CHAPTER 2

PESTS AND INTEGRATED PEST MANAGEMENT (IPM)

LEARNING OBJECTIVES:

After you complete your study of this chapter, you should be able to:

- Explain the importance of correctly identifying pests.
- Explain the importance of understanding the life cycles and habits of pests.
- Name two physical characteristics that all insects have in common.
- List the four primary types of insect mouthparts and give an example of an insect that has each type.
- Define "metamorphosis".
- List other types of pests that resemble insects or cause similar damage.
- Understand how endoparasites and ectoparasites are pests of animals.
- Explain the factors you should consider when deciding whether control of a pest is necessary.
- Discuss the five steps of an integrated pest management program.
- List and give an example of techniques used in pest management.

Accurately identifying pests is extremely important because different pests respond to different types of management tactics. Failure to identify the pest properly may result in wasted time, money, chemicals and effort. Each species of plant and animal can be identified by its scientific name. Although most plants and animals also have common names, the scientific naming system is universal — it assigns each organism one name to be used regardless of where it is found. This naming system categorizes animals based on their similarities: organisms with common characteristics are placed into large groups, then subdivided into smaller groups and finally given unique names.

In this chapter, you will learn to identify common characteristics of insect and insect-like pests of small animals. Examples of the types of animal injury caused by these pests will be discussed.

INSECTS

All insects and related animals such as mites and ticks belong to a large group (phylum) called Arthropoda. Members of this group are called arthropods and have segmented bodies; segmented appendages, some of which are modified for feeding; and a hard exoskeleton (exterior skeleton). On the basis of common characteristics, arthropods are separated into smaller groups called classes. The common classes of arthropods are Insecta, Arachnida, Crustacea, Chilopoda and Diplopoda. Most arthropod pests are insects or arachnids (mites or ticks from the class Arachnida).

Insects have unique external features and undergo developmental processes unlike those of other organisms in the animal kingdom. Correct identification of pests and a knowledge of their characteristics, development and behavior are keys to effective pest control.

Physical Characteristics of Insects

The external characteristics of insect adults that set them apart from other animals are bodies with three regions — head, thorax, and abdomen — and three pairs of jointed legs.

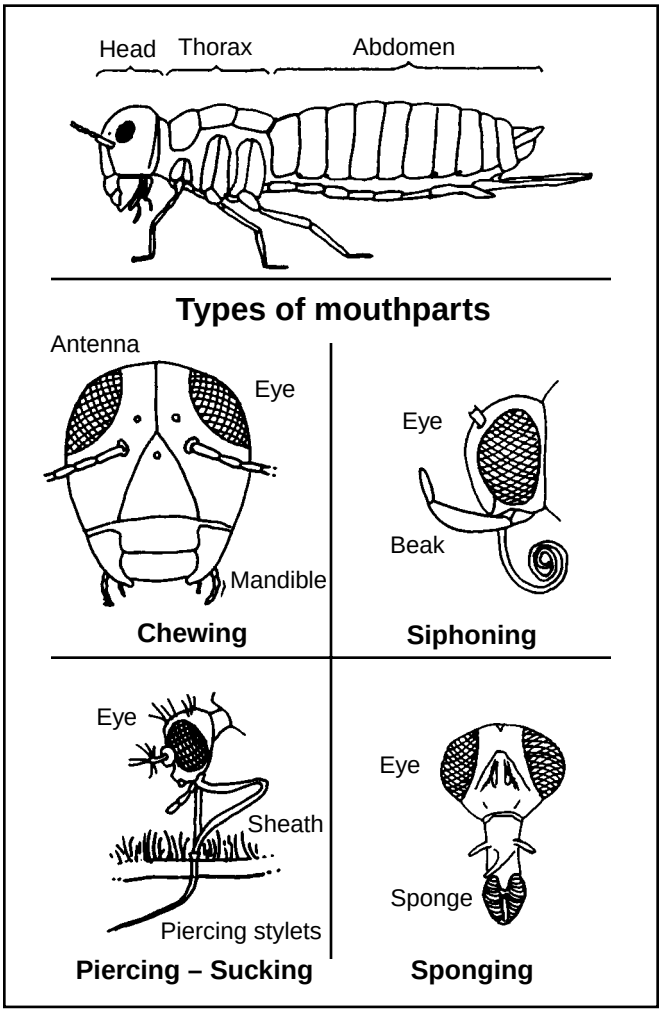
1. Head. The head contains one pair of antennae, eyes and mouthparts. Antennae contain many sensory receptors for smell, wind and temperature. The four general types of mouthparts are chewing, piercing-sucking, sponging and siphoning.

Chewing mouthparts have toothed jaws that bite and tear food. Cockroaches, grasshoppers, ants and beetles have chewing mouthparts.

Piercing-sucking mouthparts consist of a long, slender tube that penetrates plant or animal tissue to suck out fluids. True bugs, aphids, mosquitoes and sucking lice have this mouth type.

Sponging mouthparts are tubular, tongue-like structures with a spongy tip to suck up liquids. This type of mouthpart is found on flies.

Siphoning mouthparts form a long tube for sucking nectar. Butterflies and moths have this type of mouth.



2. Thorax. The thorax consists of three segments with one pair of jointed legs per segment. If one pair of wings is present, they will be on the second segment. If two pairs of wings are present, they will be on segments two and three and are called forewings and hindwings. The forewings are modified in some insect groups. Beetles have shell-like forewings; grasshoppers have leathery forewings. Forewings of true bugs are part membranous, while forewings of moths and butterflies are membranous but covered with scales. Most hindwings of insects are membranous.

3. The abdomen has as many as 11 segments, though eight or fewer visible segments are common.

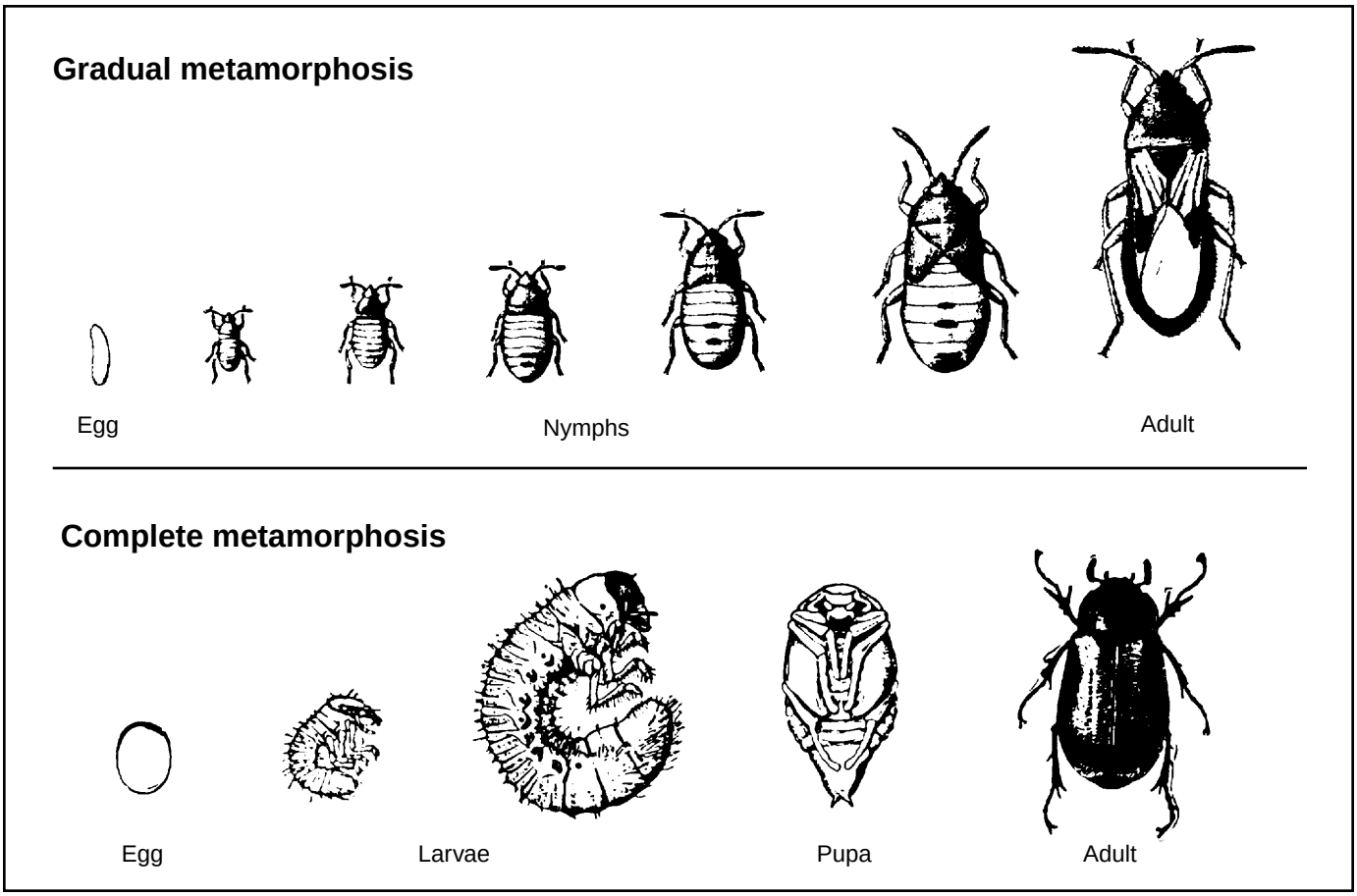
Insect Development and Metamorphosis

The series of events from egg to adult is called the insect's **life cycle.** Life cycles vary among species and knowledge of the life cycle is absolutely essential to apply correct and timely pest management procedures.

Most insect reproduction is sexual — that is, a female's egg cell develops only after union with the male's sperm cell. The females of many insect species lay eggs. Some insects have special modes of reproduction such as those that develop from unfertilized eggs. The number of eggs produced by females varies from one egg to many thousands for some social insects.

A newly hatched insect differs in size and often in form from the parents. The change that takes place before the young insect assumes the adult form is called **metamorphosis.** The degree of change varies widely. In some insects, it is slight and gradual; in others, it is abrupt and complete. Insects fall into three groups according to degree of metamorphosis:

- **No metamorphosis**. Body proportions and internal organs of these primitive insects remain similar after each molt. Examples: Collembola (springtails) and Thysanura (silverfish).
- **Gradual metamorphosis.** Changes are slight and gradual. The young or nymphs resemble the adults and feed in the same habitat, and wing development is external. Example: grasshoppers.
- **Complete metamorphosis.** Drastic alterations occur as insects grow through the egg, larval, pupal (an inactive, resting stage) and adult stages. This classification includes the majority of insects, such as flies and fleas.



MITES AND TICKS

Mites and ticks belong to the class **Arachnida.** Though they are relatives of spiders, scorpions and daddy longlegs, mites and ticks belong to their own scientific grouping within this class, called the **Acari** (a-CAR-ee). Two features distinguish mites and ticks from insects. Mites and ticks have:

1. **Four pairs of legs** (insects have three pairs).

2. **Two major body units**—the cephalothorax and abdomen (insects have three body units —- head, thorax and abdomen).

Unlike insects, ticks and mites do not have segmented abdomens.

Mite Development

The generalized mite life cycle begins when mites mate and the females lay eggs. The eggs hatch and six-legged **larvae** emerge. These larvae feed and molt to become eight-legged **nymphs.** Later, after feeding, the nymphs molt and become **adult male** or **female** mites. This entire life cycle can take as little as eight days to as long as four weeks, depending on the species of mite and the temperature and humidity.

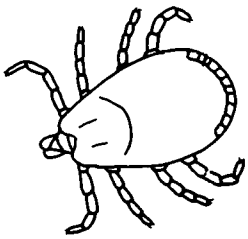
Tick Development

Tick development starts with the egg stage, followed by six-legged larvae, eight-legged nymphs and eight-legged adults. Hard ticks have only one nymphal instar (that is, one molt to the nymph stage, followed by a molt to the adult stage). Soft ticks may go through up to seven nymphal molts, depending on the species of tick and its life cycle.

DAMAGE CAUSED BY INSECTS AND INSECT-LIKE PESTS

Insects, ticks and mites injure animals, plants and structures in a variety of ways. The damage or discomfort of the host often provides clues to the identity of the pest, as well as the fate of the host (the organism the insect is on). For example, hair loss (alopecia) under the eyes and near or on the ears of puppies may be the first recognizable symptoms of demodectic mange mites. Consult with a veterinarian for correct diagnosis — sampling for burrowing mites requires a skin scraping. Scratching may be symptoms of fleas or ticks, and head shaking may indicate the presence of ear mites.

Animals can be troubled with pests on their bodies, in their bodies or in their environment. Many arthropods (spiders, mites and ticks) have evolved to live in close association with animals, and some have become true pests of animals. Arthropods may use animals as hosts for food, hosts to lay their eggs in, sites for resting and for other uses.



Tick

Arthropods may be endo- or ectoparasites. **Ectoparasites** live on the outside of the body of the host (animal the pest is associated with) more or less in permanent association. Fleas are an example of ectoparasites. They are pests of our pet dogs and cats. All the many species of fleas are ectoparasites on the bodies of wild or domestic animals. Even human beings can have ectoparasites such as head lice, follicle mites and crab lice. Arthropod pests that invade internal parts of the body are called **endoparasites.** Roundworms and hookworms are endoparasites.

Arthropods can be pests of animals in several ways:

- They may **invade and infest** the skin and tissues of animals, causing direct damage such as hot spots (moist eczema) and weakness.
- Arthropods can cause **blood loss** and tissue damage by **blood feeding.**
- Infestation and blood feeding can open the skin to **secondary infection** by bacteria.
- Blood-feeding can also cause **anemia** (weakness, lack of vitality due to blood loss or iron deficiency).
- Some arthropods have **venomous bites and stings** or have body secretions that cause the animal to have **toxic or allergic reactions.**

The direct damage and inflammatory reaction of animal skin to arthropod bites or body secretions is called **dermatitis**. Some animals develop extreme allergies to insect bites, stings or secretions. This kind of allergic reaction is called **hypersensitivity.** Veterinarians should be consulted to diagnose the cause of dermatitis. Once the cause is identified, the licensed veterinary technician, animal groomer, kennel manager or other trained animal pesticide applicator can be involved in treating the animal and controlling the problem.

Animals can be greatly **annoyed** by the presence and activity of certain arthropods. For example, cattle will bunch up and put their lowered heads together to seek relief when "fly strike" is severe. Dogs can be greatly bothered by biting fly attacks to the ears.

Many arthropods **transmit disease-causing agents** to animals, either by contact, body secretions or biting. For example, mosquitoes transmit viruses that cause encephalitis (inflammation of the brain) in horses and black-legged ticks can transmit Lyme disease among animals and humans.

The arthropod pests of animals fit into many groups or taxonomic categories. Table 2.1 lists these groups and gives both common and scientific names with an example of each group. The following chapters discuss in detail how each of these groups affects agricultural and companion animals, as well as how to detect, identify and manage the arthropod pests.

Among these arthropods are **arachnids** (the class Arachnida), including mites, ticks and poisonous spiders. Spiders will not be considered further in this manual, because they are not normally pests of domesticated animals.

Among the insects (the class Insecta), the important pests of animals belong in the following groups:

- Biting and non-biting flies.
- Invasive flies (flies whose maggots invade and infest animal flesh).
- Chewing and sucking lice.
- Fleas.

Stinging wasps and ants sometimes bother companion animals but will not be discussed in this manual.

The "key" at the end of this chapter, is an illustrated guide to identifying arthropods of medical and veterinary importance. To use the key, read the choices given by each number and select the choice that best describes the arthropod specimen you are trying to identify. Some knowledge of the body structure and life cycles of insects, ticks and mites is required to use this identification key. So, it is an educational tool as well as an identification guide. Give it a try! You will not be required to use the key to answer questions on the Michigan Department of Agriculture pesticide certification exam. You will need to be able to identify the general appearance of arthropod pests of animals by looking at a drawing similar to those found in later chapters, i.e., the difference between a mite and a flea.

Table 2.1 Major groups of arthropods affecting animal health.

Group	Scientific Name	Example
Class Arachnida		
Mites	Order Acari	*Sarcoptes scabei* Scabies or itch mite
Ticks	Order Acari Class Arachnida	*Dermacentor variabilis* American dog tick
Class Insecta		
Biting flies	Order Diptera (Mosquitos, Black flies, Biting midges, Deer and horse flies,Stable fly, horn fly, sheep ked)	*Stomoxys calcitrans* Stable fly, dog fly
Nonbiting flies	Order Diptera (Face fly, house fly, eye nats, other filth flies)	*Musca domestica*
Fleas	Order Siponaptera	*Ctenocephalides felis* Cat flea
Chewing lice	Order Mallophaga	*Trichodectes canis* Dog chewing louse
Sucking lice	Order Anoplura	*Linognathus setosus* Dog sucking louse

INTEGRATED PEST MANAGEMENT FOR ANIMAL HEALTH

Agricultural animals (those used for production of food and fiber—livestock) and **companion animals** (pets such as dogs and cats) may be affected by arthropod pests. These pests must often be managed, controlled or prevented. Managing arthropod pests of animals can improve the living conditions, health and well-being of animals and humans. The principles of **integrated pest management (IPM)** apply to the operational practice of pest control for animals, whether the pests are actually on the animals or in the environment the animals occupy. IPM can be defined as "the use of all available tactics or strategies to manage pests so that an acceptable yield and quality can be achieved economically with the least disruption to the environment."

Establishing an IPM program for pests of animals follows the same five steps outlined for managing any pest (weeds, diseases, etc.).

1. Detection

The first step in an IPM program is pest detection. Detection requires thorough and regular monitoring of animals for pest infestations or other signs and symptoms that indicate a pest is present on the animal or in the environment where animals live. Observing an animal's body, feces, living quarters, bedding, surroundings and behavior will help you discover potential pest problems. For example, if a pet dog is scratching or chewing more than usual, this behavior may cause the owner to suspect fleas and, therefore, to inspect the dog's body to see if fleas are present. More severe conditions will require a veterinarian's diagnosis of the health condition. The problem may be inhalant allergies or a secondary bacterial infection that should be treated only by a licensed veterinarian.

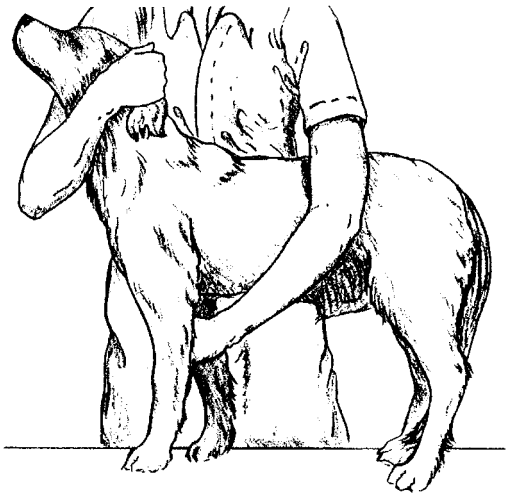
Animal health management requires frequent and routine monitoring. Frequent observations allow for early pest detection. Early detection of small pest populations may allow for more control options. Some control measures may work on limited numbers of pests but not on larger populations. Early pest detection also reduces or prevents the discomfort that would be caused by the pest if its population were to increase.

Commonly the pet professional is not around the pet routinely enough to maintain a pest monitoring program. The groomer is often faced with

Table 2.2 Common Questions Asked by Pet Professionals	
1.	Where on the body is the pet scratching?
2.	Have you recently bathed your pet?
3.	Did you use a pet shampoo appropriate for this breed?
4.	Does your pet scratch all the time or only during certain times of the year? Have you looked for fleas?
5.	Was your carpet recently cleaned at home?
6.	Have you recently installed new carpet?
7.	Are you using carpet fresheners?
8.	In the winter, does the pet lie in front of heat vents? Do you use a humidifier?
9.	When was the last professional grooming of your pet?
10.	If the pet is scratching the head area, have you looked into the ears for hair, insect-type pests or infection?
11.	If the pet is chewing or scratching the anal area, have you consulted with a veterinarian?
12.	Has your animal's veterinarian prescribed drug therapy for a scratch-itch syndrome, and are you administering it per directions?
13.	What type of food are you feeding your pet? Has this been a recent diet change recommended by your pet's veterinarian?
14.	Have you treated for fleas? Did you treat the pet, its bedding and the entire house at the same time? (See Chapter 8 for flea management and control information.)
You may have other questions that lead to answers for easing a pet's discomfort. **Pet professionals should never attempt to make veterinarian diagnoses.**	

a one-time opportunity to determine if an insect pest is causing the animal's discomfort. When a pet owner brings in an animal and says, "My pet is scratching," information must be obtained from the pet owner. Table 2.2 lists some questions that may help you get the information you need to provide the animal relief. Never attempt a diagnosis that should be made by a veterinarian. Always refer your client to a veterinarian if you don't find or cannot identify the pest problem.

Persons who handle animals should be trained in correct handling and restraining techniques to avoid injury to the handler and the animal. Animals are often apprehensive when at veterinary clinics or grooming facilities and should be handled with extreme caution. A pet owner may be able to examine a pet easily at home in familiar surroundings and the animal may show no



Source: Manual of Clinical Procedures in the Dog and Cat

Source: Practical Animal Handling

resistance. Animal aggression may become obvious in strange surroundings or the animal may react unpredictably out of fear. Correct use of restraining holds and devices may benefit both the animal and the handler. Inspecting an animal for pests may be accomplished effectively with two persons—one handler-restrainer and the other as examiner. Wrapping a cat in a heavy towel, making sure the forelegs and hindlegs are secure, can prevent handlers from being scratched or bitten.

Not all animals will require firm restraining. The amount of restraint needed will depend on the environment and the animal's behavior. Animal behavior will vary greatly and handlers must learn to "read" the animal's body language. Speak to the animal initially in a soothing voice to prevent startling it. Use the animal's name when approaching it. If necessary, speak firmly to the animal. Verbal restraint can be a useful supplement to the physical restraint of pet animals. Obtain animal handling training from an experienced professional to protect yourself and the animal.

2. Identification

After a possible pest has been detected, the second step in an IPM program is to **identify** the organism to determine whether it is indeed the organism causing the discomfort or disorder. The identification of the problem, pest and/or the problem the pest is causing the animal, such as dermatitis, should be made by a veterinarian. Correct pest identification allows the animal manager to gain information about its life cycle and biology so management measures can be targeted at the pest's susceptible life stage. To follow the example of our pet dog's scratching behavior, it would not make sense to apply flea control measures to alleviate the itching symptoms if the dog actually has a scabies mite infestation or a dermal allergy to house dust mites or a food allergy.

3. Economical or Medical Significance

After detection and identification of the pest, the animal owner, groomer, kennel operator, veterinarian or pest management applicator must decide if the **pest is present at an economically or medically significant level.** A veterinarian must be consulted on medical conditions, such as dermatitis and its cause.

In agricultural settings involving livestock, it is often difficult to establish an **economic injury level** above which pest damage occurs. For instance, owners may observe scratching, licking or other behaviors and signs that the animals are irritated. These irritations may not cause any direct or topical (skin surface) problems. But if the irritation persists it may cause the animals enough stress to result in reduced milk or meat production—an indirect effect and an economic loss. Just before or at the point of economic loss, the pest should be controlled to relieve the stress and prevent further losses.

For companion animals, pest problems are often not tied to yield or economic loss but rather a **perception by the owner or kennel person that the animal suffers from the presence and activities of a pest.** Animal owners or veterinarians may make medical judgments on the basis of symptoms caused by pests. These judgments then are used as a basis for pest management decisions.

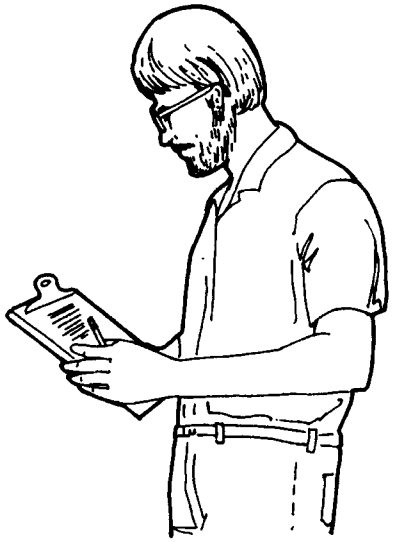
4. Method Selection

After detection and identification of a pest on an animal and determination that the pest is causing harm, it is time to **select a method or methods for managing the pest.** Depending on the situation and the nature of the problem, pesticides may or may not be required. Usually a com-

bination of pest control methods results in the most effective pest management. In any case, the methods should be effective, practical, economical and environmentally sound. Consult with a licensed veterinarian before treating pregnant or lactating dogs or cats for flea or mite infestations. These animals or their young may be negatively affected by a pesticide treatment.

5. Evaluation

After applying the chosen pest management procedures, **evaluate** their effectiveness. Keeping records and evaluating pest control techniques is necessary in a successful IPM program. Evaluation can include inspection of the animal and its premises to determine the level of pest control achieved and regular checks thereafter to determine if the pest returns to unacceptable levels.

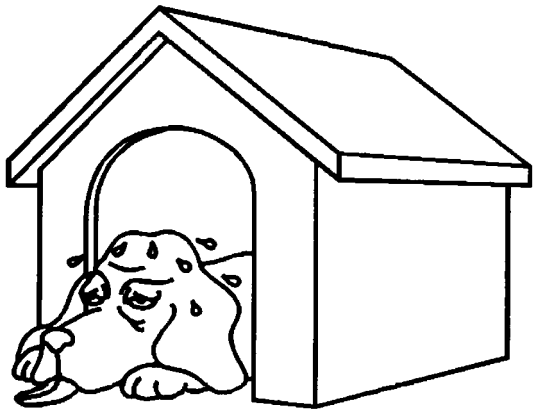


Techniques Used in Pest Management

All types of pest management strategies that protect animals from arthropod pests should be considered. Combining several strategies achieves the most effective and efficient control. Integrated pest management strategies include biological, cultural, mechanical, physical, chemical (pesticides), use of resistant breeds, sanitation in the animal's environment and legal quarantines to prevent spread of pests.

Biological controls introduce, encourage and artificially increase plants and animals that are parasites or predators of pests. Biological controls are most commonly used to manage insects, mites and some weeds in agricultural or landscape settings.

Cultural pest control includes maintaining overall good health of the animals. A healthy animal can



tolerate low levels of pests better than a weak or stressed animal. Animal diets should be well balanced and provided at consistent intervals and in appropriate portions. If animals are kept indoors, provide adequate ventilation to prevent heat stress or the spread of diseases such as kennel cough. Provide outdoor animals shelter, especially during severe weather. Population densities must be proportional to available space, food supply and water. Overcrowding may encourage pest outbreaks, whether in a cage, kennel, barn or pasture setting. Proper and routine grooming reduces the opportunity for pests to become established.

Animal ailments can be influenced by the species, diet, living conditions and treatment of the animal by the owner/manager. When any one or a combination of these things is unsatisfactory, the animal is predisposed by poor living conditions to acquire a pest problem. A healthy animal living in a stress-free and sanitary environment is less likely to suffer pest problems.

Mechanical tools for animal pest management may include grooming combs, brushes and flea combs with closely spaced teeth to monitor for insects and ticks. The pet owner should be instructed to vacuum living quarters regularly to remove flea larvae, eggs and their food. The vacuum bag should be changed and discarded after each use if a known flea problem exists. Electronic devices such as lights that attract flying insects may be used around barns or other animal quarters to reduce some nuisance pests. Trapping rodents that may be carriers of pests is also a preventive mechanical control measure. Ultrasonic collars and other devices have not been found to be effective.

Physical control of animal pests may include the use of sticky flypaper to reduce nuisance flying insects in confined areas. Physical control may also include cages that separate the animals in your care from one another. Preventing contact

between animals will reduce the spread of insects from infested animals to non-infested animals. When an infested animal is removed from a cage or kennel, the area should be thoroughly cleaned and disinfected to prevent contamination of the next animal placed in this confinement area.

Use of **pest-resistant breeds** and breeds adapted to the conditions of the area where they are raised will avoid or reduce the effect of pests. Using breeds that tolerate the climatic changes and temperature extremes that occur in Michigan will help reduce the likelihood of stress and pest problems. Some animals have been bred for disease resistance and other qualities that result in reduced problems, while other species still show signs of intolerance even in low-stress situations.

Sanitation is the foundation of most animal pest management programs. Keeping kennels, pet exercise areas and homes as clean as possible discourages pest invasion by eliminating food sources and places to breed and live. Cleaning animal bedding and the surfaces of cages and other animal confinement with disinfectants kills pathogens and reduces the spread of disease.

Quarantines help reduce the spread of pest problems. When introducing a new animal to an existing laboratory setting, kennel or other group of animals, isolate the new animal and observe it for a period of time to confirm that it is pest free before grouping it with other animals. Within an established group of animals, separate those that are suspected to be sick or infested with a pest until the problem is identified and corrected.

In some pest situations, veterinarians or licensed veterinary technicians may not differentiate between pest management and medical treatment of the animal. Heavy flea infestations on dogs, for example, can lead to secondary dermatitis and flea bite allergies that require veterinary care. The fleas are considered the arthropod pest that caused these undesirable conditions on the animals but the conditions are being treated medically. To treat the wounds without eliminating the cause (fleas) would be pointless.

Isolating new animals and observing them for a period of time, confirming that they are pest free, will prevent the spread of unknown pests. Clean environments are also essential to pest management.

Adopting a holistic, "IPM attitude" toward the management of pests of animals will help reduce pest problems. It is possible to manage a pest without any true medical treatment. Simply changing environmental conditions may prevent or eliminate a pest. Veterinarians may need to consult entomologists or commercial pesticide applicators for advice on pest life cycles or management strategies.

Pesticides are used in IPM programs for animal pests. Often, they are used in combination with other methods of prevention and control or used when other methods have failed or do not apply. For example, there currently are no effective environmental, cultural or other management options for deer flies and horse flies. Thus, insecticides or repellents on animals are the most reliable pest management alternatives.

Sometimes pests can be effectively managed with drugs, chemicals that veterinarians administer or prescribe. When a product is labeled as a drug, it is approved and regulated by the Food and Drug Administration, not the Environmental Protection Agency. An example of a drug that has antiparasitic properties is ivermectin (under trade names such as Ivomec®). This drug is injected or given orally to an animal to rid the animal of certain ectoparasites and endoparasites. An example of an insecticide that is given to animals like a

drug is Proban® for the management of fleas. Some animals treated with a drug and later exposed to another pest management chemical treatment have gotten sick. It is important that owners are made aware of the treatments administered to their animals and that they communicate this information to other handlers of the animal. Animal groomers, kennel owners and farm workers should ask for this information before administering any type of pest treatment. Ask product sales representatives, the manufacturer or a veterinarian about any possible negative interactions that may result between the products you use and other products that the animal may be exposed to. You are responsible for this knowledge. Obviously the animal cannot control these situations.

People responsible for maintaining a pest-free and healthy environment for animals must often decide whether to deal with pests as a medical problem with drugs as the sole treatment, or as a pest management problem, where IPM and possibly pesticides or drugs would be used. Treating only the damage caused by a pest and not controlling the pest will result in future injury. Animal pest problems should be controlled through environmental management and animal treatment.

Pesticide use on and around animals requires special care. **Pesticides may be toxic to the animals being treated.** The applicator must consider **dose-response relationships** and **pesticide choice** carefully when making applications. Smaller animals cannot tolerate the same dose of certain pesticides as well as larger animals. An applicator may need to consult a veterinarian to determine the appropriateness and timing of pesticide applications on animals. Before any pesticide application is made to an animal or in its environment, the applicator should read and thoroughly understand the directions for use on the label. When heavy infestations occur, pet owners should consider obtaining professional pesticide applicator pest management help.

Professionals know the proper techniques for applying pesticides to animals and wear the proper personal protective equipment.

Chapter 2 – Review Questions

Write the answers to the following questions and then check your answers with those in the back of this manual.

1. What unique external characteristics do adult insects have?

2. Which is NOT a type of mouthpart for insects?
   a. Piercing-sucking
   b. Filtering
   c. Siphoning
   d. Sponging
   e. Chewing

3. _____ is characterized by egg, larval, pupal and adult stages and includes the majority of insects.
   a. Gradual metamorphosis
   b. No metamorphosis
   c. Complete metamorphosis

4. What is a host?

5. Endoparasites live INSIDE the host body. True or False?

6. What are the causes of dermatitis?

7. List the four groups of important animal insect pests.

8. Define IPM and explain the five components of an IPM program.

9. Why is early detection of pests important?

10. Why must the animal manager identify the pest?

11. In what settings are economic injury levels of greatest concern?

12. Identify and describe the fifth and final step of an IPM program.

13. What must be considered when pesticides are used on or around animals?

14. List five or more strategies/techniques used in IPM programs and briefly describe each.

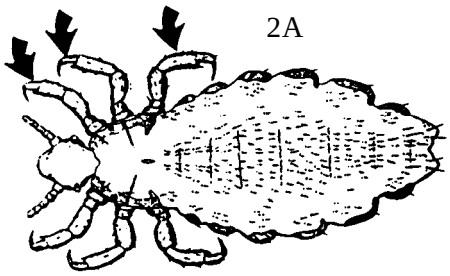
Key To Insects, Ticks and Mites of Medical and Veterinary Importance

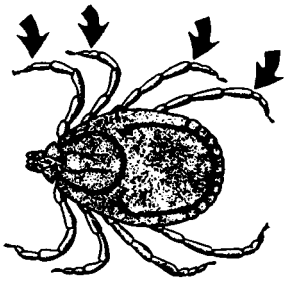
Source: **North Carolina State University Cooperative Extension Service**

1. Having 6 or 8 legs (Fig. 2) 2
   Legless and wormlike maggots (Fig. 3) 34

2. Having 6 legs and a distinct head (Fig. 2A) 3
   Having 8 legs without a distinct head (Fig. 2B) 32

2A



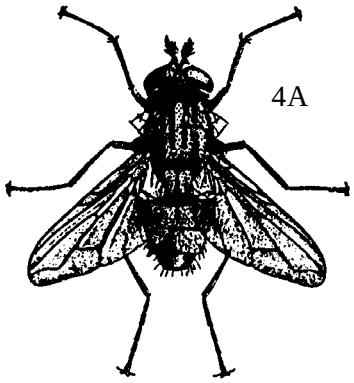


2B

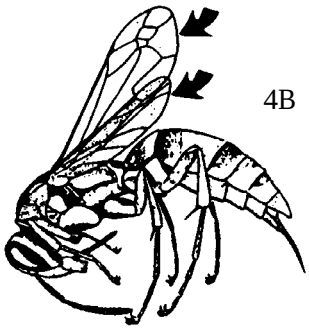
3

3. One pair of wings (Fig. 4A) 4
   Two pairs of wings or no wings (Fig. 4B, C) 21

4A



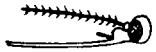
4B



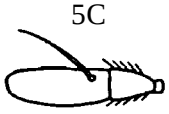
4C

4. Antennae (feelers) with 10 or more distinct segments (Fig. 5A) 5
   Antennae with 3 segments (Fig. 5B) or the apical segments more or less fused (Fig. 5C) 7

5C



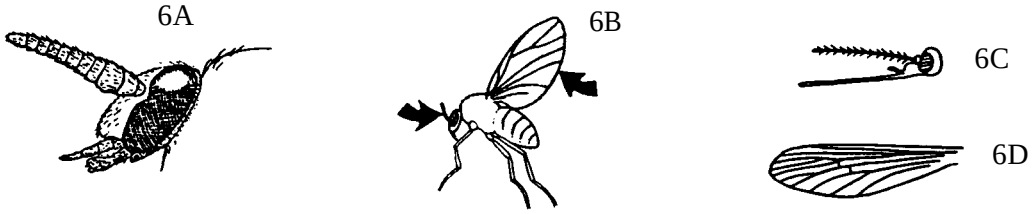
5C



5C

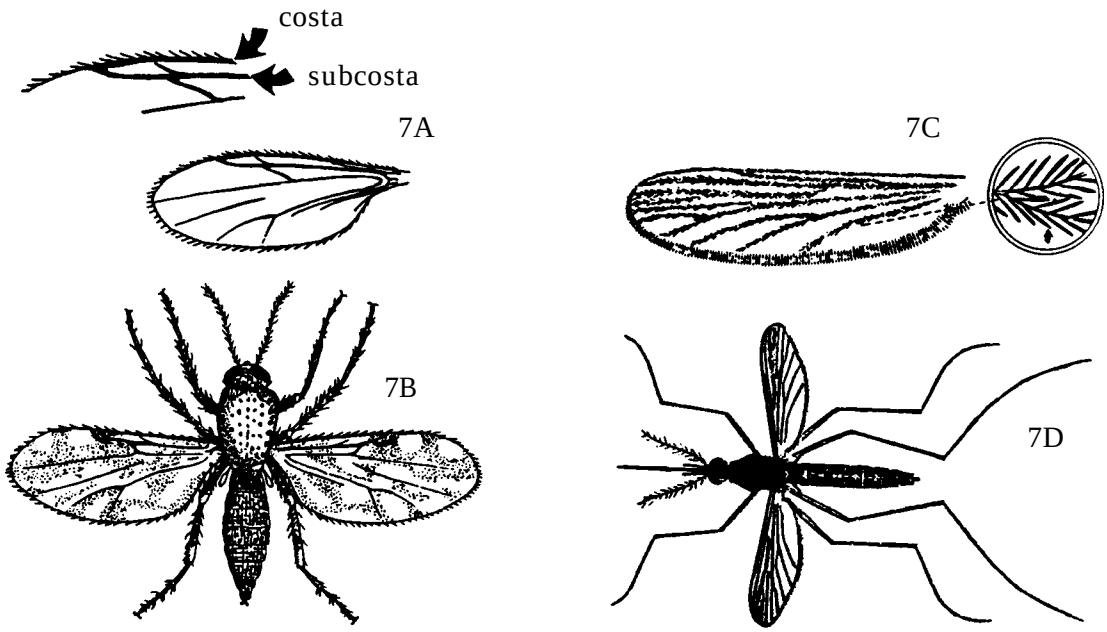
5. Short antennae with 10 or 11 segments (Fig. 6A); wing veins slender at rear (Fig. 6B); slightly humpbacked fly 4 mm long or less; bite usually painless at first but later causes swelling and pain ..... BLACK FLY or BUFFALO GNAT

Longer antennae with 12 to 16 segments (Fig. 6C); wing veins all about the same width (Fig. 6D) 6



6. Wings not very hairy, costa vein ending before wing tip (Fig. 7A); bloodsucking fly (Fig. 7B) 0.5 to 5.0 mm long .....BITING MIDGE, PUNKIE, NO-SEE-UM

Wings scaly and with numerous veins, costa vein continuing around wing tip (Fig. 7C); slender, long-legged fly (Fig. 7D) with wings 3 to 4 mm long; has slender proboscis for sucking blood ..... MOSQUITO



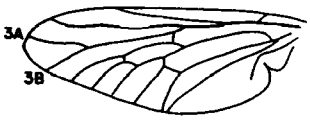
7. Each wing with 4 or 5 cells along rear edge (Fig. 8A) 8

Each wing with 3 or fewer cells along rear edge (Fig. 8B) 9

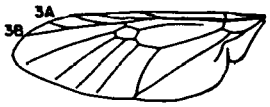
8. Third wing vein branched with vein 3A long and vein 3B ending behind wing tip (Fig. 9A); abdomen-flattened; small- to large-bodied fly (Fig. 9B) 10 to 19 mm long; female inflicts painful bite.....HORSE or DEER FLY

Third wing vein branched with vein 3A short and vein 3B ending before wing tip (Fig. 9C); dusky-winged, nonbiting fly (Fig. 9D) 15 to 20 mm long; wasplike in appearance; bronze or primarily black abdomen ..... BLACK SOLDIER FLY

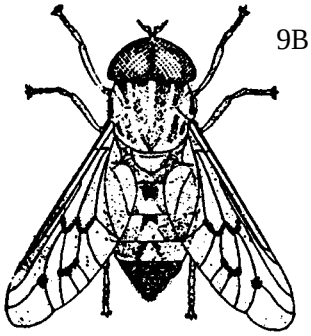
9A



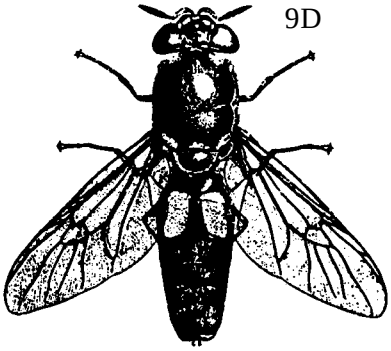
9C



9B



9D



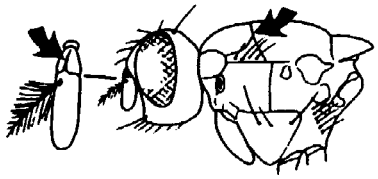
9. Second antennal segment with seam (Fig. 10A); mesonotal suture on thorax goes all the way across (Fig. 10B) 10

Second antennal segment without seam (Fig. 10C); mesonotal suture absent or note reaching all the way across (Fig. 10D) 11

10. Hypopleura (area just above base of hind legs) bare or with sparse, fine hairs (Fig. 11A) 13

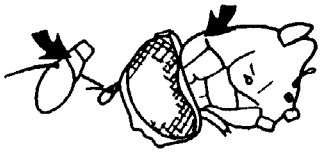
Hypopleura with row of strong bristles or with long, dense hairs (Fig. 11 B) 19

10A



10B

10C



10D

11A

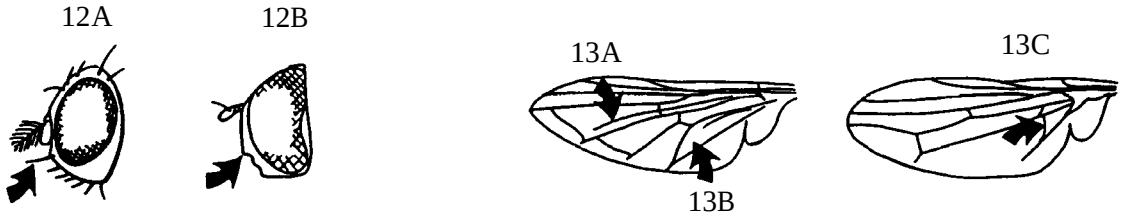
11B

11. Oral vibrissae (hairs near the front of the mouth) usually present (Fig. 12A); nonbiting, gray to black fly only about 1.2 mm long; passes easily through 16-mesh screen ..... EYE GNAT

Oral vibrissae usually absent (Fig. 12B); fly 15 to 18 mm long 12

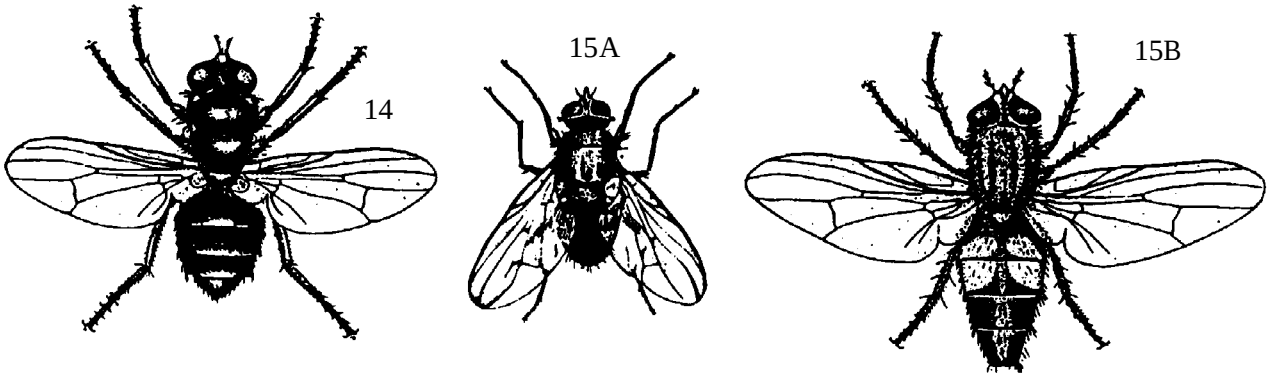
12. Spurious (extra) vein present (Fig. 13A) and anal cell nearly reaches wing margin (Fig. 13B); hairy,brownish to black, beelike fly about 15 mm long; has mouthparts but doesn't bite.... DRONE FLY

Anal cell short (Fig. 13C); hairy, brownish to reddish fly about 18 mm long; mouthparts absent ..... BOT FLY



13. Slender, shiny black, nonbiting fly (Fig. 14) about 5 mm long ..... GARBAGE or DUMP FLY

Fly dull, not shiny 14



14. Fly usually less than 6 mm long 15

Fly usually longer than 6 mm 16

15. Brownish-gray to black with yellowish cast to body; blood-sucking; 3.5 to 4 mm long; set of parallel stripes just behind head (Fig. 15A); brownish-red antennae; usually a pest of cattle and horses ..... HORN FLY

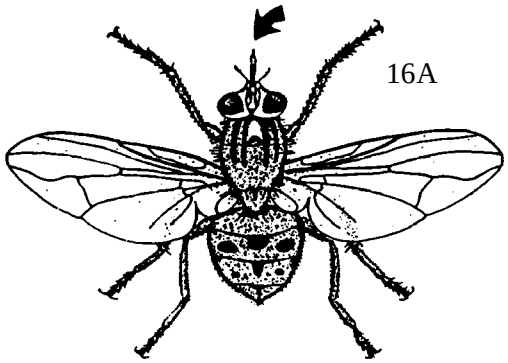
Slender, nonbiting fly 5 to 6 mm long; dark-colored body with or without stripes (Fig. 15B); hovering and jerky pattern of flight ..... LITTLE HOUSE FLY

16. Blood-sucking fly with sharp mouthparts which protrude from head (Fig. 16A); body 6 to 8 mm long; 4 dark, longitudinal stripes on thorax; several dark spots on abdomen' "squats" when at rest ..... STABLE FLY

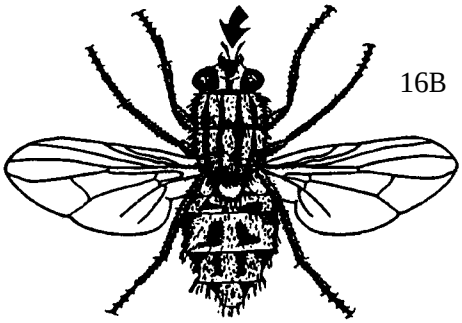
Mouthparts blunt, not protruding (Fig. 16B); nonbiting fly 17

17. Pale spot on top of thorax near abdomen; 4 dark, sometimes indistinct, stripes on thorax; abdomen black or black and red; body about 8 mm long (Fig. 16B) ..... FALSE STABLE FLY

Not as above 18



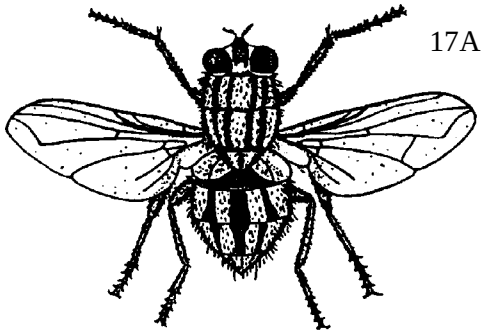
16A



16B

18. Abdomen yellow or partially yellow with dark line down the middle; gray fly (Fig. 17A) about 6.5 mm long with 4 dark, lengthwise stripes on thorax ..... HOUSE FLY

Abdomen primarily black with orange base (female) or orange-brown with black base and dorsal stripe (male); thorax gray with 4 dark, lengthwise stripes (Fig. 17B); body 6 to 8 mm long; commonly feeds on moist animal secretions ..... FACE

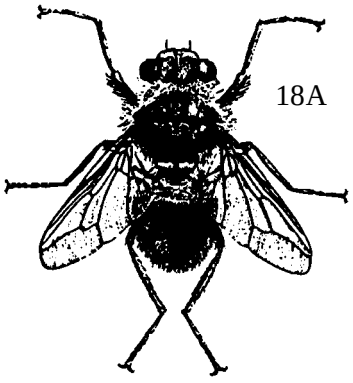


17A

17B

19. Hypopleura (area above base of hind legs) obscured by long, usually dense hairs; mouthparts absent; body about 13 mm long with 2 bands of yellow and white hairs across it (Fig. 18A); reddish-orange hairs at tip of abdomen and on legs; wings dark brown to black ..... CATTLE GRUB FLY

Hypopleura with a row of strong bristles (Fig. 18B) 20

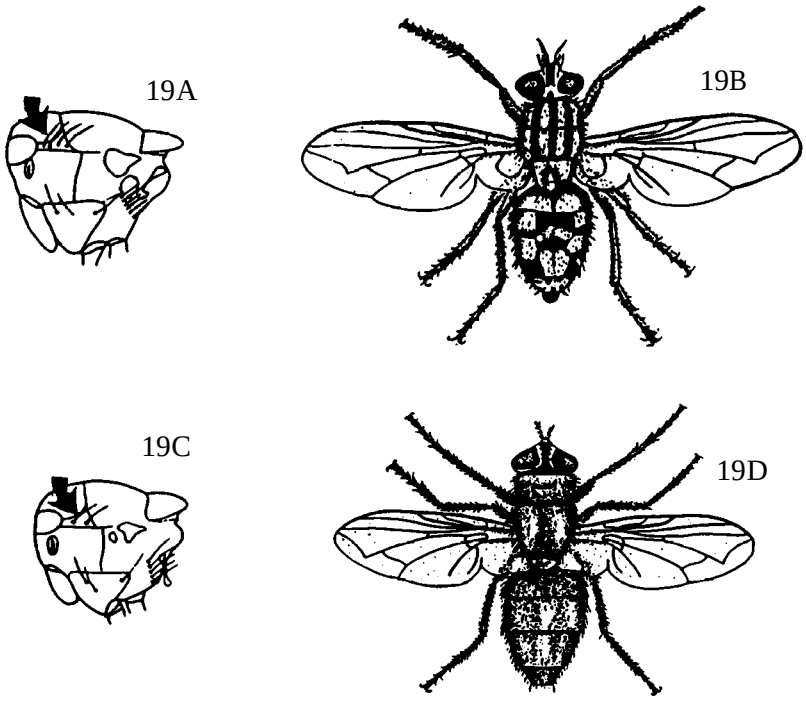


18A

18B

20. Notopleura ("shoulder" of the thorax) usually with 4 bristles (Fig. 19A); gray fly about 10 to 13 mm long; 3 black stripes on thorax; light and dark checkerboard pattern on abdomen (Fig. 19B) ..... FLESH FLY

Notopleural with only 2 bristles (Fig. 19C); black or metallic-colored fly 6 to 14 mm long; no stripes or checkerboard pattern (Fig. 19D) ..... BLOW FLY

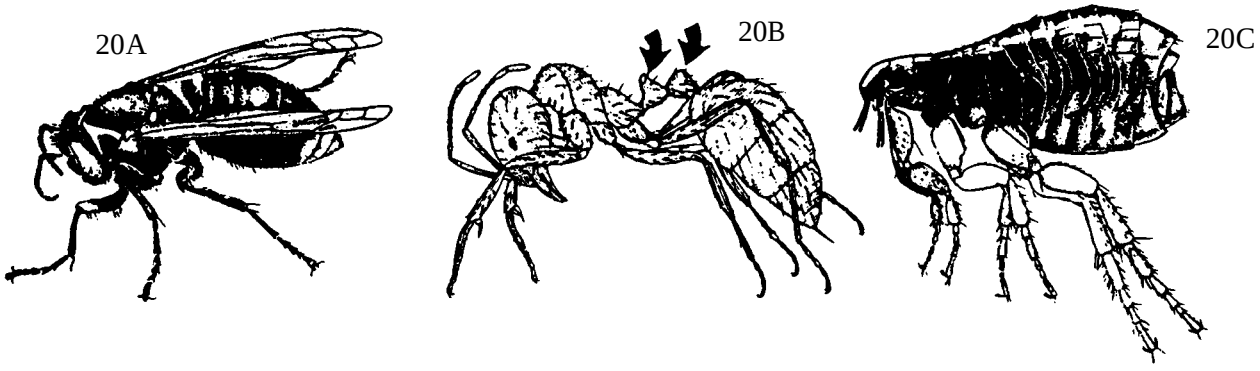


21. Two pairs of wings; constricted "waist" without nodes (bumps); smooth-bodied, stinging insect (fig. 20A) 13 to 25 mm long; color variable; associated with papery nests under or above ground ..... HORNET, WASP, YELLOW JACKET

No wings; "waist" constricted with nodes (Fig. 20B) or note constricted (Fig. 20C) 22

22. Constricted "waist" with nodes (Fig. 20B); body usually reddish or dark brown and 3 to 6 mm long; stinging ant associated with mounds 35 cm or more in diameter and 20 to 25 cm high ..... FIRE ANT

No constricted "waist" as above 23



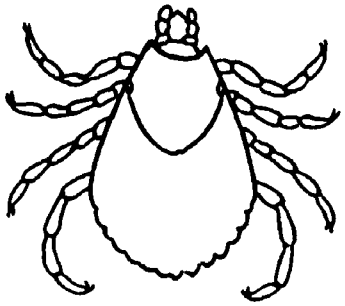
23. Body flattened laterally (from side to side); spiny, hard-skinned insect (Fig. 20C) 1 to 2.5 mm long; hind legs modified for jumping ..... FLEA

Body not flattened laterally 24

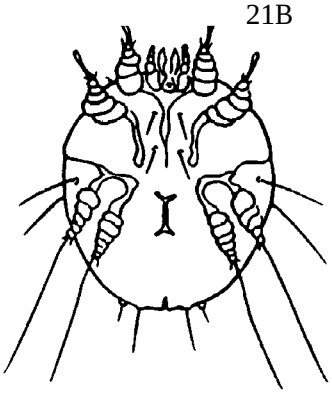
24. Pest 1 mm or less in length; associated with slightly larger, 8-legged animals which are otherwise similar in appearance (Fig. 21A, B) (key out the larger, 8-legged pests) 31

No association as above; all animals with 6 legs; size variable; body somewhat flattened dorsoventrally (from top to bottom) (Fig. 21C) 25

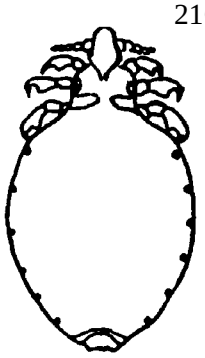
21A



21B



21C



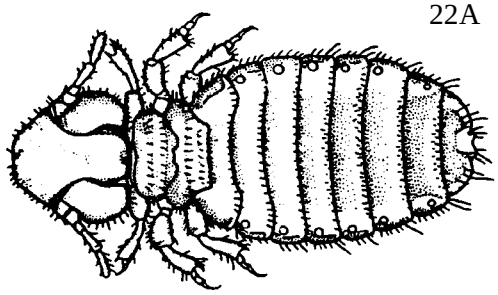
25. Chewing mouthparts; yellowish-white louse with broad, flat, reddish head (Fig. 22A); body up to 1.5 mm long with 8 dark crossbands on abdomen 26

Piercing-sucking mouthparts; body somewhat flattened dorsoventrally (from top to bottom) (Fig. 22 B) 27

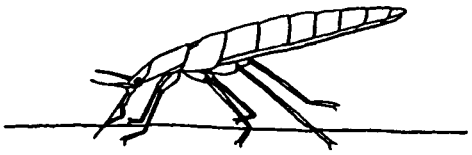
26. Feeding on cattle ..... CATTLE BITING LOUSE

Feeding on skin or feathers of poultry ..... CHICKEN BODY

22A



22B

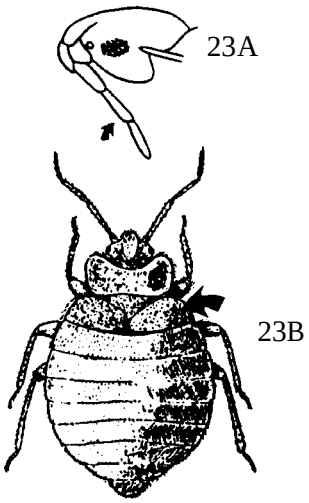


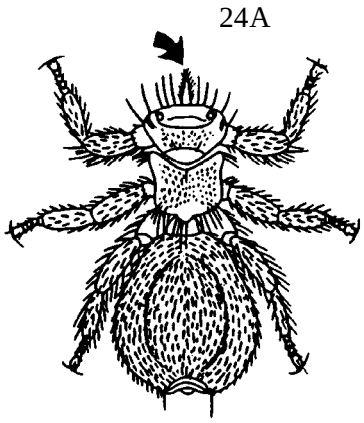
27. Jointed beak (Fig. 23A); reddish-brown, oval, flattened insect up to 9 mm long; small, padlike wing remnants (Fig. 23B); pronotum (just behind head) collarlike ..... BED BUG

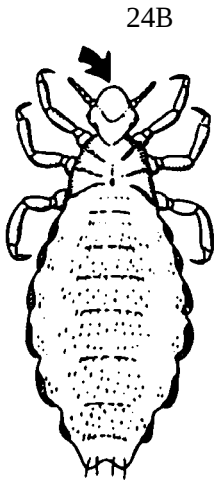
Beak not jointed, sometimes retracted into head 28

28. Needlelike mouthparts exposed (Fig. 24A); short, thick legs with apical spurs; body about 6 mm long; blood-sucking parasite of sheep ..... SHEEP KED

Mouthparts retracted into head; blood-sucking louse (Fig. 24B) 29





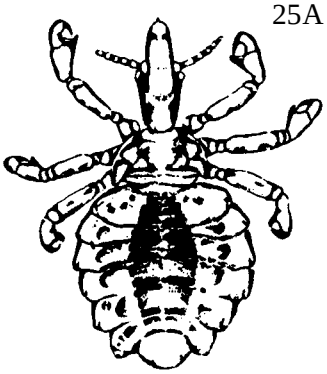


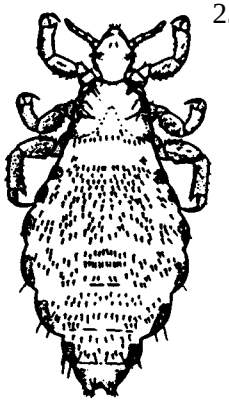
29. Parasite of hogs; oval, grayish-brown louse up to 6 mm long; brown and black markings on body; legs clawlike (Fig. 25A) ..... HOG LOUSE

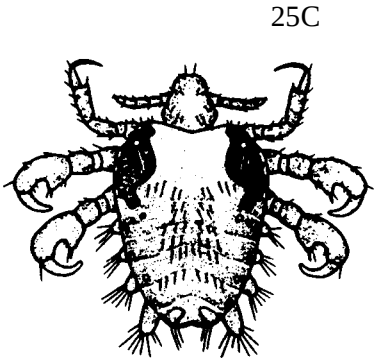
Parasite of man; grayish-white louse 4 mm or less in length 30

30. Abdomen longer than wide; body up to 4 mm long without hairy tubercles (Fig. 25B); all legs about equal in size ..... HEAD and BODY LOUSE

Abdomen about as long as wide; body up to 2 mm long with hairy tubercles (Fig. 25C); front pair of legs more slender than other pairs ..... CRAB LOUSE





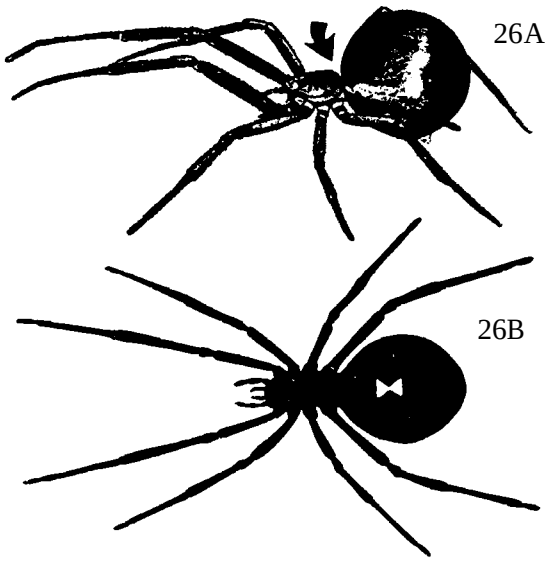


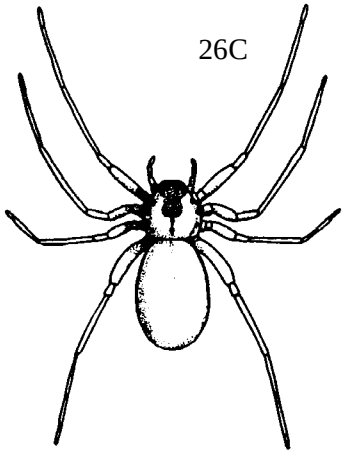
31. Abdomen constricted to form a narrow "waist" (Fig. 26A) 32

No constricted "waist" (Fig. 27); bloodsucking parasite of man and animals; some immature stages 6-legged 33

32. Spider with black, globular abdomen about 9 by 13 mm with red or yellow, hourglass marking on underside (Fig. 26A, B) ..... BLACK WIDOW SPIDER

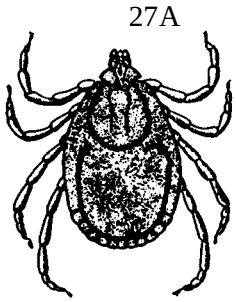
Grayish- to reddish-brown spider with black, fiddlelike marking on the head and thorax; body 7 to 13 mm long with a leg span about the size of a half dollar (Fig. 26C) ..... BROWN RECLUSE SPIDER

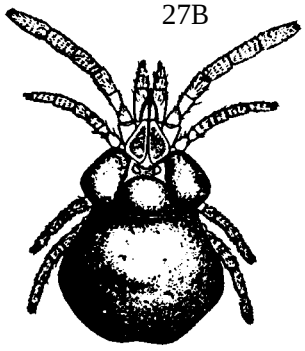


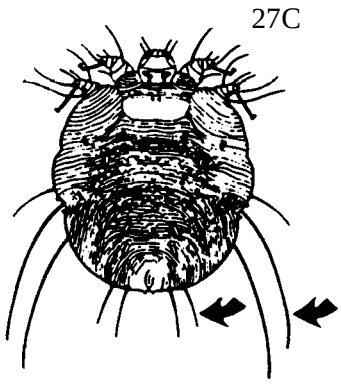


33. Hairless body from 0.5 mm up to 7 mm long (immature to adult) (Fig. 27A); usually brown, reddish brown or gray ..... TICK

Body with long or short hairs (Fig. 27B, C); body usually 1.25 mm long or less; color variable ..... CHIGGER or MITE







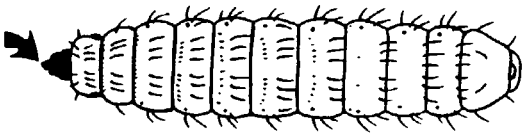
34. With a definite head (Fig. 28A) 35

Without a definite head (the mouthparts are tucked into the thorax, Fig. 28B) 36

35. Body large and flattened, 12 to 27 mm long when fully grown; creamy white to reddish brown; develops in decaying organic matter (Fig. 28A) ..... BLACK SOLDIER FLY LARVA

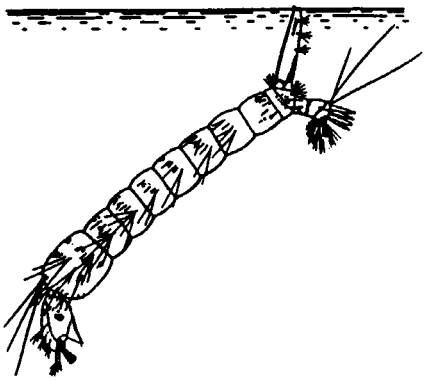
Slender, aquatic larva up to 10 mm long or curled pupa; transparent to greenish brown; develops in still rather than running water (Fig. 29A and B) ..... MOSQUITO LARVA and / or PUPA

28A

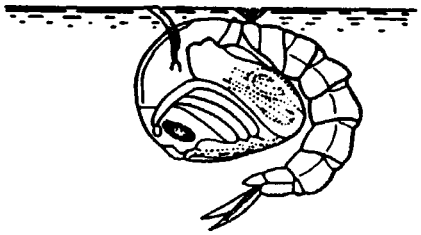


28B

29A



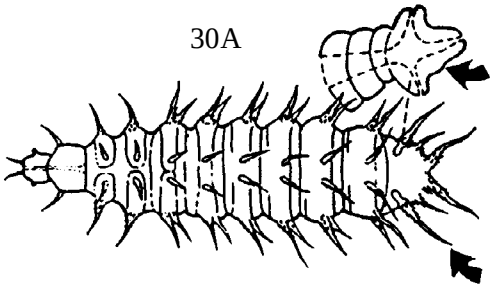
29B



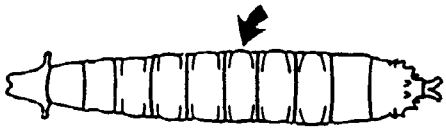
36. Body with pointed projections on each segment (Fig. 30A); posterior spiracles (breathing openings) on small bumps; white to light brown body up to 8 mm long ..... LESSER HOUSE FLY LARVA

Body smooth or with short spines; no long pointed projections; posterior spiracles not on bumps (Fig. 30B) 37

30A

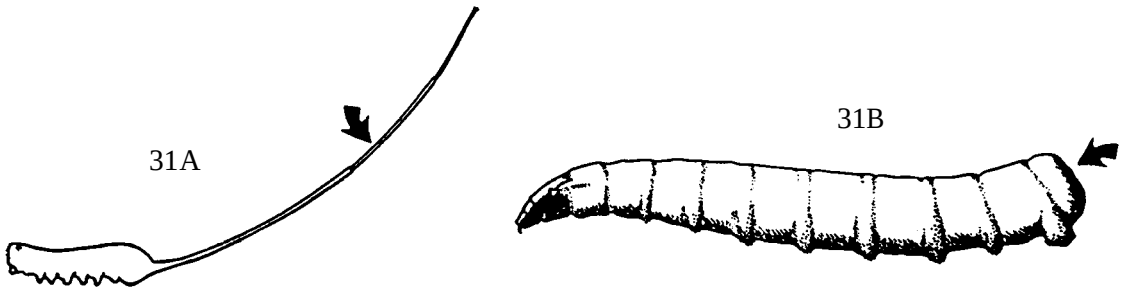


30B



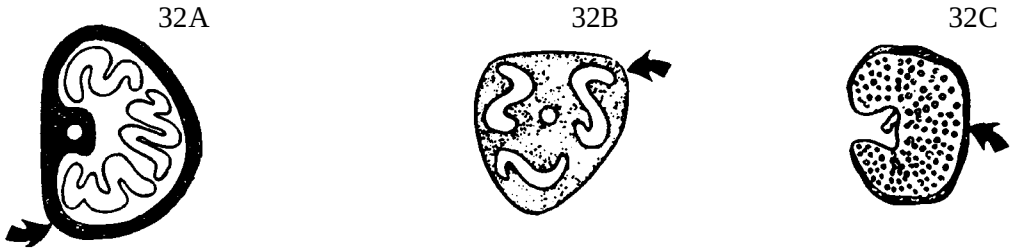
37. Leathery; aquatic; larva up to 20 mm long, with long, taillike breathing tube (Fig. 31A) ..... RAT-TAILED MAGGOT

Larva without a taillike process (Fig. 31B) 38



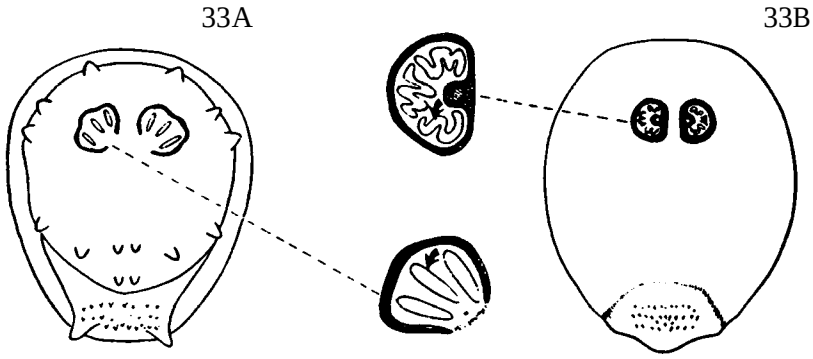
38. Hard, dark line (peritreme) present around hind spiracles; each spiracle with 3 distinct slits (Fig. 32A) 39

No peritreme around hind spiracles (Fig. 32B); or, if peritreme present, then 3 slits absent (Fig. 32C) 45



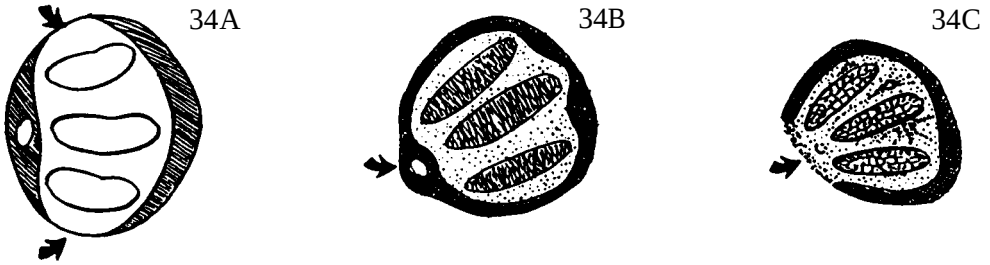
39. Slits of hind spiracles straight (Fig. 33A) 40

Slits of hind spiracles strongly curved (Fig. 33B) 44



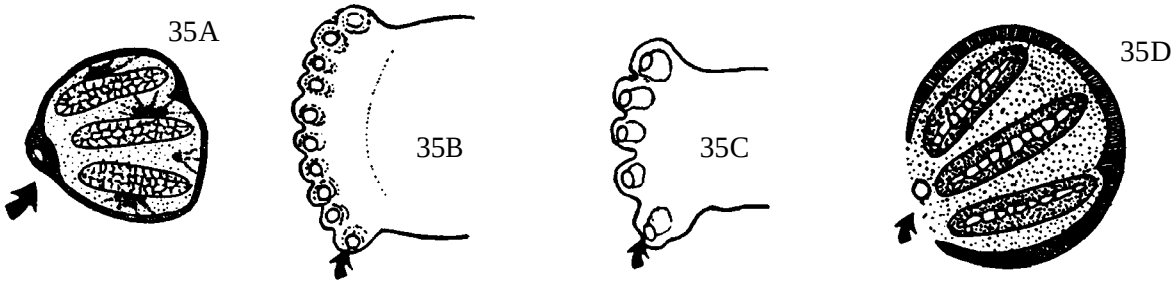
40. Peritreme of hind spiracle very thin on top and bottom (Fig. 34A); spiracles slightly elevated and, when viewed from rear, slanted toward each other; hardened, spiny larva at least 10 mm long when fully grown; develops in decaying organic matter ..... BLACK GARBAGE or DUMP FLY LARVA

Peritreme complete (Fig., 34B) or with only lower portion missing (Fig. 34C) 41



41. Hind spiracles with peritreme complete (Fig. 35A); at least one of the two prothoracic spiracles (close to front end) with 8 or more openings (Fig. 35B, a green bottle fly) or prothoracic spiracles with 6 or less openings (Fig. 35C, a bronze bottle fly); yellowish to white maggot up to 14 mm long; develops in decaying organic matter, sometimes carrion or animal wounds ..... BOTTLE FLY LARVA

Hind spiracles with peritreme incomplete, not enclosing a “button,” (the “button” is a tiny, round pale area which is sometimes hard to see, Fig. 35D) 42



42. Slits of hind spiracle not pointing toward opening in peritreme (Fig. 36A); white to yellowish maggot 10 t0 22 mm long when fully grown; develops in wounds, carrion or excrement .... FLESH FLY LARVA

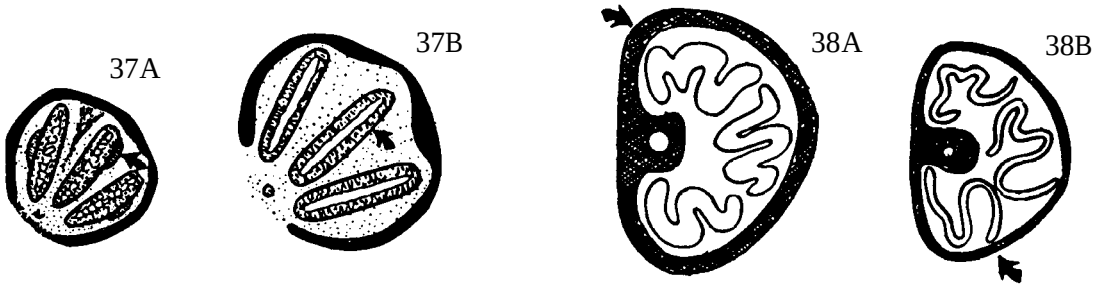
Slits of hind spiracle pointing toward opening in peritreme {Fig. 36B); at least one of the prothoracic spiracles (close to front end) with 10 or more openings (Fig. 36C) 43

43. Hind spiracle with button distinct or absent, walls of slits with lateral swellings (Fig. 37A); white or yellowish maggot up to 18 mm long; develops only on dead animal tissues ..... SECONDARY SCREWWORM

Hind spiracle with button present, walls of slits without lateral swellings (Fig. 37B); white or yellowish maggot up to 17 mm long; develops in decaying organic matter, carrion or animal wounds. ..... BLACK BLOW FLY LARVA

44. Peritreme of hind spiracle thick (Fig. 38A); nearly white maggot up to 13 mm long; common in moist feces and decaying organic matter ..... HOUSE FLY LARVA

Peritreme of hind spiracle thin (Fig. 38B); white maggot 6.5 to 7.5 mm long when fully grown; common in fresh bovine feces ..... HORN FLY LARVA



45. Small or slender, maggot-type larva usually, but not always, less than 13 mm long, tapering toward the head (Fig. 39A); develops in decaying organic matter 46

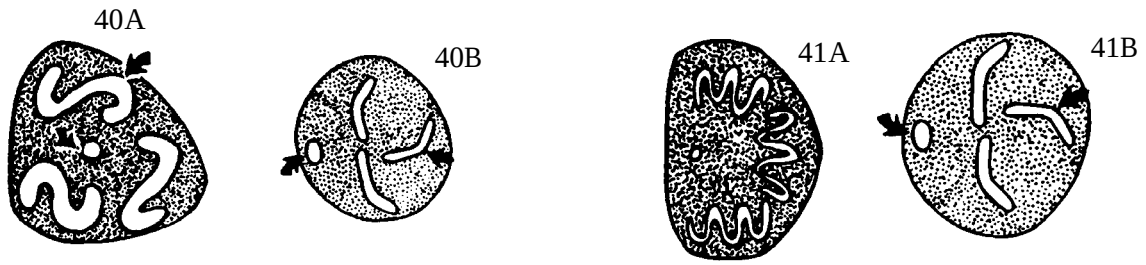
Large, robust larva with very stout spines (Fig. 39B); over 15 mm long when fully grown; internal parasite of animals 48

46. Button of hind spiracle centrally located (Fig. 40A); creamy white to pale yellow maggot up to 12 mm long; develops in moist, decomposing organic matter (usually not in manure piles) ..... STABLE FLY LARVA

Button of hind spiracle not centrally located (Fig. 40B) 47

47. Slits of hind spiracles strongly curved (Fig. 41A); yellowish maggot up to 13 mm long; develops in fresh bovine manure ..... FACE FLY LARVA

Slits of hind spiracles not strongly curved (Fig. 41B); grayish to cream-colored larva 12 to 18 mm long when fully grown; develops in decaying organic matter, including manure ..... FALSE STABLE FLY LARVA



48. Hind spiracles with 3 distinct, slightly curved slits (Fig. 42A); yellowish- to dirty-white larva 17 to 24 mm long when fully grown; spines dark brown; internal parasite of horses ..... HORSE BOT FLY LARVA

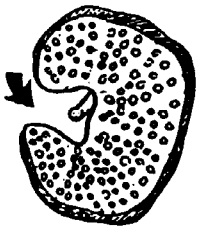
    Hind spiracle without 3 distinct slits 49

49. Button of hind spiracle not centrally located or enclosed; opening toward button wide (Fig. 42B); white when young; mature larva black, up to 28 mm long and 13 mm wide; subcutaneous along back line of cattle ..... COMMON CATTLE GRUB

    Button of hind spiracle enclosed, centrally located (Fig. 42C); larva more than 15 mm long when mature; body with stout spines ..... SHEEP BOT FLY

42A

42B



42C