# Entomology

## Unit 3

**4-H Manual 90**
**Rep. February 2001**
**For Grade Levels 9-12**

CLEMSON
EXTENSION

This manual was prepared by Donald G. Manley, Extension Entomologist.
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## WELCOME TO ENTOMOLOGY

Dear 4-H'er:

Welcome to the 4-H Entomology Project for teens. In this project, you will be introduced to many ideas about economic entomology. Some may already be known to you. Most, probably, will not. In addition to being interesting, a study of economic entomology may lead to an important and rewarding career.

This unit will first review some of the basic knowledge of insects, including what they look like and how they live. Then you will find a brief key to the major insect orders. The table that follows lists the major insects that are of economic importance in South Carolina and some important information about them. Another basic part of this book is the section on how to control insects and how to keep damage at levels we can tolerate. And finally the last part of this book will help you plan your own 4-H Entomology Project. I hope that this information will give you a better~ understanding of how insects affect our lives and what we can do about them.

Sincerely,

Don Manley

DON MANLEY
Extension Entomologist

## INSECTS AMONG OLDEST LIVING THINGS

Insects are one of the most successful groups of living creatures on earth. They are among the oldest and most numerous of all living things. Some of the reasons for their success are their small size and their tremendous reproductive capabilities. These allow them to adapt to nearly any environment. It has been said that, when all other living things approach extinction, insects will still be thriving.

Because of their great numbers, insects have a big effect upon our lives. Some insects are good. We get honey from the honeybee; we get silk from the silkworm; many of our food plants are pollinated by insects. Likewise, many insects are bad. Some carry diseases; some destroy crops; some destroy our homes.

Since insects are of such great economic importance, it is important to study them and learn how to control the harmful ones while encouraging and promoting those that are beneficial.

## ECONOMIC LOSSES FROM INSECTS

There are several ways in which insects can cause reductions in yield as we attempt to grow our crops. Insects with chewing mouthparts may eat leaves, roots, stems, seeds, fruit, or flowers. Insects with sucking mouthparts may rob plants of their necessary nutrients and thus stunt or reduce plant growth.

In addition to causing reductions in yield, insects may also cause a reduction in quality of plant products. This type of damage includes anything that makes the plant product look bad to the consumer, such as change of color, scarring of fruit, etc.

Problems due to insects do not stop when the crop is harvested. Some insects also cause stored crops to spoil. These insects, if left undisturbed, will complete one life cycle after another on the stored crop until it is destroyed.

Another way in which insects can cause damage to plants is through the transmission of disease organisms, or pathogens, from diseased plants to healthy plants. Insects with sucking mouthparts are most likely to transmit diseases. In other cases, damage caused by insect feeding may provide a place for disease to enter into an otherwise healthy plant.

The annual economic loss from insect damage of crops is staggering. These losses approach $4-5 billion per year in the United States. This does not include the costs for control measures which may, themselves, cost hundreds of millions of dollars per year. And these costs are rapidly rising.

## WHAT IS AN INSECT?

Most of us believe that we can identify an insect if we see one. But how many of us really know what an insect is? What makes an insect "an insect?"

First, let us examine how insects fit into the classification of living things.

Kingdom - - - - Animal
  Phylum - - - - Arthropoda
    Class - - - - Hexapoda
      Order - - - -
        Family - - - -

Genus - - - -
Species - - - -

Fig. 1 Classification of Insects

The preceding diagram shows the basic levels of classification. We already know, of course, that insects are animals (as opposed to plants). Now we see that they belong to the Phylum Arthropoda.

The arthropods are a successful and highly diverse group of animals. The characteristics that they share with one another include segmented bodies covered by a skeleton on the outside of the body. They also have paired, segmented appendages on at least some of the body segments. The word "arthropoda" comes from Greek words meaning "jointed feet." The class Hexapoda (the insects) shares these characteristics with several other classes, many of which we are familiar with, including the Arachnida (spiders, mites, and ticks), Crustacea (crayfish and sowbugs), Chilopoda (centipedes), and Diplopoda (millipedes).

Now, how can we distinguish an insect from the other arthropods? Several characteristics separate the insects from the other arthropods, but the most easily observed are division of the body into three distinct body regions (head, thorax, and abdomen), two pairs of wings (though some groups have a single pair or no wings at all), three pairs of legs (one pair on each of three parts of the thorax), and one pair of segmented antennae.

Once it is known that we are dealing with an insect, further identification can be made. There are 26 orders of insects, of which only about 16-18 are really common. These orders are then divided into numerous families. Classification for the common house fly is shown below.

Kingdom - - - - Animal
Phylum - - - Arthropoda
Class - - - - Hexapoda
Order - - - - Diptera
Family - - - - Muscidae
Genus - - - - Musca
Species - - - - domestica

House fly - - - - Musca domestica Linnaeus

Fig. 2. Classification of House Fly

## KEY TO THE ADULTS OF SOME IMPORTANT ORDERS OF INSECTS

A key is a tool which allows us to identify a group of organisms. In this case, we wish to identify certain types of adult insects to the order level. Each couplet has two parts. The couplet is arranged in the form of "either/or," and the user must make a choice. The user is given directions of where to go next <u>or</u> the answer to the question "what is it?" The following key is highly simplified but can still be used to distinguish between certain groups of adult insects. (Since many of the terms used in the key, as well as in other parts of the book, may be new to you, a glossary has been added to the end of the book for your convenience. The various figures may also assist you in learning some of these terms.)

1. Wings entirely absent ........................................ 2
   At least 1 pair of wings present ........................................ 6

2 (1). Small (1-2 mm); adapted to a parasitic way of life; body either depressed or laterally compressed ........................................ 3
   Not exactly as described above ........................................ 4

3 (2). Body louselike, depressed (flattened dorsoventrally); legs modified for clinging to hairs or feathers; ectoparasites of warmblooded vertebrates (lice: Mallophaga, Anoplura) ........................................ PHTHIRAPTERA
   Body compressed (flattened from side to side); legs adapted for jumping (fleas) ........................................ SIPHONAPTERA

4 (2). Tip of abdomen with 3 long, segmented appendages (2 cerci and a median caudal filament); body covered with small scales (silverfish, bristletails) ........................................ THYSANURA
   Tip of abdomen not having 3 long, segmented appendages ........................................ 5

5 (4). Abdomen strongly constricted at its base and joining the thorax by a narrow stalk (petiole) (ants, velvet ants) ........................................ HYMENOPTERA
   Abdomen not constricted at its base; light-colored; tarsi 4-segmented; cercus usually segmented (termites) ........................................ ISOPTERA

6 (1). Metathoracic wings reduced to small club-shaped organs (halteres) (flies) ........................................ DIPTERA
   Metathoracic wings not reduced as above; 2 pairs of wings (many variations) ........................................ 7

7 (6). Mesothoracic wing horny, leathery, or parchmentlike, at least at base, distinctly different in texture of membrane from the metathoracic wing ........................................ 8
   Mesothoracic wing not horny, leathery, or parchmentlike, usually membranous and transparent, though may be covered with scales or hairs or pigmented; always essentially similar in texture of membrane to metathoracic wing ........................................ 11

8 (7). Mesothoracic wing without distinct veins, may be greatly reduced in length or fused with its mate along a straight line middorsally over the abdomen; metathoracic wing folded transversely or radially and usually tucked under mesothoracic wing when at rest ........................................ 9

Mesothoracic wing with definite veins and, though it may be greatly reduced, never fused; metathoracic wing folded longitudinally ........................................................ 10

9 (8). Cercus present, developed as long movable forcepslike appendage; metathoracic wing folded radially (earwigs). ............................................... DERMAPTERA

Cercus absent, metathoracic wing folded transversely (beetles) ..................... COLEOPTERA

10 (8). Mouthparts haustellate (sucking), composed of greatly elongated bristles enclosed in a jointed labium (true bugs) .............................................. HEMIPTERA

Mouthparts typical mandibulate (chewing); metathoracic wing usually very different from mesothoracic, with a large, longitudinally folding vannal area (grasshoppers, crickets, mantids, walking sticks, etc.) ................ ORTHOPTERA

11(7). Metathoracic wing as long or longer than mesothoracic ....................................................... 12

Metathoracic wing not as long as mesothoracic .................................................................. 13

12(11). Wings incapable of being flexed flat over abdomen, normally held vertically above the body or stretched out horizontally (dragonflies and damselflies) ......... ODONATA

Wings long and slender and of approximately the same size, wings flexed flat over abdomen when at rest (termites) .................................................. ISOPTERA

13 (11). Small (1-2 mm); both pairs of wings long and narrow; reduced venation; wing margins with long, fringed hairs (thrips) .......................................... THYSANOPTERA

Not exactly as above ........................................................................................................ 14

14 (13). Either one or both wings covered with scales or hairs; venation obscured .......................... 15

Neither wing covered with scales or hairs; venation apparent, though may be reduced ...... 16

15 (14). Wings entirely or largely covered with overlapping scales; body similarly covered with scales; mouthparts often a proboscis coiled under the head, sometimes reduced (butterflies and moths) .................................................. LEPIDOPTERA

Not as above, but mesothoracic wings, frequently densely covered with long hairs (caddisflies) ........................................................... TRICHOPTERA

16 (14). Wings net-veined, with many longitudinal veins and at least 12 cross veins; mouthparts not produced into a beak; cercus absent ( lacewings, antlions, snakeflies, alderflies) .................................................... NEUROPTERA

Not as above; venation often greatly reduced; abdomen strongly constricted at base and joining thorax by a narrow stalk (petiole) (ants, bees, wasps) ........................................................................... HYMENOPTERA

## INSECT PARTS

Before progressing any further, it will be important to look at the insect parts that will help us to distinguish between different kinds of insects. As already mentioned, the basic characteristics common to nearly all insects are that the body is divided into 3 distinct regions, there are 3 pairs of legs attached to the middle region or thorax, and 1 pair of antennae attached to the front region or head.

It should be noted that insects do not have skeletons on the insides of their bodies, as we do. Instead, they wear the skeleton on the outside of the body, like a suit of armor. This is known as an exoskeleton. The exoskeleton serves to protect the insect from enemies, regulates the movement of water in and out of the body, serves as a point of muscle attachments, and keeps diseases from entering the body.

Each of the three major body regions has specific functions. A generalized sketch of the regions of the insect body is shown below.

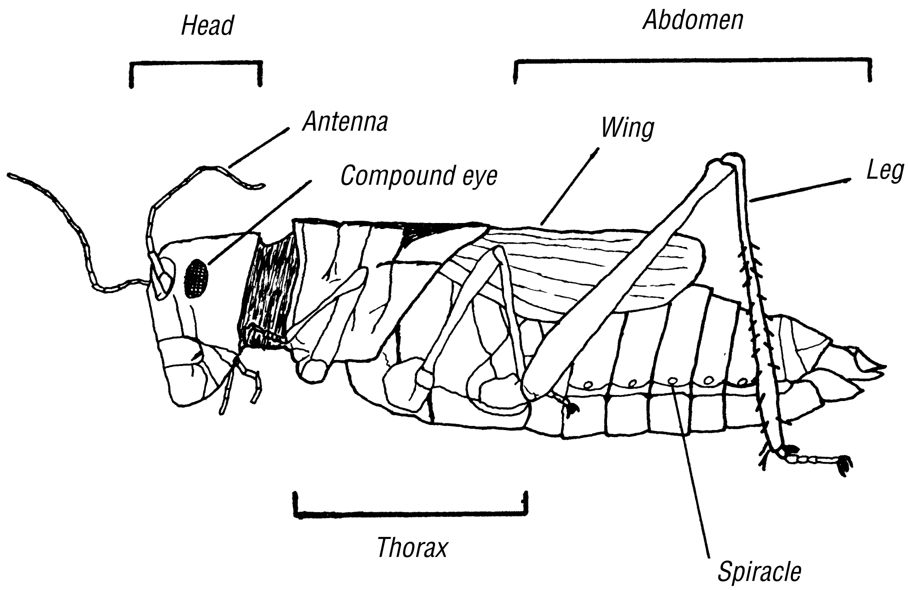



*Figure 1. Generalized Insect Body*

**HEAD**

The head serves as the major sensory headquarters for the insect. On the head one finds the antennae, both the simple and compound eyes, and the mouthparts.

The pair of antennae serve as sensory organs to help the insect detect danger, locate food, find mates, communicate, and find a proper direction of movement. Since there are several different types of antennae, and since the antennae are important in distinguishing between many different kinds of insects, Fig. 2 shows sketches of the more common types of insect antennae.

The eyes are also sense organs. Insects have two different types of eyes. The simple eye or ocellus, is used to detect changes in light intensity. The compound eye is made up of many sensory centers known as ommatidia, and are used to detect movement.

The mouthparts, too, are sense organs. They locate, gather, manipulate, and ingest food.

The most primitive mouthparts, the chewing mouthparts, are comprised of a clypeus, labrum, 2 mandibles, 2 maxillae, and a labium. Although there are many other types of mouthparts, they are all derived from the primitive chewing type, typified by the grasshopper. The chewing mouthparts of the grasshopper may be seen in Fig. 3.

Other types of mouthparts include piercing - sucking (mosquitoes, horse flies, and many bugs), rasping - sucking (thrips), sponging (house flies), siphoning (butterflies and moths), and chewing lapping (honeybees). The basic sucking-type mouthpart is shown in Fig. 4.

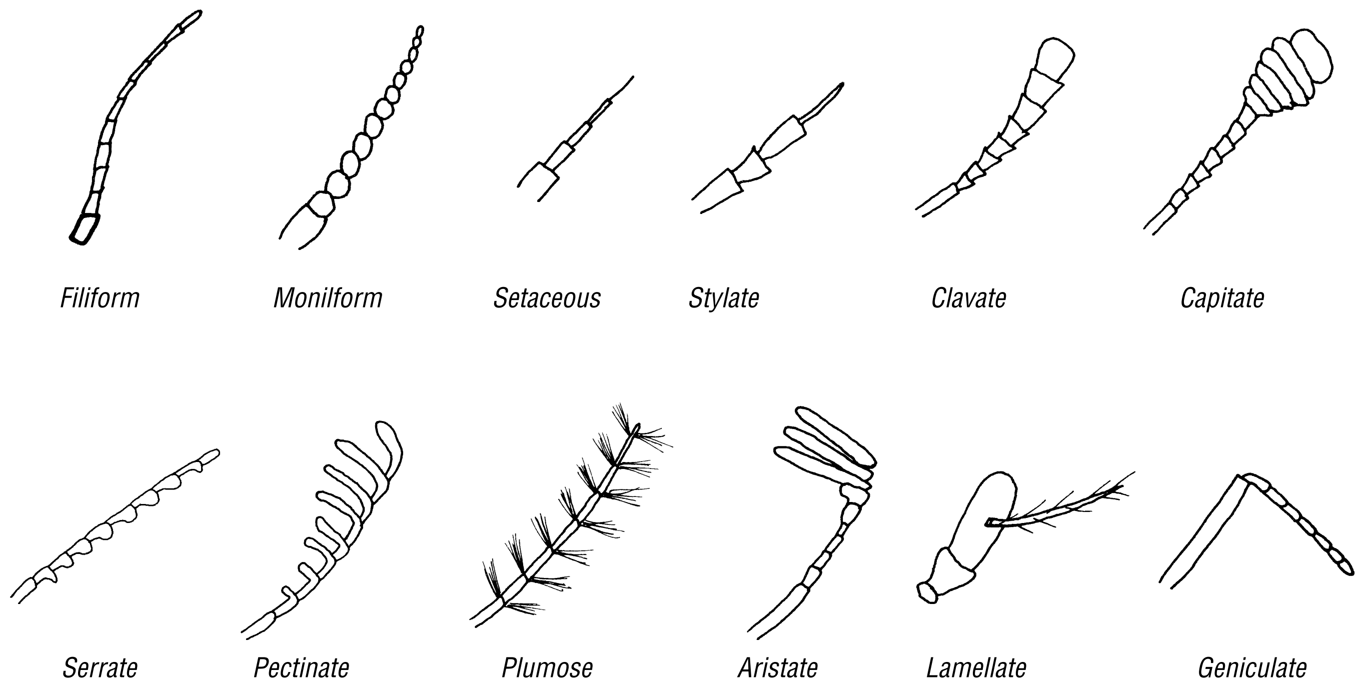



*Fig 2. Common types of insect antennae*

**THORAX**

The second major region of the insect body is the thorax, and locomotion is its major function. The thorax bears the 3 pairs of legs and the wings, and is divided into the prothorax, mesothorax, and metathorax. Each of these segments has one pair of legs. Wings, if present, are found only on the meso- and metathorax.

Insect legs are remarkable structures. They may be used for walking, running, jumping, swimming, grasping prey, digging, and carrying pollen. Most insect legs have 6 basic parts, all independently movable. They are the coxa, trochanter, femur, tibia, tarsus, and pretarsus. Fig. 7 is a diagram of the basic parts of the insect leg.

Among all of the invertebrates, only the insects are winged. Insect wings are important structures that evolved fairly early in insect evolution from lobes on the thorax. Originally, they were used for gliding. This earliest development of primitive wings probably helped the insect to escape enemies. Wings are now also used to travel great distances to find food, mates, lay eggs, and find suitable nesting sites.

As previously mentioned, when two pairs of wings are present, they are attached to the meso- and metathorax. There is a great deal of difference in the size, shape and venation of wings, which makes them important structures in the identification of many insects. A sketch of a generalized insect wing is shown in Fig. 6.

**ABDOMEN**

The third major body region of insects is the abdomen. The visceral functions of the body are carried out in this region, with a major function being reproduction. The abdomen never bears jointed legs, although small, unsegmented prolegs may be present.

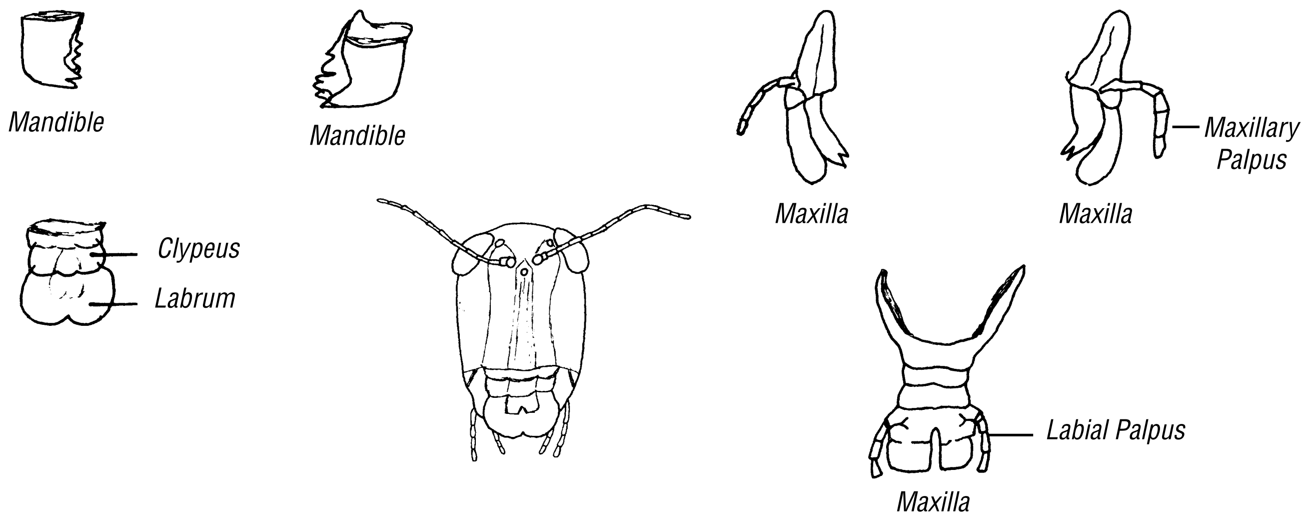



*Fig 3. Chewing mouthparts of a Grasshopper*

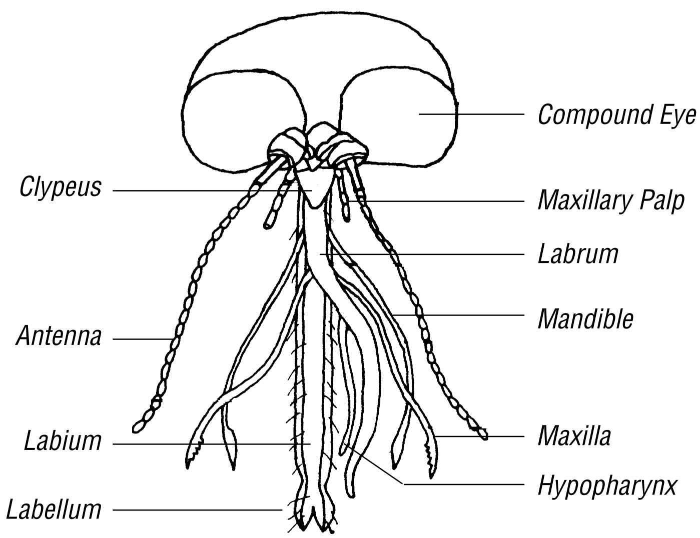



*Fig 4. Sucking mouthparts of a mosquito*

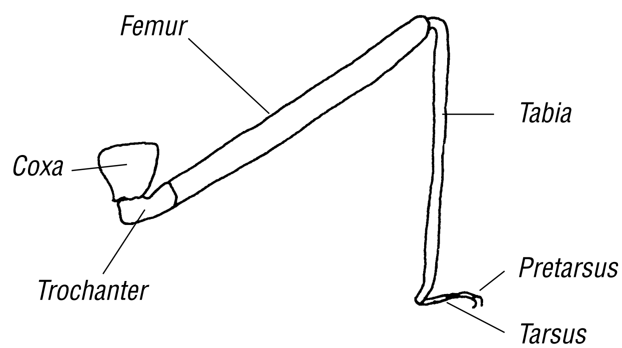
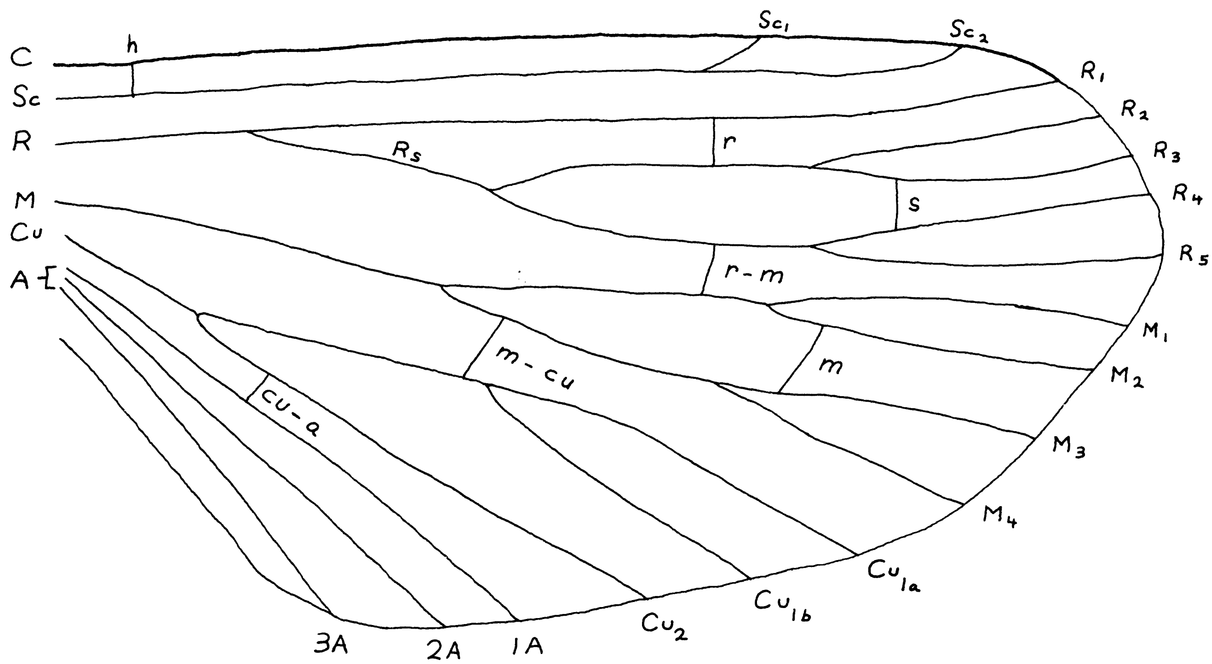



*Fig 5. Parts of the insect leg*

The internal systems of insects are simple. Respiration occurs when air enters small, paired openings known as spiracles and is carried directly to body tissues and cells through tiny tubes called trachae. These tubes branch and become smaller as they go through the body.

Insects do not have blood vessels to move nutrients from one part of the body to another. Instead, nutrients are picked up from the digestive system, pumped forward through a simple heart, and are dumped into the body cavity where they flow backwards, bathing the body tissues as they go. Wastes are removed by the malpighian tubules.




*C - costa*
*Sc - subcosta*
*R - radius*
*Rs - radial sector*
*M - media*
*Cu - cubitus*
*A - anal veins*
*h - humeral*
*r - radial*
*s - sectorial*
*r-m - radio-medial*
*m - medial*
*m-cu - medio-cubital*
*cu-a - cubito-anal*

*Fig 6. Generalized insect wing*

The digestive system is like a tube. It is divided into three regions: the foregut the midgut, and the hindgut. The foregut is further subdivided into the mouth (in some form or another), esophagus, crop, and proventriculus. The midgut, also known as the ventriculus, serves as the insect intestine. The hindgut is divided into the ileum and the rectum. Excretion takes place through malpighian tubules that are attached to the rear part of the ileum.

## INSECT LIFE CYCLES

A life cycle represents the development of an individual from the egg to mature adult to egg(s) of the next generation. Insects possess three different kinds of life cycles. The series of stages through which they pass is known as metamorphosis. The different types of life cycles are ametamorphosis (meaning without metamorphosis), incomplete or gradual metamorphosis, and complete metamorphosis. Some types of insects also give live birth to nymphs, which resemble the adult in general appearance, but lack wings.

An ametamorphic life cycle has 3 stages, the egg, young, and adult. However, the young, from the time that they hatch from the egg, look like the adult. Although they grow and pass through successive stages, they always look the same. The young and adult also live in the same environment and have the same life styles. Insects with this type of life cycle are primitive and wingless and include silverfish and springtails. Fig. 7 shows an example of an ametamorphic life cycle.

Insects that go through incomplete metamorphosis also go through 3 stages, the egg, nymph, and adult. With each successive molt (or stage), the nymph resembles the adult more, as wing pads are formed, which eventually transform into wings. Insects that undergo incomplete metamorphosis include grasshoppers, termites, thrips, earwigs, and true bugs. An example of incomplete metamorphosis is shown in Fig. 8.

The third type of life cycle is complete metamorphosis. Insects having this type of life cycle go through 4 developmental stages, the egg, larva, pupa, and adult. With this type of life cycle the young do NOT resemble the adults in appearance. The larva is a feeding stage; the pupa is a "resting" stage during which the change from larva to adult is made, and the adult is the reproductive stage. Insects going through this type of life cycle include butterflies and moths, beetles, flies, and bees and wasps. An example of a complete life cycle is shown in Fig. 9.

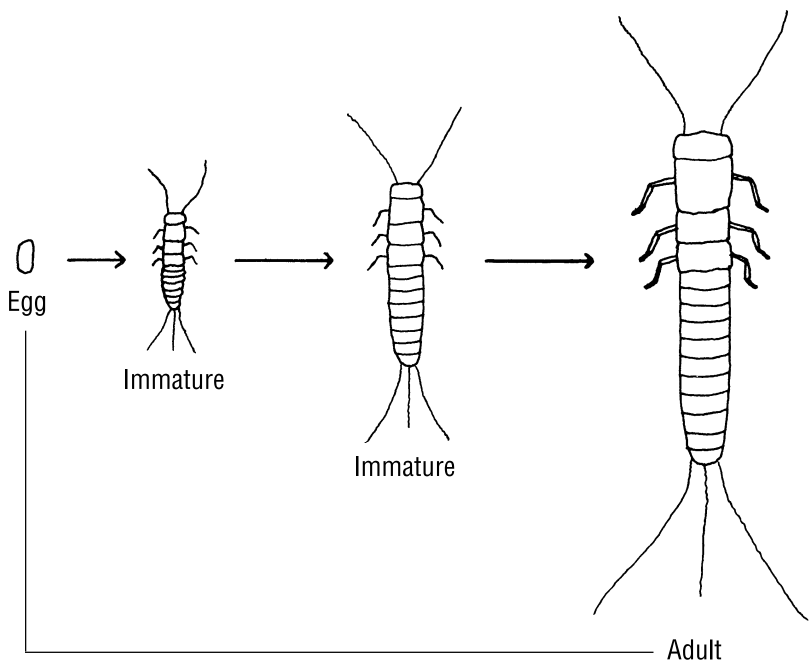



*Fig 7. Silverfish Life Cycle (Ametamorphosis)*

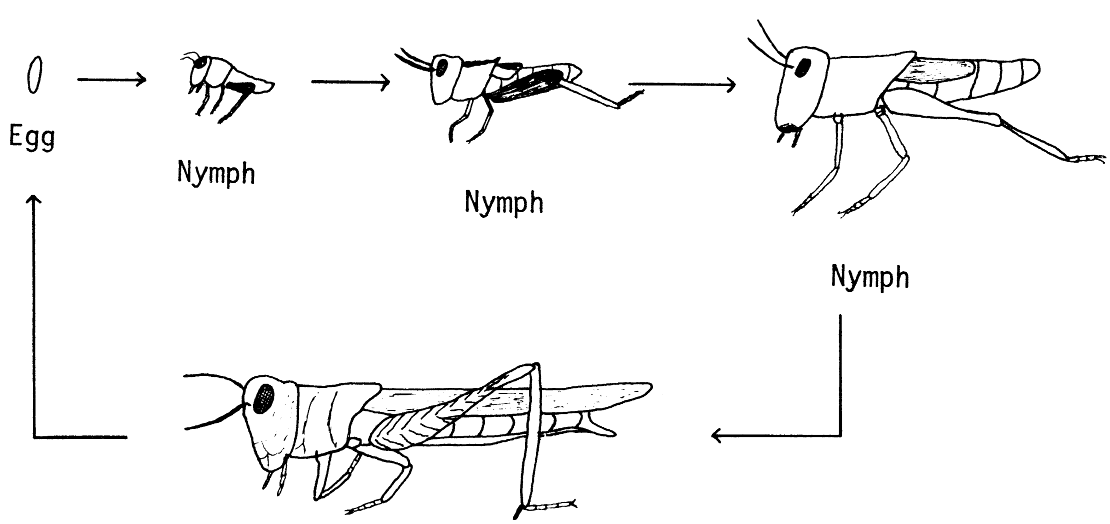



*Fig 8. Grasshopper Life Cycle (Incomplete Metamorphosis)*

## ECONOMIC INSECTS

It has already been noted that insects are a successful group of animals. Also, it has been noted that many of them are capable of doing economic damage to our crops. But that is not the only way that insects can be of economic importance. And, not all insects are of economic importance.

Nearly half of all insects seem to have no effect on people. That is not to say that they do not have any importance in the overall scheme of things, but they do not seem to enter into the life of people.

The insects that do have some effect on our lives are known as economic insects. Although we often think of economic insects as being bad, there are a great many beneficial insects. Many are important in controlling other insects or harmful pests. They are predators and parasites. Many are also important as pollinators of our crops and flowers. Some produce honey and beeswax; others silk. In fact, our whole way of life would probably be very different if it were not for the beneficial insects.

In addition to the pest insects that eat our crops, other pests may affect us in other ways Some carry diseases, such as malaria and the plague, which have drastically affected the history of mankind. Some destroy our dwellings.

Insects are important in both positive and negative ways.. Table 1 is a list of some of the more important economic insects in South Carolina. Also listed are the order to which the insects belong, whether they are harmful or beneficial, their host, the type of mouthparts that they possess, and the type of life cycle through which they pass.

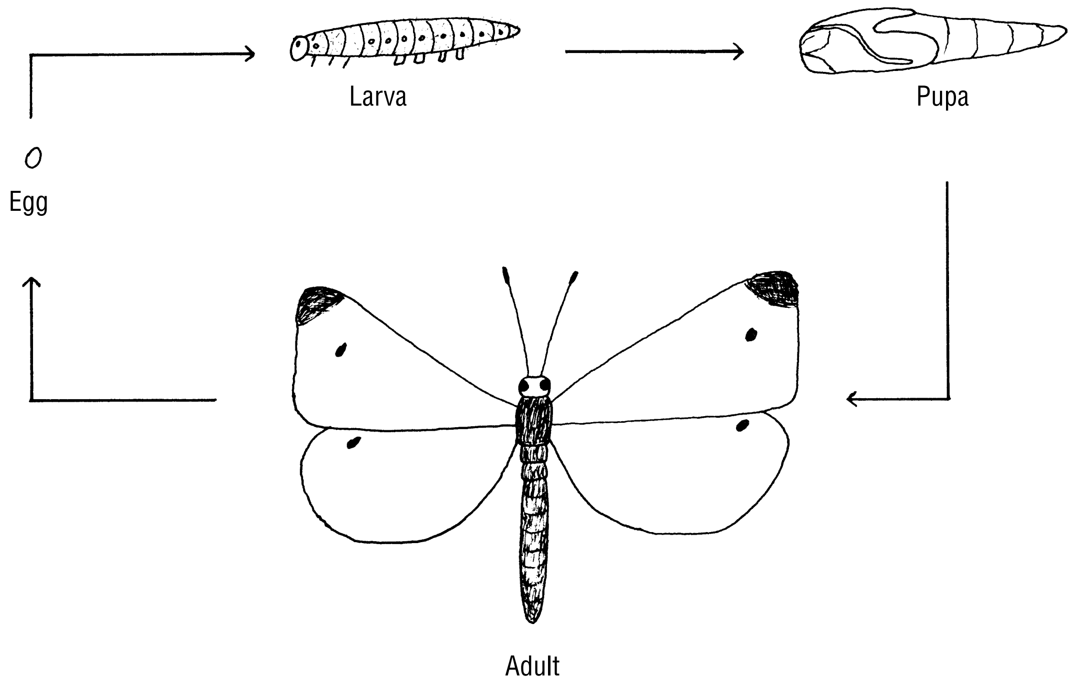



*Fig 9. Butterfly Life Cycle (Complete Metamorphosis)*

**TABLE 1** ECONOMIC INSECTS

| *Insect* | *Order* | *Economic Effects* | *Host (*or economic importance)* | *Mouth Parts (of damaging state)* | *Metamorphosis* |
|---|---|---|---|---|---|
| Ant lions | Neuroptera | Beneficial | Insects | Piercing-Sucking | Complete |
| Assassin bugs | Hemiptera | Beneficial | Insects | Piercing-Sucking | Incomplete |
| Big-eyed bug | Hemiptera | Beneficial | Insects | Piercing-Sucking | Incomplete |
| Billbugs | Coleoptera | Harmful | Corn-Grasses | Chewing | Complete |
| Cattle grub | Diptera | Harmful | Cattle | Chewing | Complete |
| Chewing lice | Mallophaga | Harmful | Birds | Chewing | Incomplete |
| Cockroaches | Orthoptera | Harmful | Household Products | Chewing | Incomplete |
| Corn earworm | Lepidoptera | Harmful | Cotton-Corn | Chewing | Complete |
| Cucumber beetle | Coleoptera | Harmful | Cucumbers-Corn | Chewing | Complete |
| Dragonflies | Odonata | Beneficial | Insects | Chewing | Incomplete |
| European corn borer | Lepidoptera | Harmful | Corn-Many Crops | Chewing | Complete |
| Fall armyworm | Lepidoptera | Harmful | Corn-Grasses | Chewing | Complete |
| Flea beetles | Coleoptera | Harmful | Tobacco-Corn-Potatoes | Chewing | Complete |
| Fleas | Siphonaptera | Harmful | Dogs-Cats | Chewing | Incomplete |
| Green June beetle | Coleoptera | Harmful | Fruit | Chewing | Complete |
| Green peach aphid | Homoptera | Harmful | Tobacco-Fruit Trees | Piercing-Sucking | Incomplete |
| Ground beetles | Coleoptera | Beneficial | Insects | Chewing | Complete |
| Honey bee | Hymenoptera | Beneficial | Honey Production* | Chewing-Lapping | Complete |
| Horn fly | Diptera | Harmful | Cattle | Piercing-Sucking | Complete |
| House fly | Diptera | Harmful | Household Pest | Sponging | Complete |
| Lacewings | Neuroptera | Beneficial | Insects | Chewing | Complete |
| Lady beetles | Coleoptera | Beneficial | Insects | Chewing | Complete |
| Lesser cornstalk borer | Lepidoptera | Harmful | Corn-Peanuts | Chewing | Complete |
| Lesser peachtree borer | Lepidoptera | Harmful | Peach Trees | Chewing | Complete |
| Lygus bugs | Hemiptera | Harmful | Cotton-Alfalfa | Piercing-Sucking | Incomplete |

**Class Arachnida

**TABLE 1** ECONOMIC INSECTS (Contunied)

| *Insect* | *Order* | *Economic Effects* | *Host (*or economic importance)* | *Mouth Parts (of damaging state)* | *Metamorphosis* |
|---|---|---|---|---|---|
| Minute pirate bug | Hemiptera | Beneficial | Insects | Piercing-Sucking | Incomplete |
| Mosquitoes | Diptera | Harmful | Man & Other Animals | Piercing-Sucking | Complete |
| Nabid bugs | Hemiptera | Beneficial | Insects | Piercing-Sucking | Incomplete |
| Peachtree borer | Lepidoptera | Harmful | Peach Trees | Chewing | Complete |
| Pecan weevil | Coleoptera | Harmful | Pecans | Chewing | Complete |
| Plum curculio | Coleoptera | Harmful | Plums-Apples | Chewing | Complete |
| Powderpost beetles | Coleoptera | Harmful | Wood | Chewing | Complete |
| Praying mantids | Orthoptera | Beneficial | Insects | Chewing | Incomplete |
| Red spider mite** | Acarina** | Harmful | Cotton-Alfalfa | Piercing-Sucking | Incomplete |
| Saddleback caterpillar | Lepidoptera | Harmful | Stinging Pest* | Chewing | Complete |
| Scales | Homoptera | Harmful | Trees-Shrubs | Piercing-Sucking | Incomplete |
| Soybean looper | Lepidoptera | Harmful | Soybeans | Chewing | Complete |
| Spittlebugs | Homoptera | Harmful | Grass-Shrubs | Piercing-Sucking | Incomplete |
| Stilt bug | Hemiptera | Beneficial | Insects | Piercing-Sucking | Incomplete |
| Stink bugs | Hemiptera | Harmful | Soybeans-Cotton | Piercing-Sucking | Incomplete |
| Sucking lice | Anoplura | Harmful | Man & Other Mammals | Piercing-Sucking | Incomplete |
| Syrphid fly larvae | Diptera | Beneficial | Insects | Piercing-Sucking | Complete |
| Termites | Isoptera | Harmful | Wood | Chewing | Incomplete |
| Ticks** | Acarina** | Harmful | Dogs & Other Mammals | Piercing-Sucking | Incomplete |
| Tiger beetles | Coleoptera | Beneficial | Insects | Chewing | Complete |
| Three-cornered alfalfa hopper | Homoptera | Harmful | Soybeans-Alfalfa | Piercing-Sucking | Incomplete |
| Tobacco budworm | Lepidoptera | Harmful | Tobacco-Cotton | Chewing | Complete |
| Tobacco hornworm | Lepidoptera | Harmful | Tobacco | Chewing | Complete |
| Velvet ants | Hymenoptera | Harmful | Stinging Pest* | Chewing | Complete |
| Wireworms | Coleoptera | Harmful | Tobacco-Corn | Chewing | Complete |

**Class Arachnida

## INSECT CONTROL

There are many ways to control harmful insects. Cultural, biological, and chemical control methods are probably the most commonly practiced and well known. But a few other methods are also worth mentioning.

### NATURAL CONTROL

Natural control is one of the most overlooked control methods, though it very well may be the most important. Since natural control is natural, we tend to forget its presence unless something happens and we don't have it. Natural control may cause as much as 90-95% of all insect deaths. Unfortunately, the 5-10% that remains may be enough to be economically damaging. Such environmental factors as temperature and moisture availability are important natural control components. Natural biological control is also in this category. It is in no way manipulated by people.

### HOST PLANT RESISTANCE

This is a relatively new area of study which is becoming more important. Some plants have "built-in defenses" which help them resist insects. Some of these include hairs on the plant surface, toughness, bad taste, or lack of some essential nutrients.

### QUARANTINES

Quarantines are a form of legal control. Pests are identified and kept from moving or being carried into areas where they may become pests. This is a useful control method but we do not have the manpower, money, nor facilities for it to work completely.

### PHEROMONES

Pheromones may be placed in the category of chemical control , but will be mentioned separately because they are special. They are chemicals produced by the insects themselves. The most common pheromones are sex attractants. One sex emits a chemical that attracts the opposite sex for the purpose of mating. By isolating and synthesizing many of these chemicals, we are now able to attract some pests to traps or to put so much of the chemical in the area that individuals cannot find mates. By eliminating or reducing mating, we can reduce populations.

### CULTURAL CONTROL

There are several different farming practices that fall into the category of cultural control. The wonderful advantage of cultural control is that these are practices that are, or should be, done anyway. And by doing these practices the grower can get additional insect control as well. In short, cultural control provides inexpensive insect control. For cultural insect control, it is necessary to identify the insects involved and their life cycle. Then, the life cycle can be broken at its weakest link.

One means of cultural control is proper field sanitation. This includes removing plant debris, burning chaff, and disposing of volunteer plants. This eliminates both habitat and food source for many pests, especially caterpillars and beetles that hibernate in the plant debris.

Proper crop rotation is another type of cultural control. Insects with fairly long life cycles and limited mobility that also exhibit strong host preferences may be adequately controlled in this manner. By rotating to a crop that the insects do not like, pest habitat and food source are removed.

Proper tillage operations, such as cultivation or plowing, also help to control pest insects. This may be caused by changing the physical condition of the soil, by burying the insects, by removing the host plants, or by exposing the insects to natural predation or adverse weather conditions.

Date of planting and date of harvest can also reduce losses due to pest insects. Planting and harvesting are planned so that the plants are available a minimum length of time as a host at the time that the insect pest is present and ready to do damage.

One last practice worth mentioning is proper fertilization. Healthy plants that are growing rapidly will often outgrow insect infestations.

**BIOLOGICAL CONTROL**

The importance of natural biological control has already been mentioned. There are three major components of biological control, those being predators, parasites, and pathogens. The difference between natural (biological) control and biological control is that biological control is in some way influenced by people.

The list of animals that are predators of insects is impressive. It includes fish, frogs, lizards, birds, bats, badgers, skunks, some other mammals, and some insects. Those most often used by people in controlling pests are other insects. Lady beetles and praying mantids are predatory insects that have been used for biological control.

There are also some insects that act as parasites of other insects. These include certain flies and wasps.

Just as people have diseases, so do insects. Insects may be affected by certain protozoa, fungi, viruses, and bacteria. Viruses and bacteria are the pathogens most commonly used in biological control efforts.

**CHEMICAL CONTROL**

Chemicals are our last line of defense against insect pests. When all other efforts fail, we must use chemicals. Chemicals that are used to kill insects are called insecticides. Insecticides are seldom used full strength. They are usually diluted to make them safer and easier to use. The most commonly used insecticide formulations are dusts, granules, fumigants, and sprays.

Insecticides are generally classified in one of two different ways. The first is according to the mode of ~ (how the insecticide gets into the insect body). The second is the chemical composition of the insecticide (of what it is made).

Mode of Entry. Materials that are ingested by insects as they feed are called stomach poisons. They kill primarily by action on the digestive system. These work best against leaf-feeding insects.

Contact poisons are absorbed through the insect's skin. These poisons act upon the insect nervous system when it comes in direct contact with the insecticide.

Poisons that enter through the insect's breathing system are called fumigants. Fumigants are especially useful in closed containers, such as grain bins.

Systemic poisons are ingested, but differ from stomach poisons in that they are applied to the plants. The poison is absorbed into the plant and transferred throughout it. When it is eaten by the insect, the insect ingests the poison and is killed.

Chemical Composition. There are three generally recognized categories of insecticides. The first of these is inorganic compounds. Many of the earlier insecticides were inorganic compounds and include sulfur, lime-sulfur, lead arsenate, calcium arsenate, and cryolite. They are generally effective only as stomach poisons and are therefore effective primarily against insects with chewing mouthparts.

The second group is composed of natural organic compounds. Although these compounds are chiefly contact poisons, they may act as stomach poisons and fumigants as well. They are used primarily against sucking insects. Examples include nicotine sulfate, rotenone, pyrethrum, and sabadilla.

The final group is the synthetic organic compounds. Like the natural organics, these materials act primarily as contact poisons, though they may act as stomach poisons, fumigants, or even systemics. Table 2 is a list of some of the synthetic organic insecticides.

**TABLE 2** SOME SYNTHETIC ORGANIC INSECTICIDES

| Category | Type of Activity | Examples |
|---|---|---|
| Chlorinated hydrocarbons | Contact and stomach; some fumigant action | DDT, BHC, lindane, toxaphene, aldrin, dieldrin, endrin, heptachlor or |
| Phosphorus compounds | Contact, stomach, and systemic | Parathion, methyl parathion, malathion, Guthion, diazinon |
| Systemic phosphorus compounds | Systemic and contact; some fumigant action | Di-Syston, Systox, Thimet |
| Carbamates | Contact and stomach; some systemic | Sevin, methomyl, Temik, Furadan |
| Fumigants | Fumigant action | Ethylene dichloride, ethylene dibromide, methyl bromide |

## THE PEST MANAGEMENT CONCEPT

Just because insects are present in a field does not necessarily mean that an insecticide should be used. The insects may be beneficial. Or, they may be causing less damage than an insecticide application would cost. The act of looking over the situation before making a decision is called pest management. Integrated pest management means using ALL available information and methods to keep pest populations at or below levels at which they can be economically tolerated.

There are four basic components of a pest management system. The first component is natural control. As mentioned earlier, a large percentage of pest insects die of natural causes. Use of insecticides when they are not needed may reduce populations of predators and parasites and actually create more of a problem than originally existed. Natural control should be used for as long as practical.

The second basic component of pest management is knowledge of the biology and ecology of the pest(s). By knowing what pests are present and their life cycles, it will be possible to identify the weakest stage(s) of the life cycle and to use control strategies toward that weakness.

The third component is scouting. A scout is a person who goes into the fields and counts what is there. It has been said that "scouting is the key" to pest management. Scouts are able to identify the pest(s), the population sizes with which we are dealing, and numbers of beneficial insects that are present. It may also be important to identify the stage of plant development. Then we can determine how susceptible the plant is to attack by insects or the degree of damage that might result.

Finally, we must have sound economic thresholds. An economic threshold is the point at which something must be done to prevent economic losses from pests; it is the point where loss by insect damage is equal to the cost of controlling the pest. We should not allow insect pest populations to surpass economic thresholds.

By using these components in a good pest management program, we can reduce the number of unneeded applications of insecticides to crops. In so doing we can reduce the levels of insecticides in the environment, slow the rate of resistance by insects to insecticides, and maximize profits by minimizing production costs of insect control.

## PESTICIDE SAFETY

Pesticides are poisons! Their sole purpose is to kill things! By their very nature, pesticides are dangerous to people, to other animals, and sometimes to plants. Pesticides are dangerous when carelessly or improperly used. When proper concentrations, rates, application methods, and safety recommendations are followed, they can be used safely. The following information is taken from Clemson University's Pest Management Handbook.

When the following steps are observed, misuse will seldom if ever occur:

1. Properly identify the pest problem and determine what pesticide to use. Seek an expert's advice if in doubt.

2. Apply the recommended material according to the labeled instructions.

3. Store pesticides in their original labeled containers in a locked storage area out of the reach of children, pets, and livestock.

4. Dispose of empty containers promptly, safely, and according to the law.

General Precautions

Read the manufacturer's label carefully and completely, paying particular attention to the precautions and antidotes.

- Wear clean protective clothing and equipment as specified on the label.

- Remove clothes after using poisonous chemicals and bathe with plenty of soap and water. Wash work clothes before using again.

- Avoid ingesting or inhaling pesticides.

- Insofar as possible, avoid contact of the insecticides with the skin. Make a habit of washing your hands often. Be sure to wash your hands before eating, drinking, or smoking.

- If concentrates or highly toxic pesticides are spilled on the skin or clothing, remove the clothing at once and wash the skin thoroughly with soap and water.

- Always mix pesticides in an open area where ventilation is adequate; never mix pesticides in an enclosed area.

- Use only recommended materials at recommended rates and by recommended methods of application. Never use a pesticide for a purpose not specifically stated on the label.

- Notify nearby beekeepers before applying insecticides.

- Never use sprayers with leaking hoses or connections.

- Never use the hands and arms to stir pesticides or to reach into a container of pesticides to retrieve tools or other items dropped into them.

- Never allow drift onto neighboring fields, especially pasture and forage crops or fields containing produce ready to harvest.

- Never contaminate fish ponds, streams, or lakes.

- When application equipment is not being used, keep it in an area where children and livestock cannot get to it. Wash spray equipment after each use to avoid hazardous accumulation.

- Store pesticides in the original labeled containers away from food, feed, or medicine, and out of reach of children, pets, and livestock.

- Never guess at what is in the pesticide container. If the label has been damaged or removed, discard the entire container with its contents in an approved landfill.

- Dispose of empty containers promptly and safely, placing them in an approved landfill after triple rinsing.

- Call a doctor or get the patient to a hospital immediately if the symptoms of poisoning occur during or shortly after spraying or dusting. Carry the pesticide label or labeled containers with you.

- Never spray directly into the wind or directly overhead.

Call your Poison Control Centers for detailed information on antidotes, etc.
A listing of S. C. Poison Control Centers follows:

**SOUTH CAROLINA POISON CONTROL CENTER**

| City | Name and Address | Telephone | Director |
|---|---|---|---|
| Charleston | Pesticide Control Information<br>for Applicators and Dealers<br>for Health Professionals | 1-800-922-0193/0194<br>792-4201 | Dr. Harold Trammell |
| | Medical University Hospital of SC<br>55 Doughty Street | | |
| Columbia | Palmetto Poison Center*<br>College of Pharmacy<br>University of South Carolina 29208 | 765-7359<br>Toll Free:<br>1-800-922-1117 | Brooks Metts |

*Information only—24 hours—no treatment facilities.
Charleston offers 24-hour availability with treatment in Emergency Room. Information may also be obtained by contacting your nearest hospital.

## 4-H ECONOMIC ENTOMOLOGY PROJECTS

We have now come to the end of this 4-H Entomology booklet and to the beginning of 4-H economic entomology. The burden now shifts to you, the 4-H'er. As mentioned earlier in this booklet, the field of economic entomology, in addition to being interesting, is one in which career opportunities are plentiful.

The opportunities for self-study through 4-H project work in economic entomology are equally plentiful. You will be limited only by the boundaries of your own imagination. Some suggestions and ideas for planning your own self-study in Entomology can be found on the following page. These are only some suggestions. This list is not exclusive. After looking over these suggestions, use the "planning sheet" and "evaluation sheet" as you proceed with your own self-study in Entomology. Good luck, and HAVE FUN.

## IDEAS FOR PLANNING YOUR OWN SELF-STUDY IN ENTOMOLOGY

| WHAT YOU MIGHT WANT TO LEARN IN YOUR 4-H PROJECT | HOW YOU COULD LEARN THESE THINGS | WHO COULD HELP |
|---|---|---|
| More about: insects<br>insect evolution<br>insect parts<br>insect life cycles | -Talk to people who know about insects<br>-Read books about insects<br>-Dissect an insect<br>-Study a host/parasite life cycle<br>-Be a teen leader | Entomologists<br>Librarians<br>Biology teachers |
| About economic insects | -Talk to a farmer<br>-Talk to a nurseryman<br>-Talk to a beekeeper<br>-Make an economic insect collection<br>-Talk to a pest control operator<br>-Make observations of crops; gardens | Farmer or gardner<br>County agent<br>Entomologists<br>Pest control operator<br>Beekeepers<br>Nurseryman |
| About insect control | -Talk to an insect scout<br>-Talk to a nurseryman<br>-Talk to a farmer<br>-Talk to a pest control operator<br>-Talk to parents about insect control around the home | Insect scouts<br>Nurseryman<br>Farmer or gardner<br>Pest control operator<br>Parents<br>County agent |
| About pest management | -Study economic thresholds<br>-Talk to entomologists<br>-Talk to insect scouts<br>-Study pest control techniques | Entomologists<br>Insect scouts |
| About pesticide safety | -Study labels on pesticide containers<br>-Read <u>Pest Management Handbook</u><br>-Attend pesticide safety school | Pesticide dealer<br>Clemson publication<br>County agent |
| About careers in Entomology | -Talk to: farmers<br>entomologists<br>pesticide dealers<br>researchers<br>field crop scouts<br>county agents<br>pest control operators<br>beekeepers | |

## PLANNING SHEET

PLAN FOR MY SELF-STUDY IN ENTOMOLOGY

1. List one or two things that you want to learn more about through 4-H Entomology. (You will find some ideas on the preceding page, or you can make up your own).

   a). ____________________

   ____________________

   b). ____________________

   ____________________

2. For each thing that you have listed above, describe how you will learn about it:

   a). ____________________

   ____________________

   b). ____________________

   ____________________

3. Name some people you will ask to help you learn the things you have listed. How can they help?

   ____________________

   ____________________

   ____________________

   ____________________

   ____________________

## EVALUATION SHEET

EVALUATION OF MY SELF-STUDY IN ENTOMOLOGY

CHECK ONE:

_____ I completed my plan with no changes.

_____ I did not complete my plan because

______________________________________________

______________________________________________

______________________________________________

______________________________________________

_____ I completed my plan with the following changes (list):

______________________________________________

______________________________________________

______________________________________________

______________________________________________

The self-study that I planned and carried out in Entomology was valuable to me because:

______________________________________________

______________________________________________

______________________________________________

______________________________________________

______________________________________________

______________________________________________

## GLOSSARY

**Abdomen** - the third or tail section of the three body parts into which an insect is divided.

**Antenna(s)** - the paired sense organs found, one on each side, on an insect's head.

**Appendage** - any part or piece attached by a joint to the main body.

**Cercus (cerci)** - an appendage (usually paired) of the tenth abdominal segment.

**Clypeus** - a part of the head of an insect, to which the labrum is attached.

**Compressed** - flattened from side-to-side.

**Depressed** - flattened from top-to-bottom.

**Dorsoventral** - from top (dorsal) to bottom (ventral).

**Ectoparasite** - a parasite that lives on the outside of its host's body (for example, fleas).

**Exoskeleton** - the outside skeleton in insects.

**Halter(es)** - the balancers found on each side of the thorax of flies that represent the hind pair of wings.

**Haustellate** - formed for sucking.

**Head** - the first or front section of the three body parts into which an insect is divided.

**Host** - that which is fed upon.

**Invertebrate** - an animal without a backbone.

**Labium** - the lower lip or floor of the mouth of an insect's mouthparts. In insects with sucking mouthparts, the labium may form the tube in which the other mouthparts lie.

**Labrum** - the upper lip or roof of the mouth of an insect's mouthparts.

**Larva(e)** - a stage in some insects' life cycle that follows the egg and that does not resemble the adult in appearance or habits.

**Lateral** - relating to, or pertaining to, the side.

**Longitudinal** - in the direction of the long axis; from front to back.

**Malpighian tubule(s)** - long, slender tubes that serve as an insect's urinary system and which empty into the hind intestine.

**Mandible(s)** - the first pair of insect jaws.

**Maxilla(e)** - the second pair of insect jaws.

**Mesothorax** - the second, or middle, segment of an insect thorax. This segment bears the second or middle pair of legs and the first pair of wings.

**Metamorphosis** - the series of changes through which an insect passes in its growth from egg to adult to eggs of the next generation; the process of an insect life cycle.

**Metathorax** - the third, and last, segment of an insect thorax. This segment bears the third pair of legs and the second pair of wings.

**Nymph** - a stage in some insects' life cycle that follows the egg and which resembles the adult in appearance and habits except that it does not have fully developed wings or reproductive organs.

**Ocellus (ocelli)** - a simple eye of insects that contains only a single bead-like lens.

**Parasite** - any animal that lives in, or on, or at the expense of another

**Pathogen** - disease organism.

**Petiole** - the slender stem or stalk between the thorax and abdomen in certain insects.
**Predator** - an animal that preys on, or eats, others.
**Proboscis** - any extended mouth structure (for example, the tongue of butterflies and moths).
**Prothorax** - the first, or front, segment of an insect thorax. This segment bears the front pair of legs but no wings.
**Pupa(e)** - the "resting" stage of insects with complete metamorphosis; the intermediate stage between the larva and the adult.
**Radial** - arranged like rays starting from a common center; like a fan.
**Spiracle(s)** - a breathing pore; an opening on the side of an insect body that allows air to enter the tracheae.
**Thorax** - the second, or middle, section of the three body parts into which an insect is divided.
**Trachea(e)** - an internal elastic air tube within the insect body; the basic component of the insect respiratory system.
**Transverse** - across; cutting the longitudinal axis& at right angles.
**Vertebrate** - an animal with a backbone.

## DID YOU KNOW?

- Insects are not something to avoid. Collecting insects is FUN.'
- ALL bugs are insects, but only SOME insects are bugs.
- There are more different kinds of insects than of all other living things COMBINED.
- Far more insects are good than bad.
- There are NO poisonous insects (though some people may have an allergic reaction to some insect bites or stings).
- Insects have been on earth for about 350 MILLION years.
- Some prehistoric insects (dragonflies) had wingspans of 2 to 3 feet.
- Some adult insects may live for no longer than a few minutes under natural conditions.
- Some beetles living today may be more than 6 inches long.
- Some insects are so small that they cannot be seen except through a microscope.

4-H Club Pledge

I pledge:

My Head to clearer thinking,
My Heart to greater loyalty,
My Hands to larger service, and
My Health to better living for
My Club, My Community, My Country,
and My World.