INTRODUCTION

This manual contains the information needed to become a certified commercial applicator in public-health pest management. It is intended for use in combination with the Pesticide Applicator Core Training Manual available in each state through the pesticide coordinator or the extension service.

The primary objective of the manual is to provide a relatively easy means of updating existing certification manuals. This material may be used by states to replace or update existing manuals for certification of public-health pesticide applicators. States are encouraged to excerpt and modify portions for the specific needs of their readers, adhering to the citation guidelines presented below. To expedite this process, electronic versions will be distributed to the pesticide coordinator in each state. HTML and PDF files, including tutorials on mosquitoes, also are available on the Internet at the Public-Health Pest Control Web site (http://vector.ifas.ufl.edu/).

In those states that accept this training tool, applicators may test their knowledge using the mosquito tutorials and may earn continuing-education units (CEUs). Every state periodically holds formal examinations so that public-health pesticide applicators can become certified or recertified by providing evidence of sufficient continued education.

Funding and personnel for the preparation of this manual were provided by a grant from the U.S. Department of Agriculture coupled with the resources of the Department of Entomology and Nematology of the University of Florida and the American Mosquito Control Association. The manual includes a glossary and a key to acronyms at the end. Glossary terms are indicated in bold print throughout the text and are defined according to their meaning in the context of this manual. Some definitions found in the glossary may not be applicable in other contexts.

I. OBJECTIVES OF CERTIFICATION TRAINING

A wide variety of pests fall within the public-health domain as a great many species of arthropods and vertebrate animals impact the health and well-being of residents in the U.S. Some public-health pest threats have similar origins throughout the country, whereas others are unique and require different management approaches. This document attempts to cover all applicable pest categories found in the U.S., which generally is broader coverage than found in most existing state manuals.

The coverage includes information on the biology and management of pests and the pathogens or disabilities they inflict. It describes the behaviors and habitats of specific vectors and pests, as well as modes of disease transmission and current management concepts. The text provides specific information concerning accepted surveillance practices and routines commonly used to detect the presence of vector threats to public health.

An extended discussion on rules, regulations and methods for the safe use and handling of pesticides is available in the Core Manual issued by each state's pesticide coordinator. That discussion includes such relevant topics as toxicology, pesticide classification, worker safety, equipment, equipment

calibration and environmental protection. Readers are encouraged to review the information provided in the Core Manual.

Specific information unique to public-health pest control that may not be included in the Core Manual is provided in the chapter on control organization responsibilities in this manual. The text also deals with individual vs. community responsibility for mitigation of public-health pest threats. It provides information on the infrastructure and responsibility of control organizations. It explains how those organizations fit into the overall scheme for protection from the variety of public-health pest threats encountered in the U.S., as well as those that might be introduced through international commerce, individual travel, or by mobile vectors and hosts.

Public-health pests abound throughout the nation. In some states pesticide applicator training includes more topics and more specific pests than in others. But the principles are similar throughout. Use of this manual or excerpts will allow each state to continue to determine which pests and issues to include in its own certification manual without the need to conduct an in-depth upgrade of existing documentation. In most cases, this text avoids references to specific pesticides. Each state's pesticide coordinator can provide current information in that area.

The general public and governmental agencies expect broad comprehension of these topics by pesticide applicators. Within the guidelines specified by the U.S. Environmental Protection Agency (EPA), each state decides which aspects are key features that require specific knowledge. This perspective may be provided during the formal training sessions and in the practice questions provided at the state and local levels. By understanding the nature of these issues and the strengths and limitations of the tools available for resolving them, public-health pesticide applicators can effectively conduct their tasks in a responsible manner.

II. SOURCES

This document contains excerpts from many published agency manuals. The authors gratefully acknowledge input in the form of printed and electronic materials, graphics, and review and constructive criticism received from the states, agencies and individuals listed below.

Materials and Reviews

California – Bruce Eldridge, University of California, Davis
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Nebraska – Clyde Ogg, Nebraska Cooperative Extension Service
Nevada – Wayne Johnson, Nevada Cooperative Extension Service
New Jersey – Christine Musa, Warren County Mosquito Control
New York – Ronald Gardner, Cornell Cooperative Extension Service
North Carolina – Barry Engber, North Carolina Department of Environmental and Natural Resources
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Oklahoma – Jim Criswell, Oklahoma Cooperative Extension Service
Texas – Jimmy Olson, Texas A&M University
Utah – Clark Burgess, Utah Department of Agriculture and Food

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Department of Defense – Donald Driggers, Armed Forces Pest Management Board
Environmental Protection Agency – Robert Rose, Training and Certification Division

Peer Reviews

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Robert Rose – Environmental Protection Agency, Certification and Worker Protection Branch

Reference Materials Submitted

The specific reference materials provided by the above collaborators and the dates of publication, if known, are as follows:

California	Pesticide Applications and Safety Training for Applicators of Public Health Pesticides. Mosquito and Vector Control Association of California. 88 pp.
Florida	Public Health Pest Control Applicator Training Manual. Florida Department of Agriculture and Consumer Services. 1998. 30 pp.
	Imported Fire Ants and Their Management in Florida. SP 161. University of Florida. 1994. 20 pp.
Georgia	Public Health Pest Control. University of Georgia Cooperative Extension Service. 1993. 51 pp.
Hawaii	Vector Control Training Manual. Hawaii State Department of Health. 1991. 127 pp.

Louisiana	Mosquito Control Training Manual. Commercial Pesticide Applicator. Category 8A – Mosquito Control. Louisiana Mosquito Control Association. 1993. 119 pp.
Michigan	General Pest Management, A Guide for Commercial Applicators. Extension Bulletin E-2048. Michigan State University Extension. 1998. 231 pp.
	Public Health Pest Management. Extension Bulletin E-2049. Michigan State University Cooperative Extension Service. 139 pp.
Minnesota	Category L, Mosquito. Pesticide Applicator Training Manual. University of Minnesota Extension Service. 2000. 98 pp.
Missouri	Public Health Pest Control Manual 98. University of Missouri – Columbia Extension Service. 1989. 35 pp.
Nebraska	Public Health Pest Control for the Commercial/Noncommercial Pesticide Applicator. University of Nebraska Cooperative Extension. 76 pp.
Nevada	Nevada Pesticide Applicator's Certification Workbook. SP-87-7. University of Nevada Cooperative Extension. 1997. 194 pp.
New Jersey	Pesticide Applicator Training, Category 8B, Mosquito Pest Control. Rutgers Cooperative Extension. 1998. 52 pp.
	Commercial Pesticide Operator Training Manual. Warren County Mosquito Extermination Commission. 1994. 18 pp.
New York	Pesticide Applicator Training Manual, Category 8, Public Health Pest Control. Cornell University Cooperative Extension. 1983. 175 pp.
Ohio	Mosquito Pest Management. Bull. 641. Ohio State University Extension. 1998. 11 pp.
Texas	Using Pesticides, Commercial Applicator Manual, Health-Related Pest Control. Texas Agricultural Extension Service. 1977. 30 pp.
Utah	Public Health Pest Control, Pesticide Application and Safety Training Study Guide. Utah Department of Agriculture. 1996. 21 pp.
Washington	Public Health Pest Control. Washington State Cooperative Extension Service. 42 pp.
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	Introduction to Arthropods of Public Health Importance, HEW Publ. (CDC) 79-8139. U.S. Department of Health, Education and Welfare. 1979. 48 pp.
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Mosquitoes of Public Health Importance and Their Control. Vector-Borne Disease Control Self Study Course 3013-G. U.S. Department of Health and Human Services. 1993. 85 pp.

Mosquitoes: Their Biology and Control (An IPM Approach). National Park Service, National Capital Region, 1980. 49 pp. (unpublished pamphlet)

Pictorial Keys. Arthropods, Reptiles, Birds and Mammals of Public Health Importance. U.S. Department of Health and Human Services. 1994. 192 pp.

Tick-borne Diseases: Vector Surveillance and Control. Defense Pest Management Information Analysis Center. 1998. 74 pp.

Venomous Arthropod Handbook. Envenomization, Symptoms/Treatment, Identification and Control. U.S. Air Force School of Aerospace Medicine. 1977. 49 pp.

Acknowledgment

Special thanks goes to Robert Rose, EPA biologist, who envisioned the long-term need for updated certification and training materials for pesticide applicators in the country. He shared with the authors the desire to provide a common format to states with public-health certification programs and easy access by the applicators who are responsible for ensuring the safe use of pesticides.

III. BIOLOGY REVIEW

Living things are divided into the plant kingdom, the animal kingdom and several smaller kingdoms of microscopic life. Two **phyla**, Arthropoda and Chordata, include the important major vectors and pests of public-health significance.

Phylum Arthropoda

The animals in this, the largest group of the animal kingdom, are the invertebrates — the insects (Figure 1.1) and their relatives. Arthropods include spiders, mites, ticks, millipedes, centipedes, crabs, shrimp and insects, all of which characteristically have jointed legs and:

Figure 1.1
Insect

- A body made of segments that are grouped or fused together.
- Legs, antennae and other appendages attached in pairs.
- A hard or tough external covering, the **exoskeleton**, with some pliable or soft parts. The exoskeleton holds the body together and gives it shape, performing the same function as the mammal's bony internal skeleton.

Principal **classes** of arthropods are:

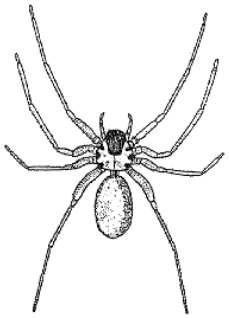

Figure 1.2
Spider

Arachnida. This class includes spiders (Figure 1.2), mites, scorpions, ticks, daddy longlegs and others. These arthropods usually have mouthparts with two prominent structures (**pedipalps**) and needlelike piercing fangs, or **chelicerae**. They have four pairs of legs and two body regions. The mouthparts and legs are attached to the first region, and the reproductive organs and digestive system are contained in the second region.

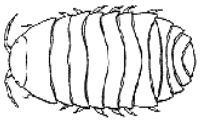

Figure 1.3
Sowbug

Crustacea. This class includes aquatic crabs, lobsters and shrimp, as well as land-dwelling pillbugs and sowbugs (Figure 1.3).

Myriapoda. This group is made up of two classes: millipedes and centipedes. The millipedes have many segments and are wormlike; they are cylindrical with short antennae and two pairs of legs per segment. Centipedes (Figure 1.4) also have many segments and are wormlike, but they appear more flattened and have one pair of legs per segment, antennae and long hind legs (all legs of the house centipede are very long).

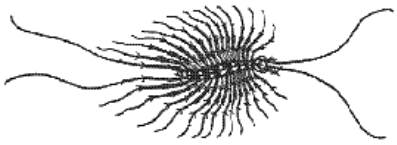

Figure 1.4
Centipede

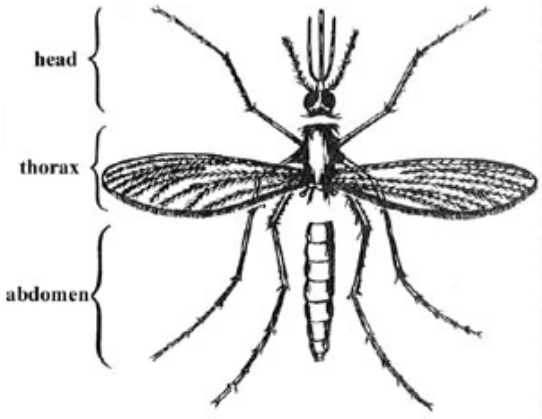

Figure 1.5
Body regions of an insect

Insecta. This class contains the insects, in which the adults have three body regions: **head**, **thorax** and **abdomen** (Figure 1.5). The head bears a single pair of antennae. The thorax bears three pairs of legs and usually one or two pairs of wings. The abdomen contains most of the digestive system and the reproductive organs.

The class Insecta is divided into **orders**, which are distinct groups whose members look very much alike, for example, Lepidoptera (moths and butterflies), Coleoptera (beetles) or Diptera (flies and mosquitoes). Orders are subdivided into **families**, which in turn comprise several or many **genera** (the plural form of **genus**). Each genus includes closely related **species**. Species of animals can be thought of as specific kinds of animals.

Species are always given two-word **scientific names**. The first identifies the genus name (first letter always capitalized) and the second is the species name (always lowercase). Both names are written in italics or underlined, as in *Musca domestica*. Sometimes the name or initial of the person who described the species is also included, as in *Musca domestica* L. (L. for Linnaeus, the describer). Well-known species also may have nonscientific names called **common names**, such as “house fly.”

Structural characteristics of the mouthparts vary dramatically among insects. In addition to the filter-feeding mechanisms found in some aquatic forms, there are four basic types of insect mouthparts: chewing, **sponging**, **piercing-sucking** and **siphoning**. Adult mosquitoes, for example, have piercing-sucking mouthparts, whereas mosquito larvae swallow everything that is small enough to pass through their filter-feeding mouthparts. Among the blood-feeding species, the females are universally blood feeders, but the males may or may not feed on blood, depending on the genus.

Most insect reproduction is sexual, that is, an egg cell from the female develops only after fertilization by a sperm cell from the male of the same species. However, some insect and other arthropod species are asexual and have reproductive mechanisms that do not require a sperm cell.

Growth and development. The exoskeleton of the arthropod body can expand only a little, at the pliable or soft places. It does not grow continuously, but in stages. A new, soft exoskeleton is formed under the old one, then the old one is shed, or **molted**. The new exoskeleton then expands while it is still soft so that it becomes larger than the old one and allows the animal to grow. It hardens and darkens in a few hours. After the molting process, the arthropod resumes its normal activities.

Most arthropods hatch as tiny individuals and increase in size through this molting process, keeping the same appearance until they become adults. A spectacular and very important exception occurs in insects. The class Insecta is divided into groups according to the way the insects change during their development. This technical term for this change is **metamorphosis**, which means "change in form." The three main types of metamorphosis are:

- **Simple metamorphosis.** This group, which includes silverfish, makes no drastic change in form from juvenile to adult. Its members simply hatch and grow larger by molting periodically. Only a few insect orders are included in this group.

- **Gradual metamorphosis.** This group includes cockroaches, crickets, grasshoppers, boxelder bugs, earwigs and more, which hatch from eggs as **nymphs** (Figure 1.6) that resemble the adult form but do not have wings. Some of the orders have many species and include many pests. Nymphs and adults are often found together and usually eat the same food.

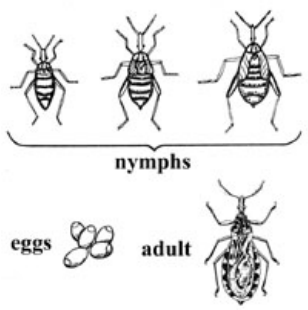

Figure 1.6
Gradual metamorphosis

- **Complete metamorphosis.** Insects that develop by complete metamorphosis (Figure 1.7) undergo a complete change in appearance from juvenile to adult. Insect species that undergo complete metamorphosis number more than all of the other species in the entire animal kingdom! This group includes mosquitoes, flies, fleas, beetles, moths, butterflies, ants, bees and wasps.

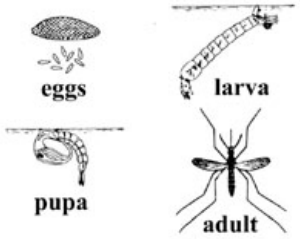

Figure 1.7
Complete metamorphosis

Insects with complete metamorphosis hatch from eggs as **larvae** (grubs, maggots and caterpillars). The larval stage feeds, grows and continues its development without changing form through a number of molts until it becomes mature. It then changes into a **pupa**, which is often immobile. During the pupal stage, change and body rearrangement occurs, for example, development of wings and legs, resulting in transformation into the **adult** stage. Reproduction occurs during the adult stage.

The developmental stages of insects with complete metamorphosis support rather than compete with each other. It is as if two or three completely different animals with different needs and habits represent a single species. The larvae feed and live in one habitat and sometimes leave that area to pupate a short distance away. The adults emerge, require a different food source and live in another area, perhaps returning to the larval feeding sites only to lay eggs. For this reason, pest management specialists must manage species with complete metamorphosis according to where the different developmental stages live

and how they behave. The reader will need to pay special attention to sections that discuss the growth cycle, behavior and **harborages** (areas where insects or other pests remain safely hidden during their periods of rest) of each invertebrate.

Phylum Chordata

The vertebrates are represented by many dominant chordate species in the animal kingdom. The characteristic that sets them apart from the invertebrates is the presence of a spinal column that is usually surrounded by a backbone or vertebral column. This structure, the skeleton, allows chordates to grow continually because the skeleton is internal.

Figure 1.8
Mammal

Individual vertebrate classes include amphibians, birds, fish, reptiles and mammals (Figure 1.8). As with the invertebrates, vertebrate species of interest to public-health considerations are found in a variety of orders, families and genera. In this manual, there are sections dealing with bats, birds, snakes, rodents and other mammals that serve as reservoirs of human pathogens or present other public-health concerns.

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Public Health Pest Control WWW site at http://vector.ifas.ufl.edu/