INSECT PATHOLOGY IN BIOLOGICAL CONTROL

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Notes

I. Insect Pathology

A. There are 3 major subdivisions of biological control:

1. BC of athropod pests;
2. BC of weeds; and
3. Insect Pathology.

B. Disease classifications:

1. Infectious: those ailments resulting from actions of living organisms. Pathogenic agents include viruses, bacteria, protozoa, fungi, rickettsia, and nematodes.
2. Non-infectious: those ailments not resulting from actions of living organisms or micro-organisms. These include:

   a. Those caused by mechanical injury;
   b. Those caused by chemical agents;
   c. Nutritional disturbances or deficiencies;
   d. Those caused by physiological or metabolic arrangements;
   e. Genetic diseases;
   f. Congenital (non-genetic) abnormalities; and
   g. Tumors (abnormal growth of tissue).

C. Insect pathogens can be used as BC agents in IPM in 3 different ways:

1. By the maximum utilization of naturally occurring diseases;
2. By the introduction of insect pathogens into the insect population as permanent mortality factors;
3. By the repeated application of insect pathogens as microbial insecticides for temporary control of an insect pest.

D. Definition of Microbial Control: that control which includes all aspects of the utilization of micro-organisms or their by-products in the control of insect pest species.

II. Infectious Pathogens: Inclusion Viruses - submicroscopic, obligate, intracellular, pathogenic organisms.

A. Nuclear polyhedrosis viruses (NPV): virus particles are rod-shaped and are encased in an outer envelope which may enclose one or several virus rods (dependent on the particular NPV). The viruses enclosed in the envelope are occluded (encased) in protein crystals called polyhedra.

1. NPV is normally transmitted by oral ingestion of polyhedra. Ingested polyhedra dissolve, releasing virus rods into the lumen of the insect host's midgut.

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2. Symptoms of NPV infected host include:

    a. Larval skin darkens and may have yellow patches or appear oily;
    b. Skin becomes fragile;
    c. Hemolymph becomes turbid;
    d. Prior to death, infected larva usually climbs to highest point available and dies; and
    e. After death, integument frequently ruptures, releasing millions of polyhedra.

B. Granulosis viruses (GV): GV particles are surrounded by an envelope similar to NPV's envelope. Particles surrounded by these membranes are occluded in a proteinaceous capsule similar to the polyhedral protein that occludes NPV's.

1. GV usually contains only one GV particle rather than many virus particles contained in NPV's and Cytoplasmic Polyhedral Viruses (CPV's).
2. The fat body of lepidopterous larvae is the primary site of infection.
3. GV's are transmitted orally and via the egg.
4. Symptoms of a GV infected host include:

    a. Larvae frequently develop lighter color;
    b. Blood of infected larvae is usually turbid and contains large numbers of capsules; and
    c. GV infections involving the epidermis cause liquefaction of larvae similar to NPV infections (but only when epidermis is infected).

C. Cytoplasmic polyhedrosis viruses (CPV): particles are not enclosed in membranes as are NPV's, but are occluded in protein crystals similar to those of NPV's.

1. CPV infect the cytoplasm of the midgut epithelium of lepidopterous larvae.
2. Symptoms of CPV infected hosts include:

    a. Developmental times of host larvae are longer than normal;
    b. Infected larvae appear to have small bodies and large heads; and
    c. Body color may change.

III. Bacteria

A. Nonspore-forming bacteria

1. Potential pathogens
2. Live in digestive tracts of most insects
3. Gain entrance to hemocoel due to stress factors

    a. Temperature extremes
    b. Other pathogens

Notes

c. Parasites
d. Poor food

B. Spore-forming bacteria - most important bacterial pathogens

1. *Bacillus popilliae* - causes milky disease in white grubs of scarab beetles such as the Japanese beetle.

a. Transmitted orally by ingestion of spore
b. After ingestion, spores germinate and penetrate the alimentary canal (probably through the Malpighian tubules)
c. Found in blood ca. 30 hrs after initial invasion (30°C)
d. 7 to 10 days later, ca. 2-5 billion spores/larva
e. Larva's blood appears milky due to spores
f. Larva dies shortly thereafter
g. Commercial production of spores must be produced in living hosts - no artificial media available

2. *Bacillus thuringiensis* - very pathogenic to many lepidopterous larvae and immatures in 4 other orders.

a. Transmitted orally
b. When the bacteria sporulates, it forms a toxic crystal (parasporal body)

i. Different lepidoptera exhibit different responses to the various combinations of crystal and *B. thuringiensis* spores. Some are susceptible to action of either the crystal or the spore alone (some to both):

- Type I: develop a general paralysis and die 1 to 7 hrs after ingestion;
- Type II: do not develop a general paralysis and die 2 to 4 days after ingestion;
- Type III: susceptible to a combination of crystals and spores; and
- Type IV: some lepidoptera not susceptible.

c. After ingestion of spores, first symptom in both Type I and II is cessation of feeding
d. Activity of crystal is dependent on the pH of the larval foregut and midgut (pH 9-10.5) and the action of proteolytic enzymes within the gut
e. The crystal is a protoxin activated by enzymic hydrolysis
f. *Bacillus thuringiensis* can be grown on artificial media. Hundreds of tons are manufactured in the U.S. The variety in the commercial preparation Dipel is *B. thuringiensis var. kurstaki*

Notes

IV. Fungi

A. More than 36 different genera of fungi contain species which cause insect disease.
B. Identification of fungus species is difficult.
C. Most fungi are transmitted from one host to another by a spore, usually a conidium

1. Conidia germinate and form a special structure which penetrates the insect cuticle
2. Fungus then grows in insect's body until the insect is filled with mycelia (insect is usually dead at this point)
3. Under favorable conditions, fungus continues to grow and produces structures which protrude through the cuticle and forms spores or conidia

D. Development of fungus infections is dependent on environmental conditions such as high humidity and temperature and high population densities.
E. Examples of Fungi are:

1. *Metarrhizium anisopliae*
2. *Beauveria bassiana*
3. *Entomophthora* spp.

V. Protozoa

A. Flagellates, ciliates, amoebas, coccidians, and haplosporidians have pathogenic relationships with insects, but are considered the least important groups.
B. Neogregarines and microsporidians are the most important entomopathogenic protozoa.

1. They are transmitted orally from one insect to another (have a resistant spore)
2. They can be transmitted transovarially from infected females to her progeny
3. They produce diseases in insects which range from very pathogenic to chronic debilitating infections
4. They can be important naturally occurring mortality factors
5. They are obligate parasites which cannot complete their life cycles in artificial media

VI. Nematodes

A. Several entomopathogenic nematode families (Mermithidae, Steinernematidae, Heterorhabditidae) contain species that are parasites of insects during at least part of the nematodes development.
B. Normally, they have 4 molts between the egg and adult stages and between stages are referred to as juveniles.

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C. Most nematodes infect insect hosts as infective stage juveniles.

1. They may enter through the host cuticle or through the midgut
2. After entrance into the hemocoel, juvenile undergoes a period of rapid growth, then leaves the host, enters the soil and molts to form the adult nematode

D. Mating and oviposition occur external to the host in the Mermithidae.
E. Some species kill their hosts upon leaving.
F. Some species transport bacteria when they enter the cavity of the host and the insect dies from bacterial septicemia and the nematode feeds on the bacteria in the dead host tissue.
G. Most nematodes are difficult to culture on artificial media.
H. Only obligate endoparasitic nematodes are found in the genus *Steinernema* (= *Neoaplectana*).

VII. Introduction and application of insect diseases for long-term suppression.

A. Control by insect pathogen is dependent on the relationship between the economic level of the host density and the threshold level of the disease.

1. If the threshold level of the disease is significantly lower than the economic threshold for the pest, then long term control can be achieved by introduction of the pathogen into the system.
2. If the threshold of the disease is significantly higher than the economic threshold for the pest, then only short term control will be achieved analogous to the use of chemical insecticides.

B. Several factors should be considered when introducing a pathogen into an insect population. These include:

1. The concentration of the insect pathogen must be high enough to produce infection in at least some of the insect hosts.
2. The host population in which the pathogen is to be applied should have a relatively high density in order to assure propagation of the pathogen and its survival from one generation to the next.
3. The pathogen should be applied when a susceptible stage of the host is present.

QUESTIONS

1. What is an infectious disease?
2. How are insect pathogens used against pests in IPM programs?
3. Distinquish NPV from CPV.
4. What organism causes milky disease in white grubs? Describe the disease process.
5. What factors influence fungus infections in insect populations?
6. Why are some nematode species good candidates for augmentation programs?
7. Discuss the factors that should be considered when one wishes to introduce a pathogen into a pest population.

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