DISEASES OF DRIED FRUIT AND TREE NUT INSECTS

William R. Kellen and James E. Lindegren
Dried Fruit and Tree Nut Insects Investigations
Market Quality Research Division
Agricultural Research Service, U.S. Department of Agriculture
Fresno, California

Entomologists generally agree that all species of insects are subject to invasion by a wide variety of disease-causing microorganisms, or pathogens, including viruses, bacteria, fungi, and protozoa. Although certain pathogens that belong to these same major groups of microorganisms are responsible for causing diseases of man and other animals, the pathogens of insects are usually incapable of developing in other kinds of animals and are non-toxic to man.

Relatively little attention has been given to the study of diseases of dried fruit and tree nut insects. Such a study may have practical value because of the increased interest in the possible expanded application of a variety of microbial insecticides in pest control programs. When detailed information on pathogen-host relationships is available, it may be feasible to manipulate certain factors in the field in order to encourage the incidence and spread of various insect diseases. It may be possible to culture certain pathogens artificially and to introduce them to areas where they do not occur naturally or in sufficient density to effect an economic level of control. Moreover, since many of our economic pests are not native to this country, it may be desirable to introduce exotic insect diseases from foreign countries.

Insect diseases are known to occur commonly in nature, and when conditions are favorable, they may spread rapidly and cause extensive mortality in insect populations. Most insect pathogens are highly dependent upon the tissues of their hosts for survival; however, a resistant resting stage or spore may be formed in the life cycle of the pathogen which may act to transmit infections to healthy insects. Except for fungi, the spores of insect pathogens usually germinate in the gut, and the infective agent penetrates into the body of the host.

Spores may be voided with the feces of sick insects, or they may be liberated from the decomposed bodies of insects that have succumbed to disease. Such infective spores may contaminate the source of insect food, and become readily available for ingestion by other insects.

If moisture conditions are suitable, spores of pathogenic fungi germinate when they come in contact with the cuticle of an insect. The growing tip of the fungus penetrates directly through the body wall and quickly invades the various tissues of the host.

Some diseases of insects may be transmitted congenitally. Insects that do not acquire a fatal disease may harbor inapparent infections and survive to the adult stage. In such cases many types of pathogens, especially certain protozoa and viruses, may be transmitted from generation to generation via the egg. In some instances eggs may be contaminated externally with spores as they are laid; the

mouthparts of young larvae subsequently become contaminated with pathogens as they emerge from the egg. Many pathogens are capable of invading the ovaries of diseased insects; they are transmitted within the egg to the developing embryo.

The degree of host specificity of various pathogens varies greatly. Some insect pathogens, including many bacteria and fungi, are capable of invading a large number of unrelated species of insects, and may attack several kinds of tissue. Other pathogens, including certain protozoa and viruses, may develop in only one type of tissue, such as fat or muscle, and may develop normally in only one or a few closely related insects.

Usually there are apparent signs or symptoms by which diseased insects may be recognized. Infected individuals frequently become sluggish or flaccid, and do not react normally to strong stimuli. They may cease to eat, and exhibit signs of stunted development. Certain areas of the body may become distended, and there may be obvious changes in the color or normal transparency of certain areas of the body.

With the exception of Bacillus thuringiensis Berliner, a bacterial disease which is known to invade larvae of more than 100 species of butterflies and moths, relatively little is known about the diseases of dried fruit or tree nut insects. In our laboratory, we have examined samples of several populations of the Indian-meal moth, Plodia interpunctella Hübner, the raisin moth, Cadra figulilella Gregson, and various species of dried fruit beetles, Carpophilus sp. We have frequently observed diseased insects, and we are attempting to determine their host-pathogen relationships.

The most common pathogens that we have observed belong to the Protozoa; they have been identified as Microsporidia. This was the first time that such pathogens have been reported from dried fruit or tree nut insects. At least 5 different species of these unicellular pathogenic agents have been isolated from sick larvae. The pathogens have rather complex life cycles, and they are readily transmitted by means of resting spores. Data which we have obtained from laboratory tests indicate that these particular pathogens are not strictly host-specific, however, they appear to achieve optimum growth in certain preferred hosts.

The spores of one of the pathogens from the Indian-meal moth are less than four microns long (about 1/6000 inch). In laboratory studies it has been simple to transmit this disease by contaminating the larval rearing medium with a suspension of spores. The spores germinate readily in the larval gut, and 72 hours after exposure areas of infection are usually evident in the wall of the gut and associated fat tissue. This pathogen is capable of invading many different tissues, however, the salivary and silk glands and fat bodies are usually completely destroyed in advanced infections. About 10 days after initial infection diseased larvae are about one-half as large as healthy larvae; they are unable to pupate, and succumb to the disease as stunted larvae.

It is not possible to rear such microsporidian pathogens on artificial media, however, it may be feasible to accumulate large quantities of spores from larvae that are reared and infected in the laboratory. Spores obtained in this way may be applied in field tests to determine the feasibility of increasing the distribution and incidence of the disease.

Several other protozoan pathogens of dried fruit and tree nut insects have been also isolated in our laboratory and are under investigation to determine their host-pathogen relationships. Similarly, two distinctly different types of insect viruses have been isolated from larvae of the Indian-meal moth and the almond moth, Cadra cautella Walker. Future studies will include tests to determine the mode of transmission of these pathogens, their virulence, and the feasibility of applying them in the field to assist in the regulation of insect populations.

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