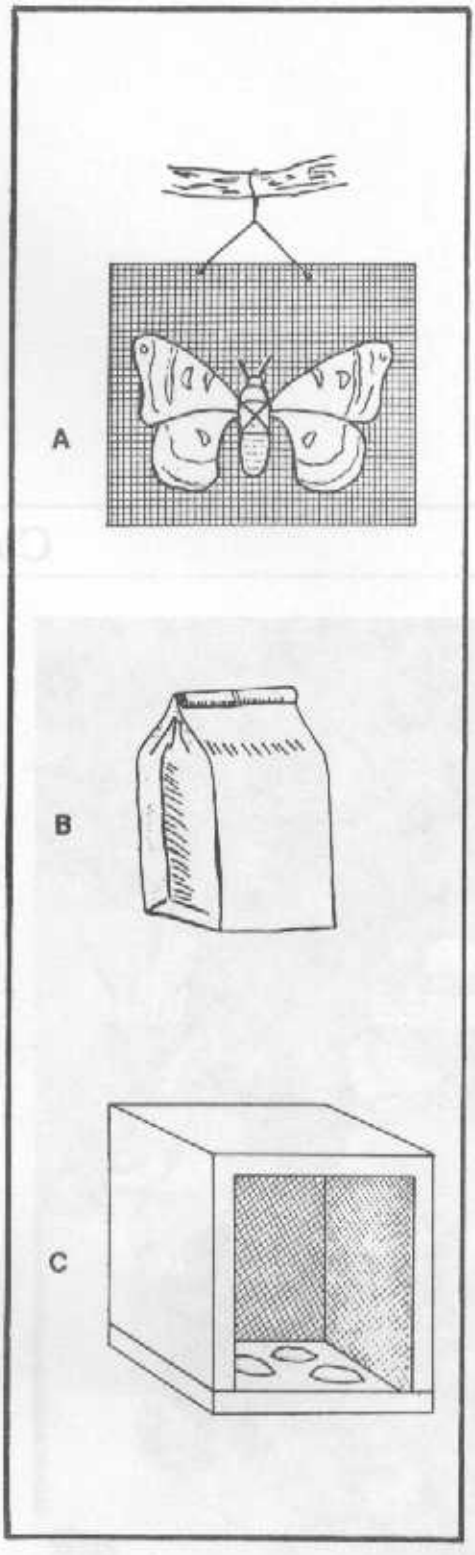
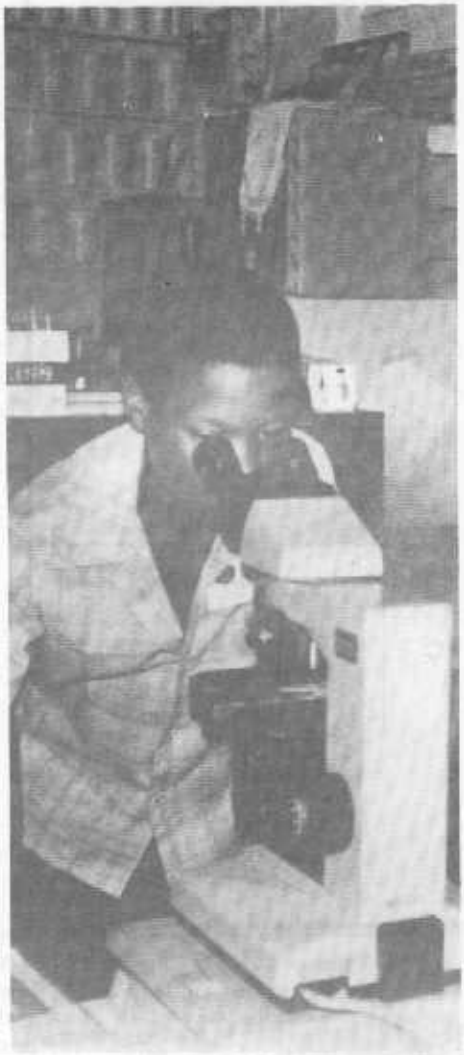


Figure 29 **Techniques in rearing moths: (A) female moth tied to a screen; (B) paper sack as egg-laying chamber; (C) emergence cage.**

gathered and put in a cool place until time for emergence. Bring the moth cocoons into the house. A screened cage, 1 foot by 18 inches by 1 foot, is ideal (Figure 29C). The moth can crawl up and hang from the top to stretch its wings. If you have missed the big event, the moth will still be perfect. Watch the cocoons closely; some get wet on one end an hour or more before the moth comes out.

If a screened cage isn't available, glue cheesecloth or netting on the inside of a cardboard box, stand it on end, and cover the front with plastic. The box must be bigger than the expanded moth will be. The netting gives the moth a foothold. If a moth has no place from which to hang to expand, he will not develop fully. Allow the moth to hang several hours before killing it so the wings will be hard enough to separate easily.

Careers in Entomology



To choose a career in entomology is to pursue a way of life that is essential, exciting and rewarding. How well insect populations are managed determines how well man can sustain life by providing the basic necessities of survival. Entomology is a profession, not just a "job." It requires intelligence, ambition, skill and dedication. It offers the satisfaction of contributing to the well-being of all mankind.

Many opportunities exist for students of entomology who graduate from college. Graduates find jobs teaching in high schools and universities. They are employed as researchers by state and federal government agencies, such as state experiment stations, U.S. Department of Agriculture and U.S. Public Health Service. Entomologists are employed by both public and privately supported museums. The chemical pesticide industry needs research entomologists to develop new products, salesmen to sell them and technical representatives to give specialized assistance. Major food processing companies hire entomologists. The commercial pest control industry uses many trained entomologists. Jobs as an entomology consultant are on the increase. These require a trained entomologist, self-employed in a community, who can provide a professional service much like a veterinarian, medical doctor, lawyer or engineer.

The student who expects to be an entomologist should have broad training in the sciences. He needs the breadth of training given in basic zoology and botany, chemistry, physics and mathematics. These subjects are integral parts of both basic and applied entomology.

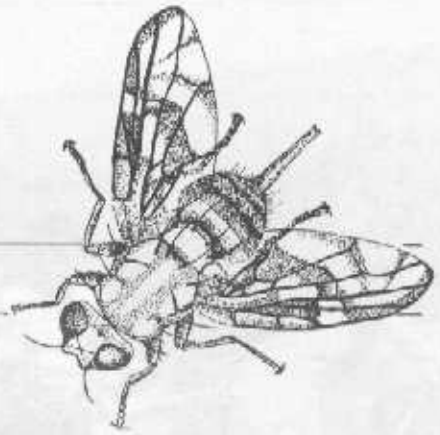
The following is a brief description of the major specialization areas of entomology.

Insect taxonomy deals with insect identification; it might be likened to genealogy. Traditionally, a taxonomist is interested in the features of a species that make it different from all other species. **Insect ecology** gives special attention to the insect's habitat, total environment, interrelationship with other insects,

other animals, plants and climate. **Insect physiology and biochemistry** involve the study of the internal processes of living insects. The physiologist and biochemist contribute to the understanding of how insects see, the function of their glands in metamorphosis, and how an insect becomes resistant to insecticides. **Insect toxicology** is the study of the action of insecticides—that is, how the chemical interferes with the vital life processes. **Insect pathology** is the study of disease organisms that affect insects. The pathologist perfects methods of insect control using pathogens, bacteria, fungi, virus and others, instead of insecticides. **Economic entomology** is concerned with the insect problems of an agricultural commodity such as a fruit, vegetable or other crop. This specialist takes basic information supplied by the physiologist, toxicologist, ecologist and others and carries out research to improve both the quality and quantity of a commodity through insect management. **Medical entomology** is the study of the insects that cause sickness in man and domestic animals. Some insects carry diseases such as malaria and dysentery; others cause disease by living in or on other animals. Still others cause disease and discomfort by injecting venom and other poisonous or irritating substances.

Sources of information about entomology careers are available in various brochures and pamphlets. For further information about entomology you can write to the Entomological Society of America, 4603 Calvert Road, College Park, MD 20740, or your local Cooperative Extension Service Pest Management Program.

In any event, both boys and girls should be encouraged to investigate entomology as a career.



Insects in the Future

Insects preceded us on earth by 300 million years and because of their adaptability will no doubt survive us. So it is not only our responsibility, but in our own best interest to live in harmony with all of earth's creatures, even though a few may make life next to unbearable at times.

It is important to remember in our haste to control an insect pest, that nature is in very fine balance. We must be very careful about "knocking" a pest insect out of the food chain, because the repercussions may be more serious than the damage done by the pest. We have now recognized the possible damage that can be done to our environment by the tons of chemical pesticides used by farmers and others. Scientists are working to develop natural or organic ways of controlling pests that will help restore a healthy environment.

Instead of abhoring, we should be more adoring of insects. Try to recognize the many benefits insects provide to mankind, several of which have been mentioned in this handbook, including products produced by insects: honey, beeswax, silk and shellac. The role that insects play in agriculture by pollinating flowers is very important. Also, they play a large role in building soil. Butterflies, moths and

other insects are also a source of such beauty they can be exhibited in displays or as wall decorations in our homes.

One thing we have not mentioned is the enormous possibility of insects as a major food source at our fingertips. In the past, different cultures have used insects in religious ceremonies and many peoples have used insects as a primary food source. We turn up our noses at the idea of eating insects but as the world's population increases, there may come a day when we will supplement our diets with insect protein. Almost all insects produce far more protein per pound of food than do cattle or pigs. It is only our cultural background that makes us cringe at caterpillar cupcakes or beetle bread. So perhaps in our lifetime or our children's, our attitudes will change and we will learn to appreciate insects for the valuable creatures they are.

Sources of Supplies for Insect Study

Company	Equipment		Specimens					
	Field	Lab.	Preserved Insects	Live Insects	Herbarium Supplies	Books	Insect Rearing Supplies	Audio-Visual Mat'ls.
American Biological Supply Company (AMBI) 1330 Dillon Heights Avenue Baltimore, MD 21228	✓	✓			✓	✓	✓	
Ben Meadows Company 3589 Broad Street Atlanta, GA 30366	✓	✓	✓		✓	✓		✓
Bio-Serv, Inc. P.O. Box 100-B Frenchtown, NJ 08825		✓					✓	
BioQuip Products P.O. Box 61 Santa Monica, CA 90406	✓	✓			✓	✓	✓	
Burkard Scientific, Ltd. Woodcock Hill Industrial Estate Rickmansworth, Herts. England WD3 1PJ	✓	✓						
Carolina Biological Supply Co. Burlington, NC 27215	✓	✓	✓	✓	✓	✓	✓	✓
Edmund Scientific Co. 7877 Edscorp Building Barrington, NJ 08007	✓	✓				✓		✓
Forestry Suppliers, Inc. P.O. Box 8397 Jackson, MS 39204	✓	✓			✓	✓		✓
Markson Science, Inc. Box 767 Del Mar, CA 92014	✓	✓				✓		
Nasco 901 Janesville Ave. Fort Atkinson, WI 53538	✓	✓	✓		✓	✓	✓	✓
Nova Scientific Corp. 111 Tucker Street, P.O. Box 500 Burlington, NC 27215	✓	✓	✓	✓	✓	✓	✓	✓
Parco Scientific Company P.O. Box 595 Vienna, OH 44473			✓	✓				
Scientific Etomological Equipment Survival Security Corp. Lakewood Ave., Lake City, MN 55041	✓	✓	✓				✓	✓
Ward's Natural Science Establishment, Inc. P.O. Box 1712 Rochester, NY 14603	✓	✓	✓	✓	✓	✓	✓	✓
Watkin & Doncaster The Naturalists Four Throws, Hawkhurst Kent, England	✓	✓	✓		✓	✓	✓	✓
Wildco Instruments & Aquatic Sampling Supplies 301 Cass Street Saginaw, MI 48602	✓	✓						

Glossary

Abdomen - The posterior section of the body behind the thorax in the arthropod.

Anoplura - (From the Greek *anolos* = unarmed + *oura* = tail) The insect order which contains true lice or sucking lice.

Aphid - An insect of the Order Homoptera also known as plant louse.

Aquatic - Living in water, such as mosquito wrigglers.

Arthropoda - One of the main groups of animals which has a segmented body and legs.

Aspirator - Device to collect small insects by sucking them into a bottle.

Caterpillar - The larvae of a butterfly, moth, sawfly or scorpionfly.

Centipede - A worm-like relative of insects with two legs per segment.

Chrysalis - The pupa of a butterfly. (*pl.* chrysalides)

Class - A subdivision of a phylum, containing a group of related orders.

Cocoon - A silken case inside which the pupa is formed.

Coleoptera - (From the Greek *coleos* = sheath + *ptera* = wings) The beetle order of insects.

Collembola - (From the Greek *colla* = glue + *embolon* = wedge or peg) The insect order which contains springtails.

Dermaptera - (From the Greek *derma* = skin + *ptera* = wings) The insect order which contains earwigs.

Diptera - (From the Greek *di* = two + *ptera* = wings) The insect order which contains true flies, gnats, midges and mosquitoes.

Elytron - The hard, leathery modified front wing of beetles. (*pl.* elytra)

Entomologist - A person who studies insects.

Entomology - The study of insects.

Ephemeroptera - (From the Greek *ephemeros* = living but one day) The insect order which contains mayflies and dayflies.

Ethyl acetate - A chemical also called acetic ether used in insect killing jars. It is a poison and must be used with care.

Exoskeleton - A skeleton or supporting structure on the outside of the body.

Family - A subdivision of an order, containing a group of related genera.

Genus - A group of closely related species; the first name in a binomial or trinomial scientific name. It should be capitalized and when printed is italicized. (*pl.* genera)

Hemelytra - The front wing of Hemiptera (true bugs) which is half leathery and half membranous.

Hemiptera - The insect order which contains true bugs.

Hexapod - Having six legs, such as insects.

Homoptera - (From the Greek *homo* = same + *ptera* = wings) The insect order which contains aphids, scales, leafhoppers and cicadas.

Hymenoptera - (From the Greek *hymen* = membrane + *ptera* = wings) The insect order which contains bees, wasps, ants and hornets.

Immature stage - The intermediate growth stage between the egg and the adult insect.

Insecta - The class of animals that is the insects.

Instars - The stage of insects between molts.

Isoptera - (From the Greek *isos* = equal + *ptera* = wings) The insect order which contains termites.

Key - An identification tool used by entomologists to classify insects into different orders or families.

Larva - A wingless early stage of certain insects. (*pl.* larvae)

Lepidoptera - (From the Greek *lepidos* = scale + *ptera* = wings) The insect order which contains the moths and butterflies.

Maggot - A legless larva stage of Diptera (fly order) without a well-developed head capsule.

Mallophaga - (From the Greek *mallos* = wool + *phaglin* = to eat) The insect order which contains bird lice or chewing lice.

Mandibles - The chewing mouthparts of the insect.

Mecoptera - (From the Greek *mecos* = long + *ptera* = wings) The insect order which contains scorpionflies.

Metamorphosis - The change during insect development from egg to adult.

Millipede - A worm-like relative of insects with four legs per segment.

Molts - The periodic shedding of the exoskeleton.

Naiad - The aquatic immature stage, primarily of dragonflies and damselflies.

Neuroptera - (From the Greek *neura* = nerves + *ptera* = wings) The insect order which contains lacewings and ant lions.

Nocturnal - Active at night.

Nymph - The immature stage, same as adult only smaller and without wings, found in insects with simple metamorphosis.

Odonata - (From the Greek *odontos* = tooth) The insect order which contains dragonflies and damselflies.

Order - A subdivision of a class, containing a group of related families.

Orthoptera - (From the Greek *orthos* = straight + *ptera* = wings) The insect order which contains grasshoppers, crickets, mantids, walking sticks and roaches.

PDB - Paradichlorobenzene is a chemical to be used in collection drawers to prevent infestation by dermestid beetles or other pests.

Phylum - Any one of the main groups into which animals are divided. (*pl.* phyla)

Plecoptera - (from the Greek *plekos* = plaited + *ptera* = wings) The insect order which contains stoneflies.

Proboscis - The siphoning mouth tube of butterflies.

Prolegs - The fleshy abdominal legs of certain insect larvae.

Pronotum - The top part of the first segment of the thorax.

Pscoptera - (from the Greek *psocho* = to rub something small or fine + *ptera* = wings) The insect order which contains booklice or barklice.

Pupa - An early stage of some insects that occurs between the larvae and the adult stages. (*pl.* pupae)

Scorpion - A member of the Class Arachnida that has a long stinging tail.

Scutellum - A triangular area on the thorax.

Siphonaptera - (From the Greek *siphon* = tube + *aptera* = without wings) The insect order which contains fleas.

Species - A group of individuals that are similar in structure and physiology and are capable of interbreeding and producing fertile offspring.

Specimen - Any individual insect.

Spiracle - A small breathing hole in the side of insects.

Terrestrial - One who lives on land.

Thorax - The insect body region which bears the legs and wings.

Thysanoptera - (From the Greek *thysanos* = tassel + *ptera* = wings) The insect order which contains thrips.

Thysanura - (From the Greek *thysanos* = tassel + *oura* = tail) The insect order which contains silverfish, bristletails and slickers.

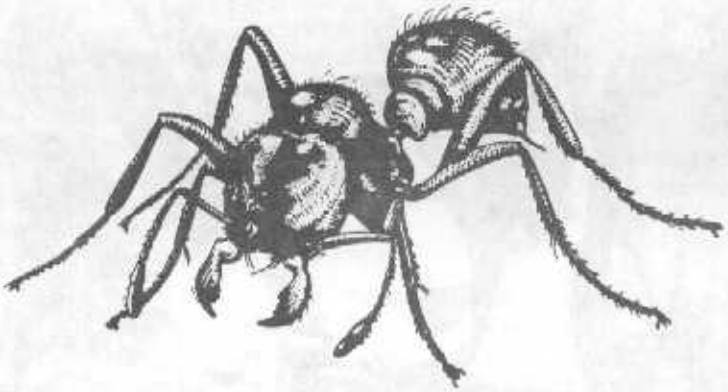
Trichoptera - (From the Greek *trichos* = hair + *ptera* = wings) The insect order which contains caddisflies.

Tympanum - A hearing organ on either the abdomen or legs of certain grasshoppers.

Young - An immature stage of insects that is identical to the adult in shape and form. It is only smaller in size and lacks mature reproductive organs.

Veins - The thickened lines that start at the base of the insect's membranous wing and go to the tip.

Venation - The pattern formed by the veins which can be used to identify species or insects.



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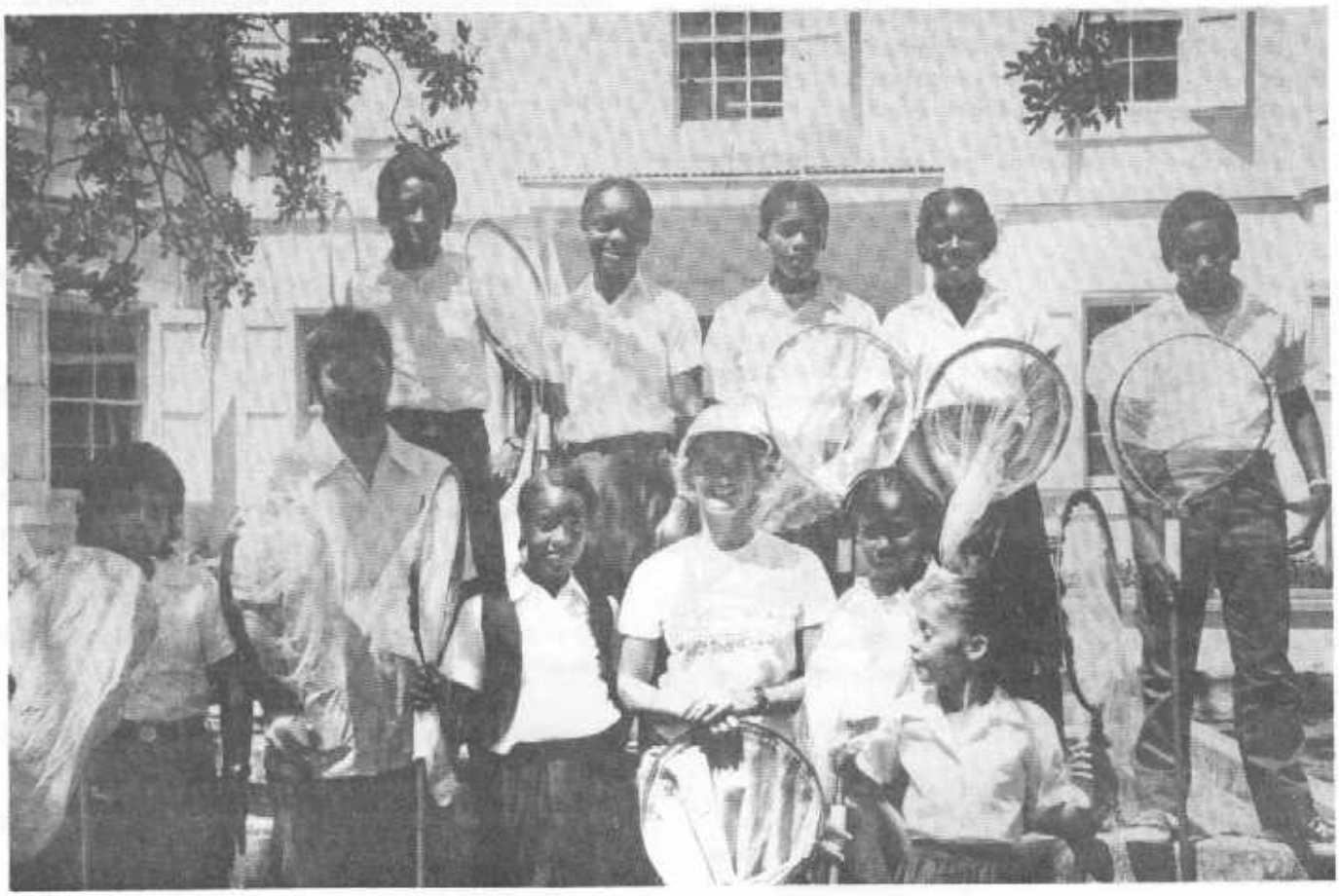

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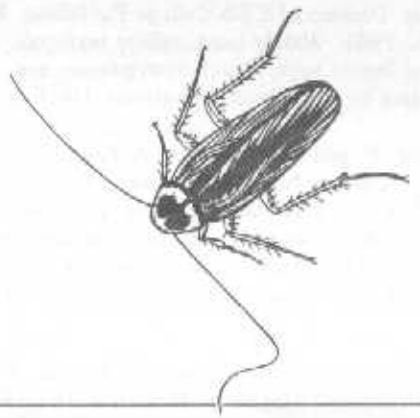

Insects and Other Arthropods of the West Indies

Compiled by Walter I. Knausenberger

In these references you will find details on identification and biology of selected groups of West Indian insects and related non-marine arthropods. Only some of the major groups are covered, and with these, emphasis is on those sources which cover either specific islands or island groups in the Lesser Antilles, or the entire region. With a few exceptions, references listed deal with whole families or orders for a given area. All these references list additional literature, so you have a springboard into a fascinating world of discovery.

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Appendix

Diagrams

External Anatomy

1. Orthoptera
2. Dermaptera
3. Anoplura
4. Hemiptera
5. Homoptera
6. Coleoptera
7. Lepidoptera
8. Diptera
9. Hymenoptera

Internal Anatomy

10. Respiratory system of the grasshopper
11. Circulatory, digestive, and nervous systems of the grasshopper
12. Cross sectional view of the grasshopper

Crossword Puzzle of Insect Orders

Insect Collection Data Sheet

Insect Identification, Order and Poison Labels

The following diagrams of insects may be used several ways:

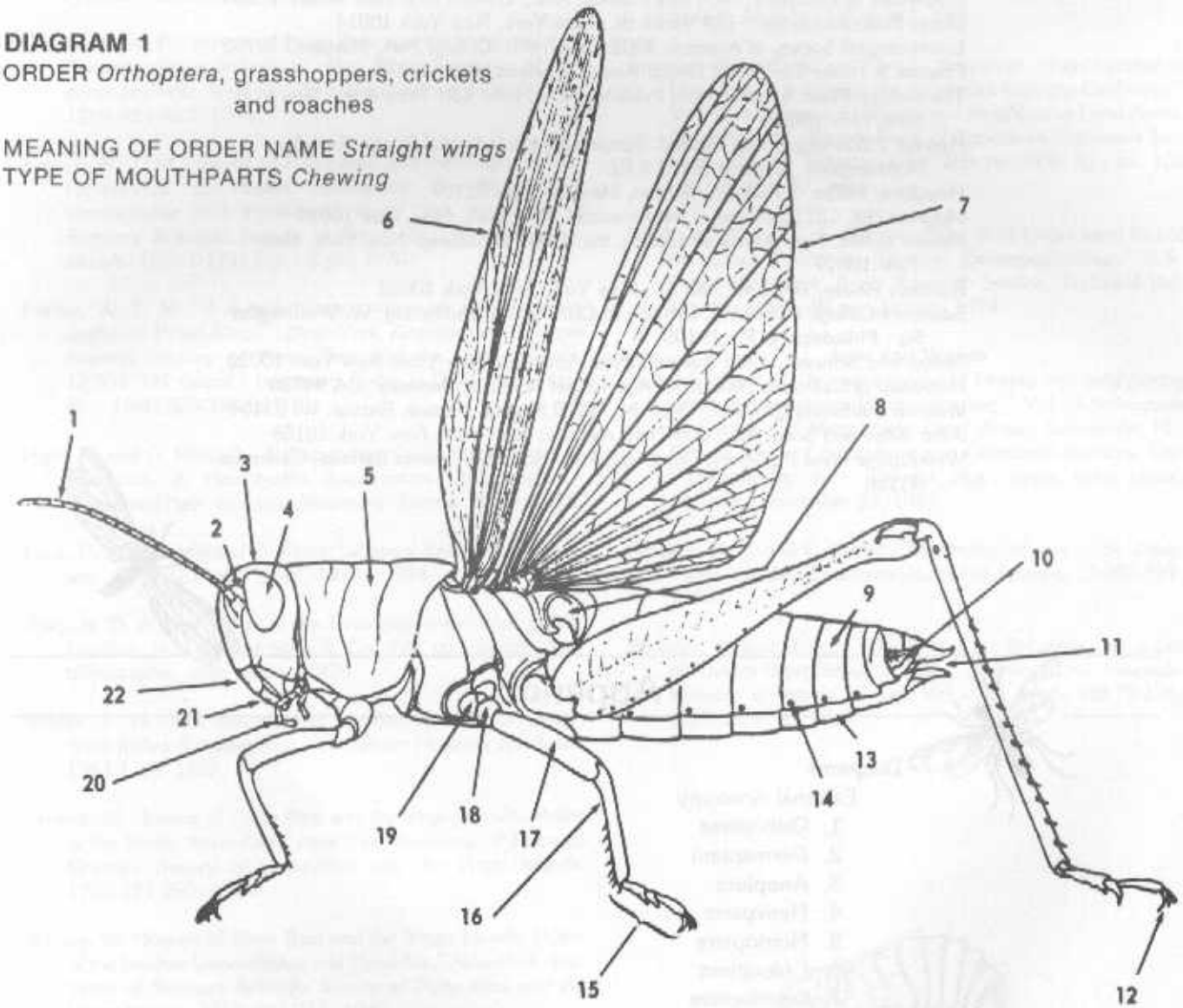
1. Teaching — insect identification, type of feeding, anatomy (external, internal)
2. Contests or quizzes
3. Coloring.

DIAGRAM 1

ORDER *Orthoptera*, grasshoppers, crickets and roaches

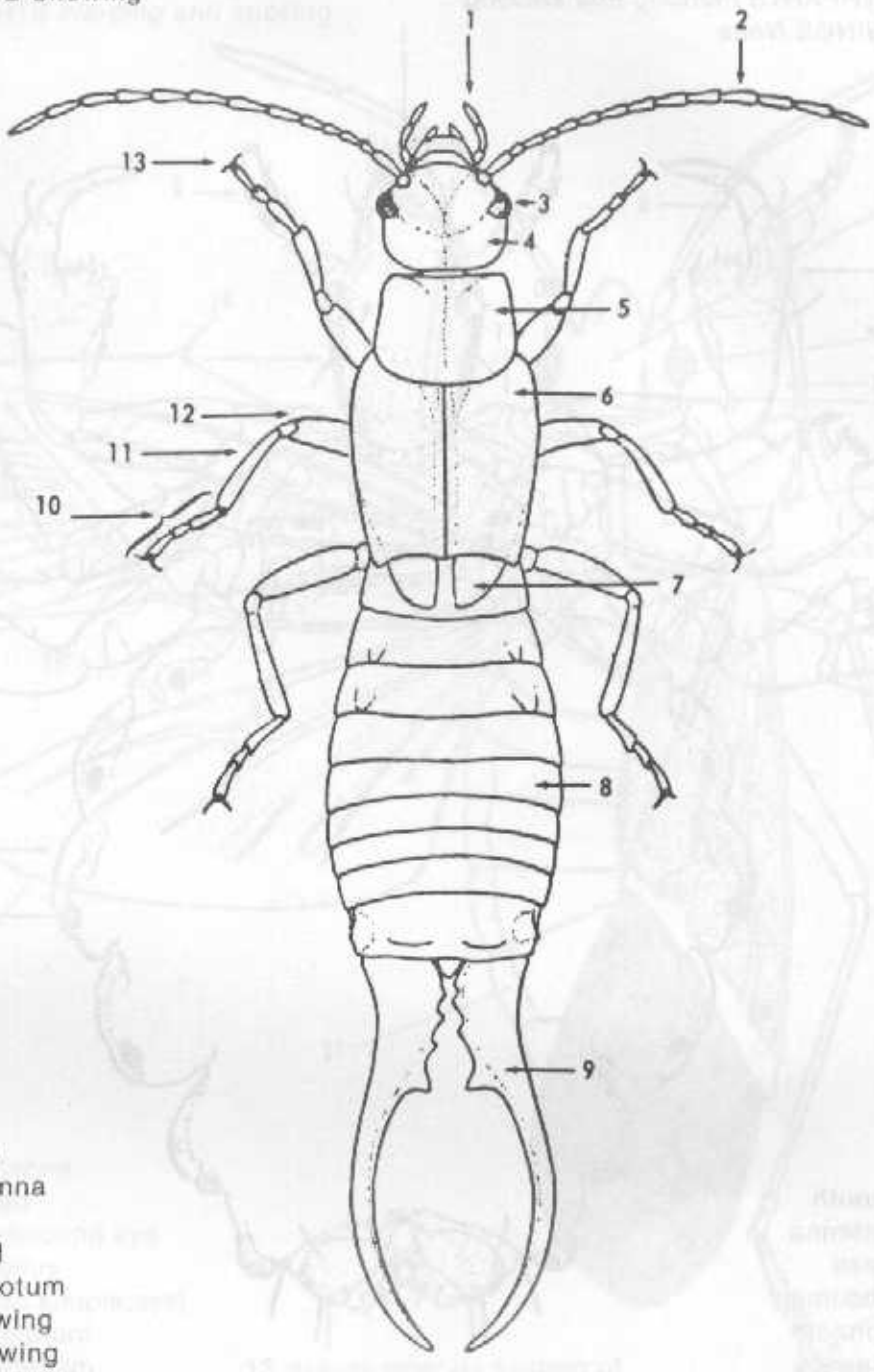
MEANING OF ORDER NAME *Straight wings*

TYPE OF MOUTHPARTS *Chewing*



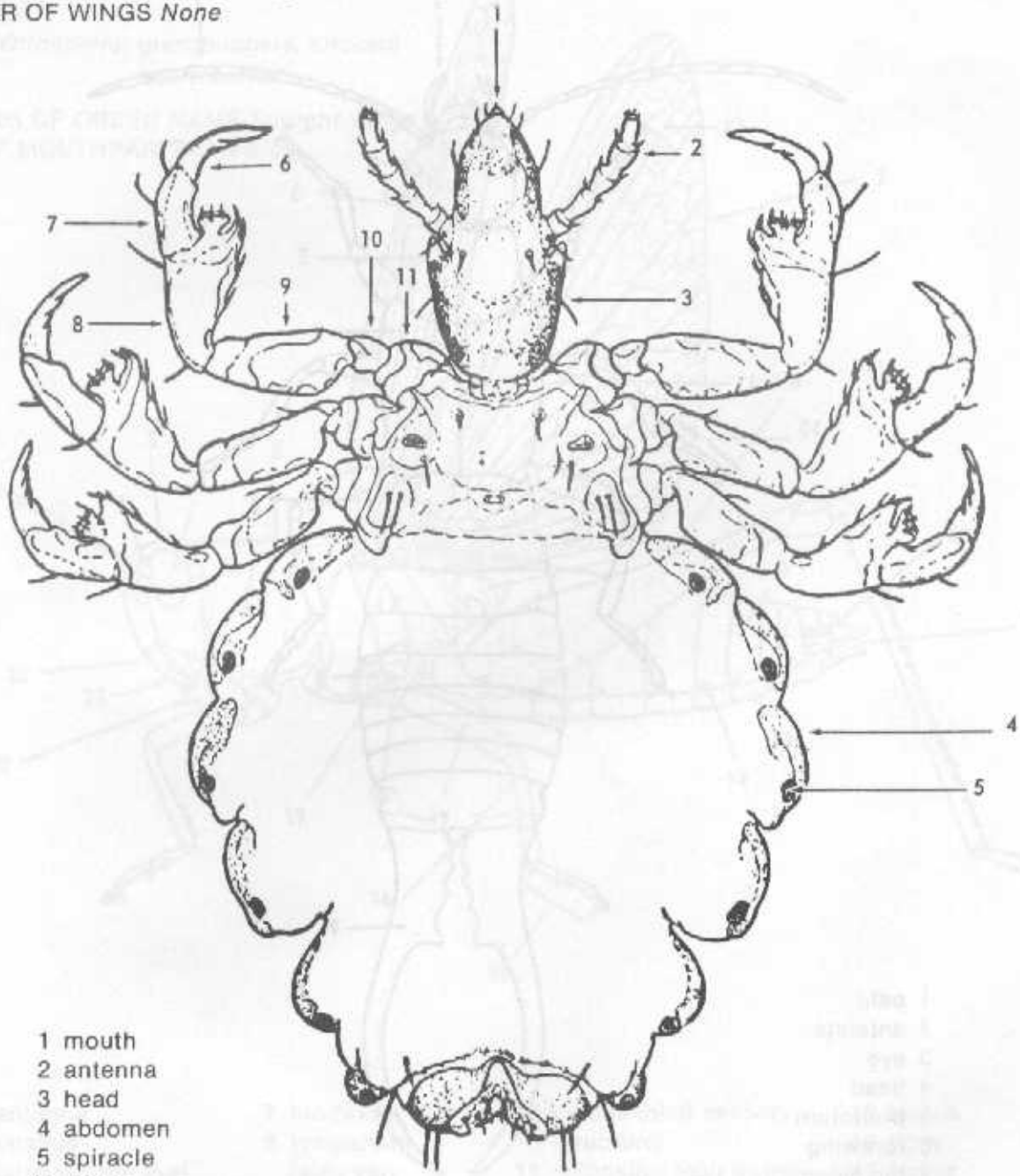
1 antenna
2 ocellus (also simple eye)
3 head
4 compound eye
5 pronotum
6 tegmen (also forewing)
7 hindwing
8 tympanum (also ear)
9 tergite (dorsal or top part of body segments)
10 cercus (hind sensory structure)
11 ovipositor (egg laying organ)
12 claw
13 sternite (ventral or bottom part of body segment
14 spiracle
15 tarsus
16 tibia
17 femur
18 trochanter
19 coxa
20 palp
21 labrum (lip)
22 clypeus (flap attached to lip)

DIAGRAM 2
ORDER *Dermaptera*, earwig
MEANING OF ORDER NAME *Skin wings*
TYPE OF MOUTHPARTS *Chewing*



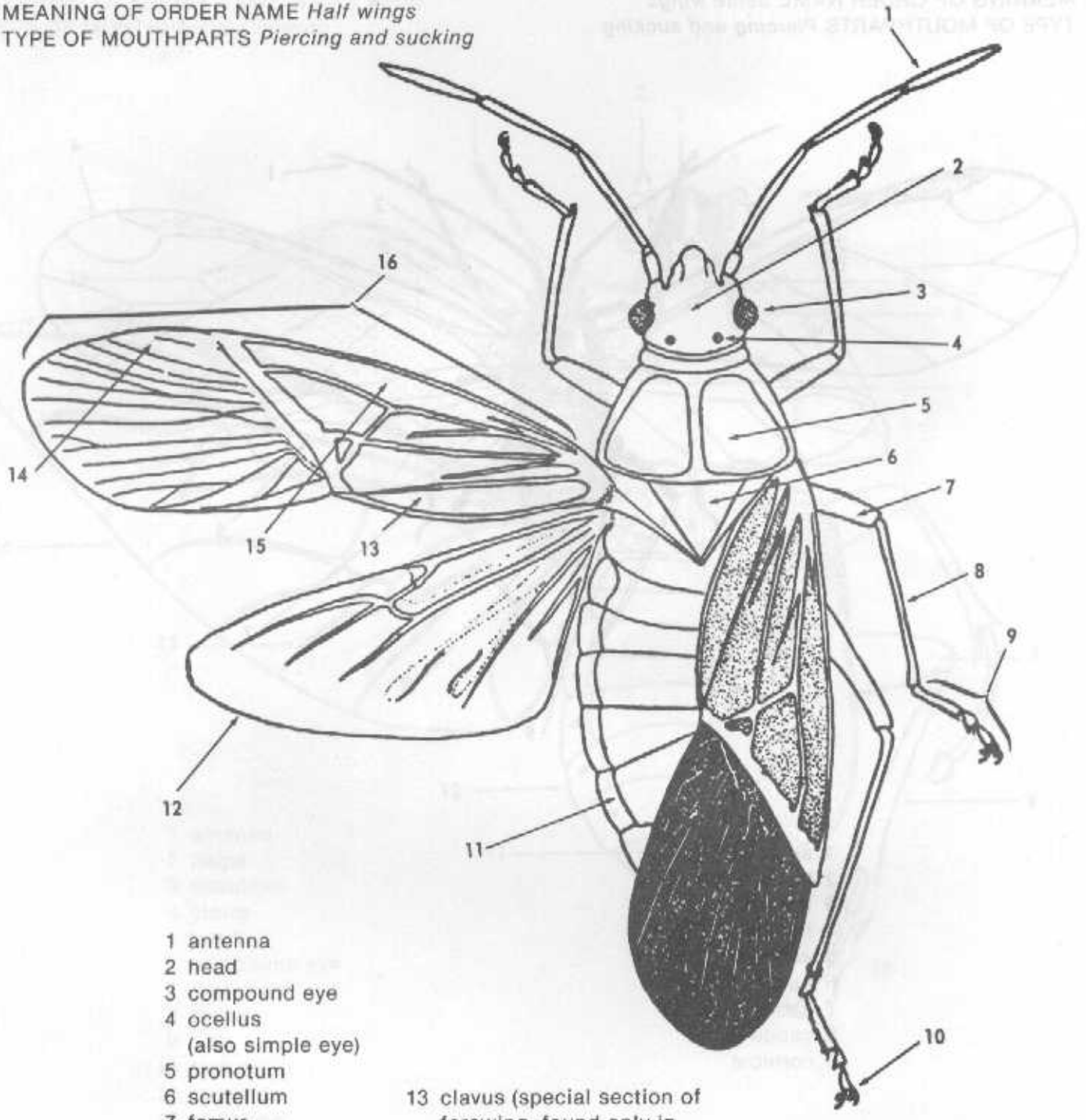
1 palp
2 antenna
3 eye
4 head
5 pronotum
6 forewing
7 hindwing
8 abdomen
9 forceps
10 tarsus
11 tibia
12 femur
13 claw

DIAGRAM 3
ORDER *Anoplura*, sucking lice
MEANING OF ORDER NAME *Unarmed tail*
TYPE OF MOUTHPARTS *Piercing and sucking*
NUMBER OF WINGS *None*



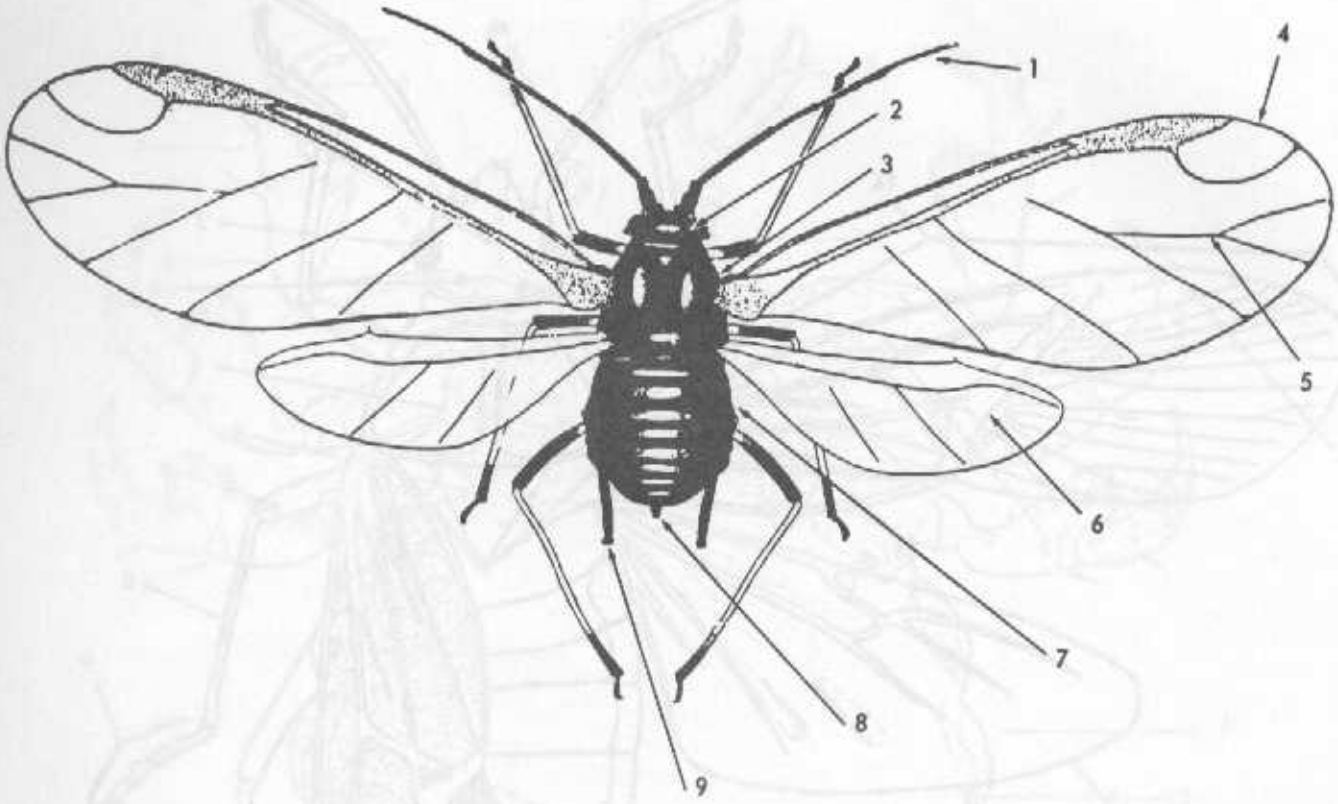
1 mouth
2 antenna
3 head
4 abdomen
5 spiracle
6 claws
7 tarsus
8 tibia
9 femur
10 trochanter
11 coxa

DIAGRAM 4
ORDER *Hemiptera*, true bugs.
MEANING OF ORDER NAME *Half wings*
TYPE OF MOUTHPARTS *Piercing and sucking*



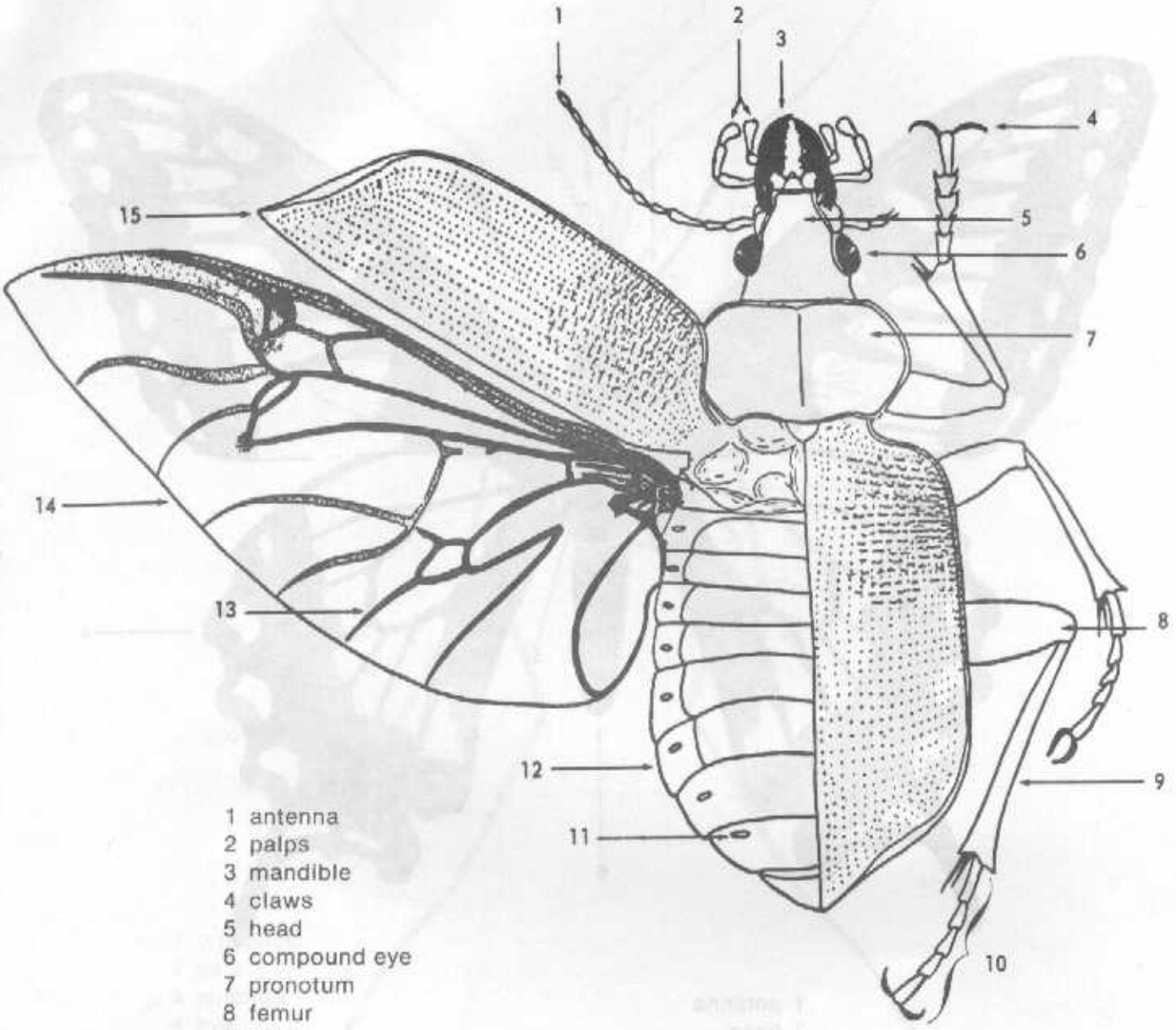
1 antenna
2 head
3 compound eye
4 ocellus (also simple eye)
5 pronotum
6 scutellum
7 femur
8 tibia
9 tarsus
10 claws
11 abdomen
12 hindwing
13 clavus (special section of forewing, found only in this order)
14 membrane
15 corium (leading edge of forewing)
16 hemelytra (also forewing)

DIAGRAM 5
ORDER *Homoptera*, aphids, scales and hoppers
MEANING OF ORDER NAME *Same wings*
TYPE OF MOUTHPARTS *Piercing and sucking*



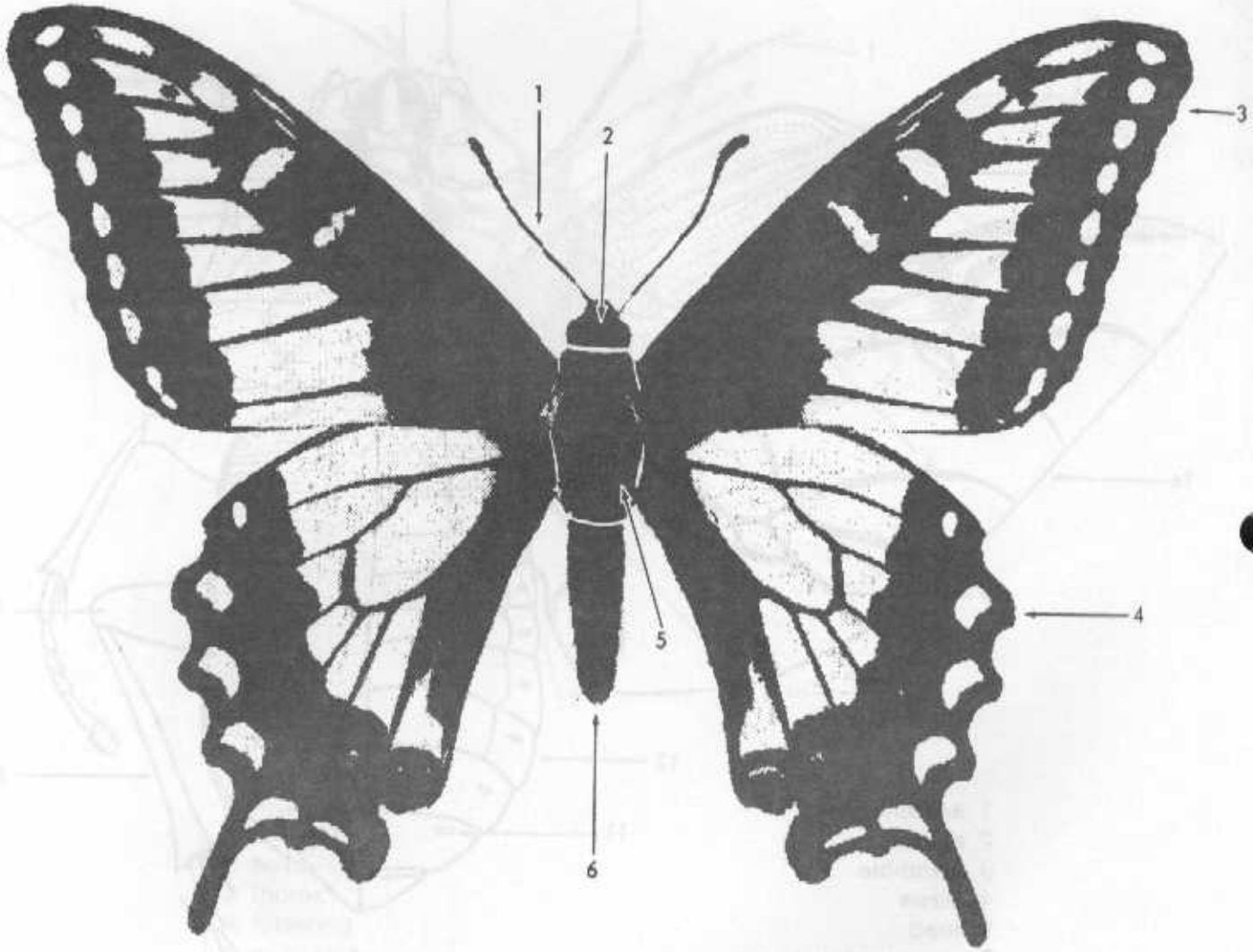
1 antenna
2 head
3 thorax
4 forewing
5 wing vein
6 hindwing
7 abdomen
8 cauda (tail)
9 cornicle

DIAGRAM 6
ORDER *Coleoptera*, beetles
MEANING OF ORDER NAME *Sheath wings*
TYPE OF MOUTHPARTS *Chewing*



1 antenna
2 palps
3 mandible
4 claws
5 head
6 compound eye
7 pronotum
8 femur
9 tibia
10 tarsus
11 spiracle
12 abdomen
13 vein
14 hindwing
15 forewing (elytron)

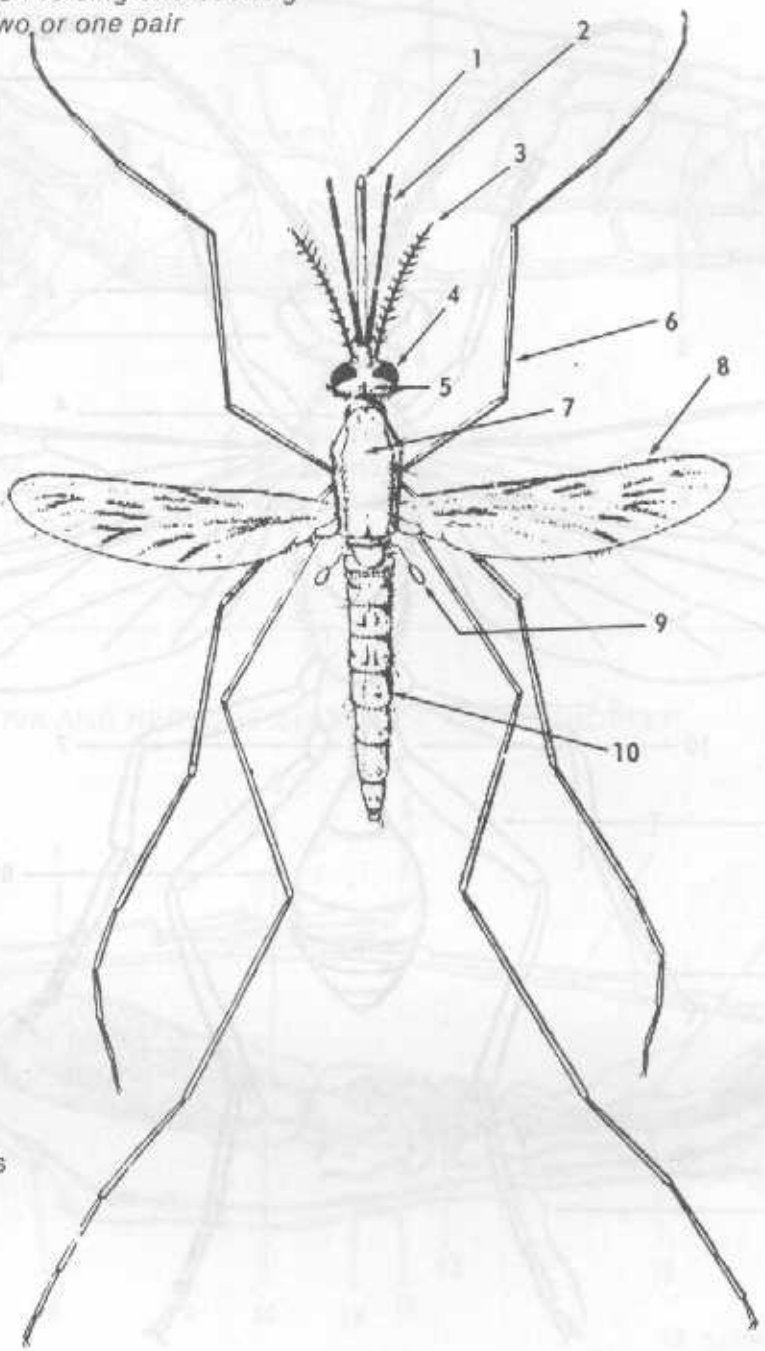
DIAGRAM 7
ORDER *Lepidoptera*, butterflies and moths
MEANING OF ORDER NAME *Scale wings*
TYPE OF MOUTHPARTS *Siphoning*



1 antenna
2 head
3 forewing
4 hindwing
5 thorax
6 abdomen

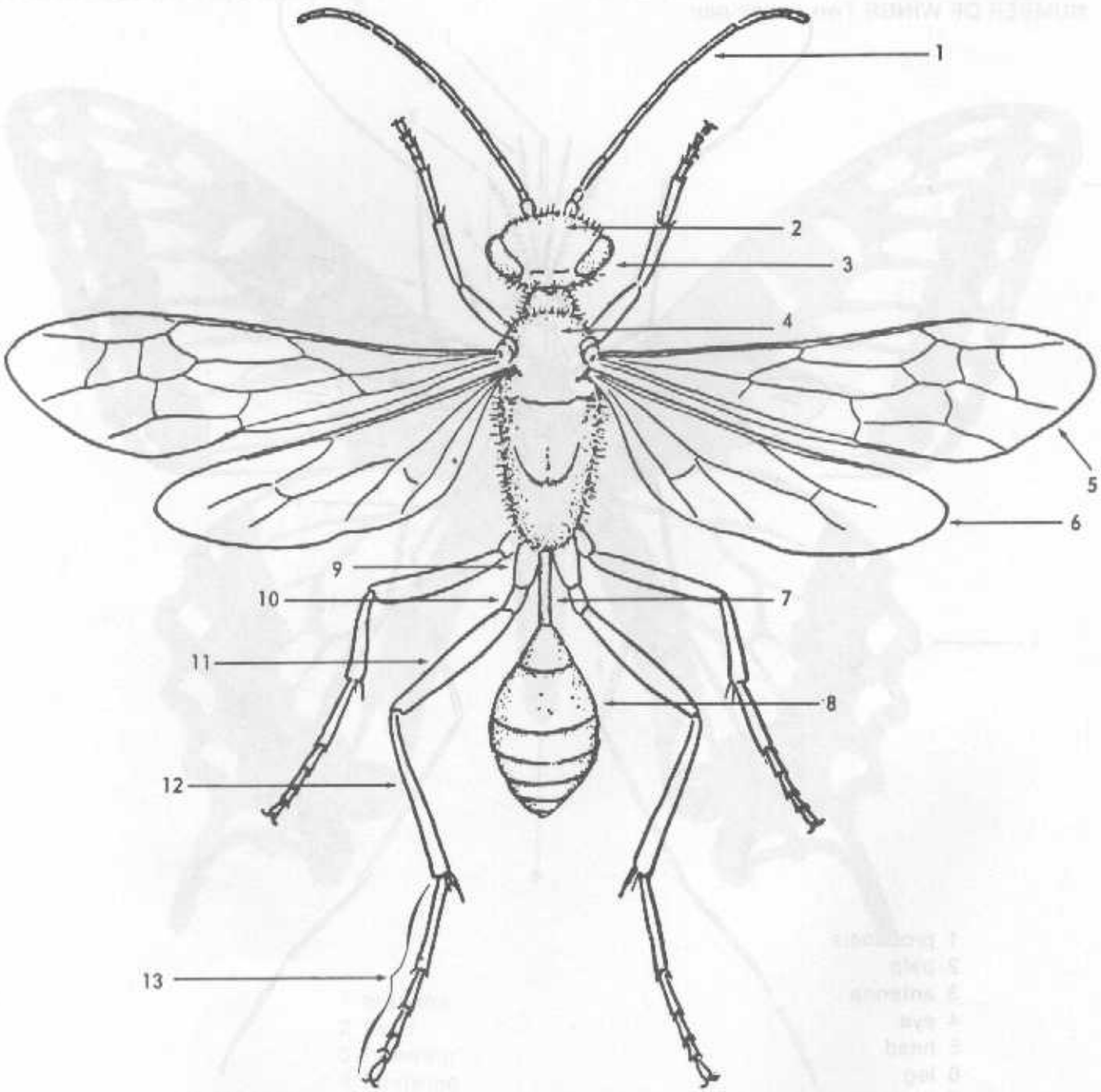
DIAGRAM 8

ORDER *Diptera*, flies and mosquitoes
MEANING OF ORDER NAME *Two wings*
TYPE OF MOUTHPARTS *Piercing and sucking*
NUMBER OF WINGS *Two or one pair*



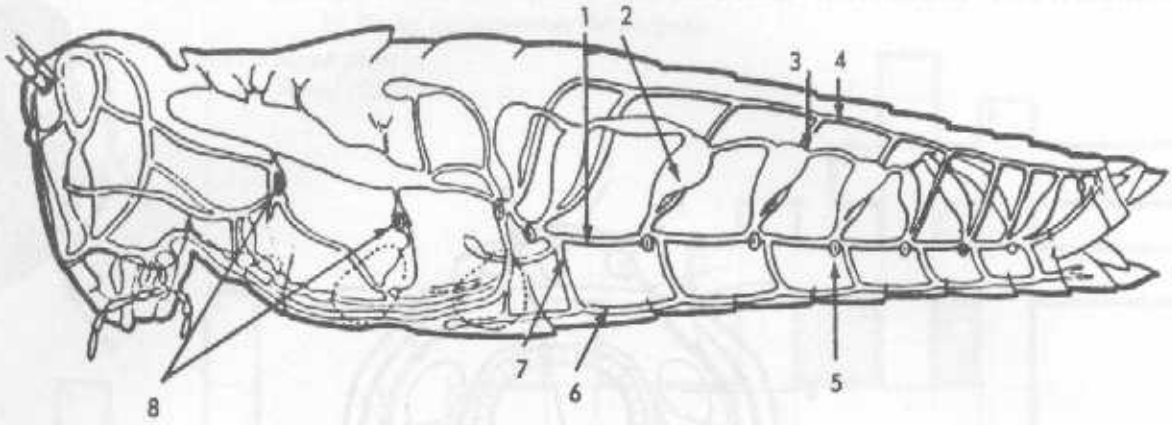
1 proboscis
2 palp
3 antenna
4 eye
5 head
6 leg
7 thorax
8 wing
9 halter (modified wing which serves as a balancing organ)
10 abdomen

DIAGRAM 9
ORDER *Hymenoptera*, bees, wasps and ants
MEANING OF ORDER NAME *Membranous wings*
TYPE OF MOUTHPARTS *Chewing*



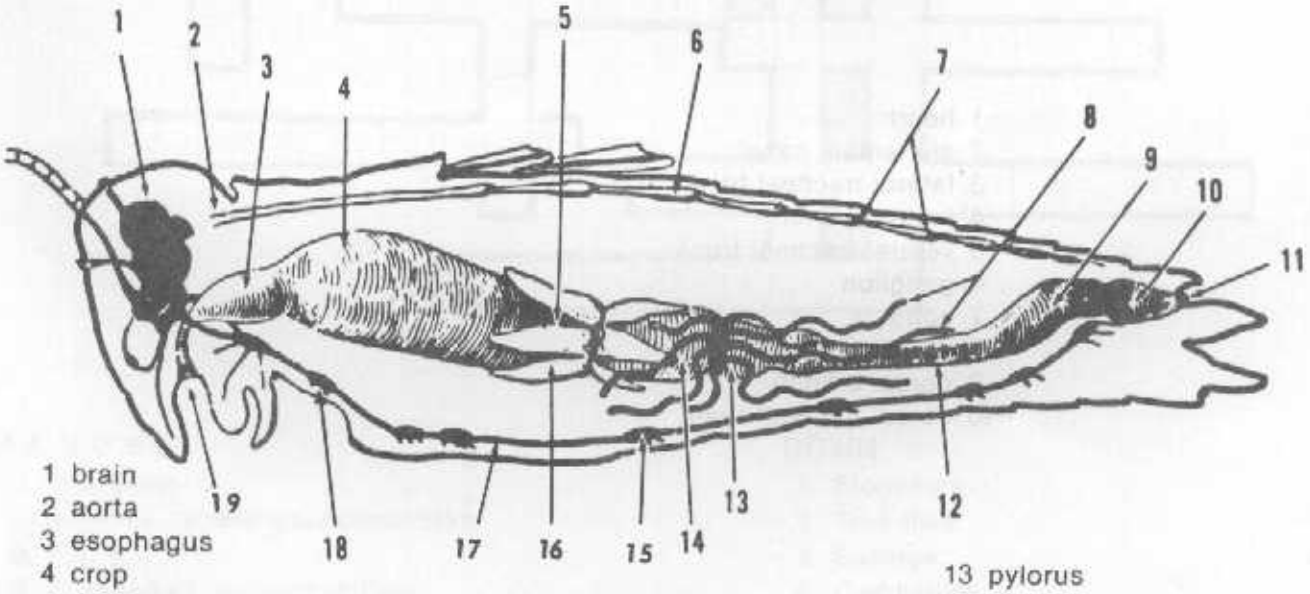
1 antenna
2 head
3 eye
4 thorax
5 forewing
6 hindwing
7 pedicle (segment connecting thorax and abdomen)
8 abdomen
9 coxa
10 trochanter
11 femur
12 tibia
13 tarsus

DIAGRAM 10
RESPIRATORY SYSTEM OF A GRASSHOPPER



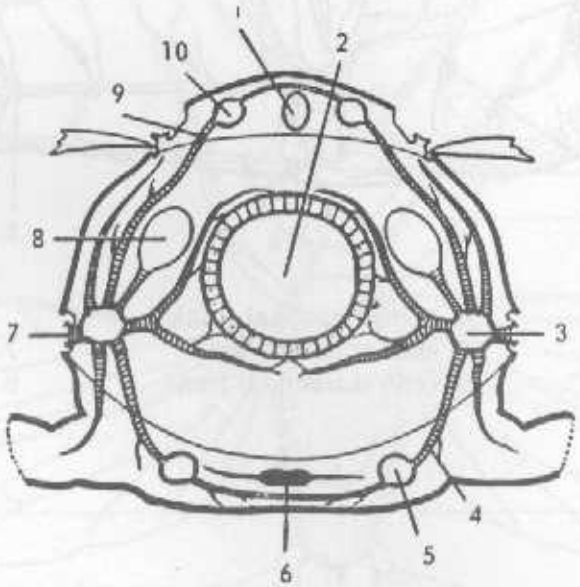
1 lateral tracheal trunk
2 abdominal air sac
3 dorsal branch
4 dorsal tracheal trunk
5 abdominal spiracle
6 ventral tracheal trunk
7 ventral branch
8 thoracic spiracles

DIAGRAM 11
CIRCULATORY, DIGESTIVE AND NERVOUS SYSTEM OF A GRASSHOPPER

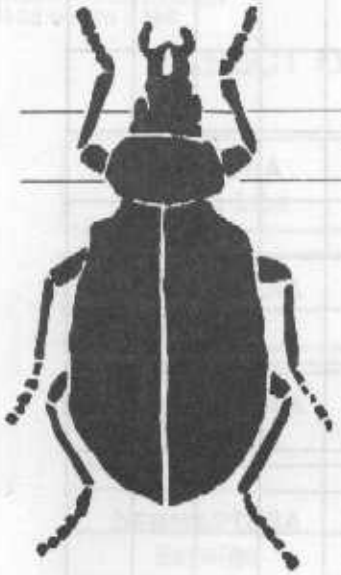


1 brain
2 aorta
3 esophagus
4 crop
5 proventriculus ("gizzard")
6 heart
7 ostia (small openings or valves)
8 Malpighian tubes (excretory "kidneys")
9 colon
10 rectal sac
11 anus
12 ileum
13 pylorus
14 ventriculus
15 abdominal ganglion
16 gastric caeca
17 nerve cord
18 thoracic ganglion
19 mouth

DIAGRAM 12
CROSS SECTIONAL VIEW OF A GRASSHOPPER'S
CIRCULATORY, DIGESTIVE, NERVOUS AND RESPIRATORY SYSTEMS



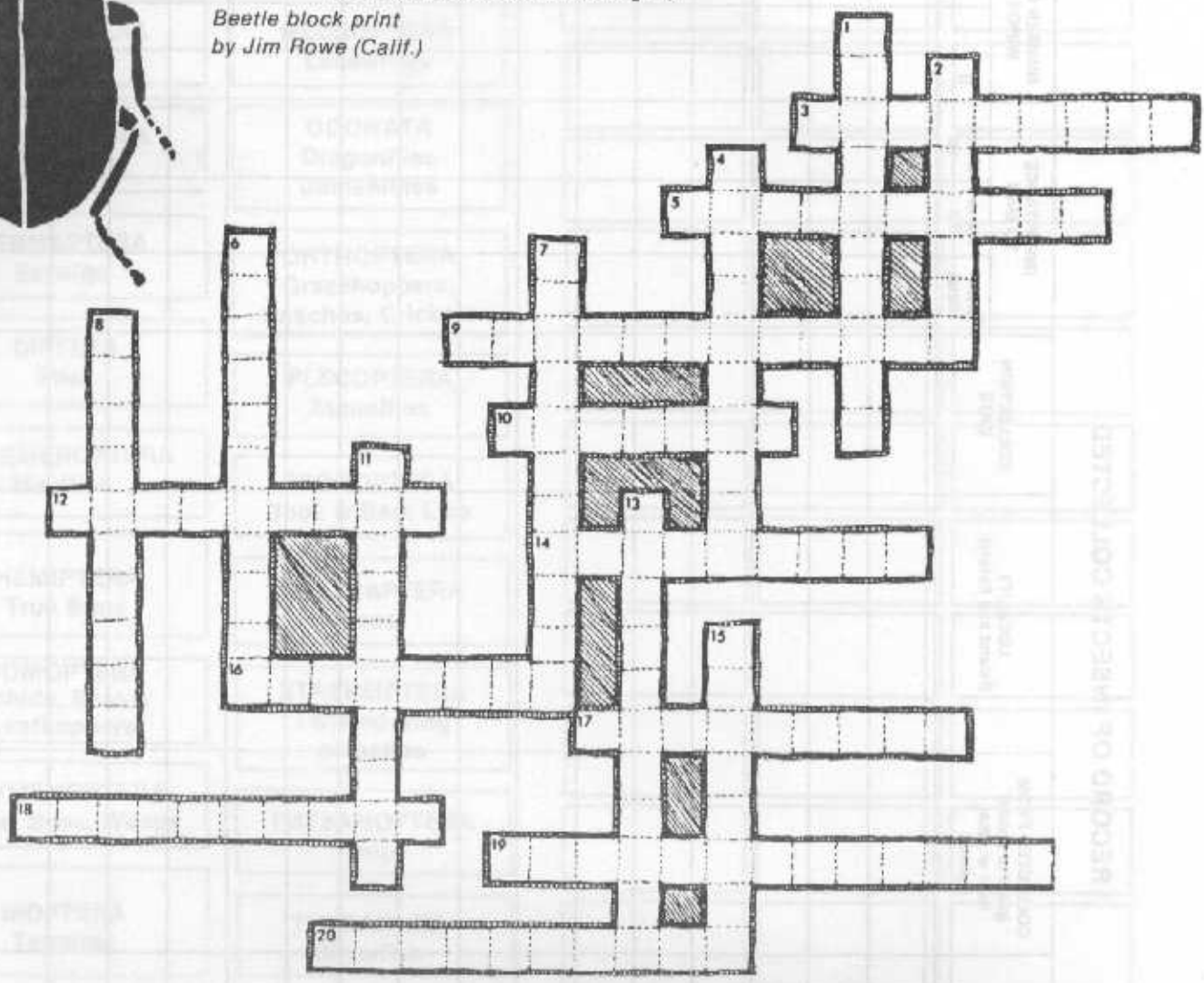
1 heart
2 alimentary canal
3 lateral tracheal trunk
4 lateral branch
5 ventral tracheal trunk
6 ganglion
7 spiracle
8 air sac
9 dorsal branch
10 dorsal tracheal trunk



The Orders of Insects Crossword

by David Eppelheimer (Michigan)

Beetle block print
by Jim Rowe (Calif.)



ACROSS

3. True bugs
5. Antlions, lacewings, dobsonflies
9. Fleas
10. Dragonflies and damselflies
12. Scorpionflies
14. Silverfish
16. Sucking lice
17. Leafhoppers, cicadas, scales
18. Beetles
19. Mayflies
20. Chewing lice

DOWN

1. Stoneflies
2. True flies
4. Earwigs
6. Caddisflies
7. Butterflies and moths
8. Springtails and snowfleas
11. Grasshoppers, crickets, katydids
13. Ants, bees, wasps
15. Termites

RECORD OF INSECTS COLLECTED

	COMMON NAME (Tiger Beetle, Stink Bug, etc.)	ORDER	COLLECTED FROM (plant or animal host or other place)	LOCALITY (Island and Estate)	COLLECTION DATE	IMPORTANCE TO MAN			NUMBER OF WINGS			KIND OF MOUTH PARTS		
						Beneficial	Harmful	Doubtful	0	2	4	Chewing	Sucking	Lapping
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
13														
14														
15														
16														
17														

INSECT ORDER LABELS

ANOPLURA Sucking Lice	MECOPTERA Scorpionflies
COLEOPTERA Beetles	NEUROPTERA Lacewings
COLLEMBOLA Springtails	ODONATA Dragonflies Damselflies
DERMAPTERA Earwigs	ORTHOPTERA Grasshoppers, Roaches, Crickets
DIPTERA Flies	PLECOPTERA Stoneflies
EPHEMEROPTERA Mayflies	PSOCOPTERA Book & Bark Lice
HEMIPTERA True Bugs	SIPHONAPTERA Fleas
HOMOPTERA Aphids, Scales Leafhoppers	STREPSIPTERA Twisted-wing parasites
HYMENOPTERA Ants, Bees, Wasps	THYSANOPTERA Thrips
ISOPTERA Termites	THYSANURA Silverfish
LEPIDOPTERA Moths, Butterflies	TRICHOPTERA Caddisflies
MALLOPHAGA Chewing Lice	

Cut out and use these labels in your insect collection.

INSECT IDENTIFICATION LABELS

INSECT KILLING JAR LABEL

Insect Killing Bottle

POISON POISON