ESTABLISHMENT AND EVALUATION OF BIOLOGICAL CONTROL AGENTS

Notes

I. Post-Importation Procedures

A. After natural enemies are shipped to the area intended for introduction, four additional phases of BC procedure must be dealt with before the process is complete. These are:

1. Quarantine;
2. Colonization & Establishment;
3. Evaluation; and
4. Cost / benefit analysis

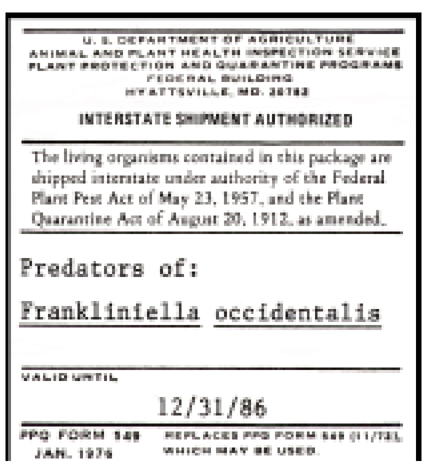
II. Quarantine

A. Philosophy of quarantine: prevention of the introduction of undesirable species of phytophagus insects, weeds, hyperparasites, plant pathogens and/or any other type of undesirable organism.

B. Pest organisms do not respect political borders and only their environmental preferences restrict organisms to certain geographic areas. These areas do not usually coincide with each other. Quarantines defend political borders.

C. Travelers to Hawaii are subject to quarantine check with respect to organisms they consciencously or unconsciencously bring into the state.

D. All insects imported into Hawaii for scientific reasons must be accompanied by importation permits allocated by the Federal Government (see Fig. 18.1). These permits are obtained after approval of state (e.g., Quarantine Branch, Hawaii Dept of Agriculture) and federal government agencies (e.g., USDA Animal & Plant Health Inspection Service [APHIS] and U.S. Fish and Wildlife Service).



U. S. DEPARTMENT OF AGRICULTURE
ANIMAL AND PLANT HEALTH INSPECTION SERVICE
PLANT PROTECTION AND QUARANTINE PROGRAMS
FEDERAL BUILDING
HYATTSVILLE, MD. 20782

INTERSTATE SHIPMENT AUTHORIZED

The living organisms contained in this package are shipped interstate under authority of the Federal Plant Pest Act of May 23, 1957, and the Plant Quarantine Act of August 20, 1912, as amended.

Predators of:

Frankliniella occidentalis

VALID UNTIL

12/31/86

PPQ FORM 540 JAN. 1976 — REPLACES PPQ FORM 540 (11/73), WHICH MAY BE USED.

Fig. 18.1. Example of importation permit issued by USDA APHIS. Natural enemy shipment containers should display an official permit.

E. Shipments which are suitably packaged and have the correct importation permits move easily through quarantine inspections in route to the quarantine facilities at the Hawaii Department of Agriculture, Honolulu (parasitoids, predators & insect and plant pathogens) or the Federal Facility, Volcano Nalt. Park (phytophagous agents for weed control)

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F. In quarantine, everything used in shipping insects is either destroyed or autoclaved. Any live host material is destroyed. Only predators and parasitoids are kept and these are cultured to insure no hyperparasites are present in the shipment.

G. Only until the natural enemies are absolutely identified and their potential for becoming a pest species is known to be zero are the imported species released from quarantine for the establish phase. Phytophagous insects imported for weed control remain in quarantine until researchers are absolutely positive that they will not attack any other host plant of value except the plant species targeted for control. In the last few years, host specificity testing has become more commonplace for natural enemies of arthropods as a result of community fears of non-target impacts on desirable species (e.g., endemic species).

III. Establishment

A. The first step in establishment of a species in an area is to colonize it. Colonization may be defined as the process of field release and manipulation of imported natural enemies so as to establish them and favor their increase and dispersal in a new environment.

B. Successful colonization results when a natural enemy has been permanently established in one locality. This locality serves as a locus for natural enemy spread and as a field colony and a source of material for further distribution methods.

C. Initial colonization may be attempted by two methods which are:

1. Direct releases from quarantine; and
2. Insectary propagation.

D. Direct Releases: these are not encouraged by many BC researchers. Many scientists insist that insectary propagation offers some distinct advantages. When the direct release method is used, repeated introductions from abroad are required followed by periodic releases. Direct releases may be the best method when:

1. Funds are lacking for insectary propagation;
2. Rearing of the host or natural enemy is difficult and;
3. Adequate facilities are lacking for propagation.

E. Insectary Propagation offers some advantages which include:

1. Provision of adequate numbers of natural enemies for releases (insures greatest latitude in the timing and geographic coverage of releases);
2. Insectary culture insures vigorous stocks for releases; and
3. Provision of an opportunity for detailed studies of biologies and host relationships of natural enemies.

F. In earlier years in the USA, upon receipt of natural enemies (and subsequent check on their potential as pests) usually a few specimens were directly released from the initial stocks imported. This is not generally practiced in the USA now, but may be in foreign countries. In some cases low numbers of individuals may be enough to achieve establishment. If establishment is achieved, then time and labour will be saved with respect to insectary propagation. However, trial releases

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are generally doomed to failure. There are a few cases where success was achieved (Establishment of the lace bug, *Teleonemia scrupulosa*, as a BC agent on the weed *Lantana camara* - established in Hawaii with 6 individuals).

G. Many ecological factors determine the success or failure of colonization efforts. Reasons for failure of colonization:

1. Failure to adapt to climatic conditions
2. Lack of alternative hosts in new environment
3. Native natural enemies (although ineffective) may (due to their high numbers) compete with introduced species and thus prevent the limited numbers of insects from establishing a pernament colony

H. Lack of establishment of species may be due to:

1. Unsuitability of host plants as shelters for new natural enemies
2. Adequate food sources unavailable
3. Unsuitability of attractant stimuli during host habitat finding phase by adult parasitoids
4. Certain host stages or species may prove physiologically unsuitable
5. Highly developed dispersal habits may retard or hender establishment of natural enemies due to problems in individuals finding each other to mate (when population densities are small)

I. The critical test in the ability of a natural enemy to become established is whether it has the ability to survive periods of climatic extremes (e.g., summer heat and winter cold).

IV. Evaluation of Established Natural Enemies

A. Three reasons to evaluate BC agents

1. To show the value and short comings of existing natural enemies
2. To provide insights into the principles of population ecology relating to the interplay of biotic and abiotic factors
3. To demostrate the effectiveness of natural enemies

B. Two distinct questions may be asked in evaluation of natural enemies. These are:

1. Does regulation of the host population by the introduced natural enemies actually occur?
2. How does the regulation of the host occur?

C. Experimental proof of regulation is needed

1. Sometimes new pest invasions and outbreaks eventually subside to lower levels even when no BC agent is introduced for control (e.g., two-spotted leafhopper in Hawaii)
2. Increased levels of parasitization or predation by newly established natural enemies is not the best measure of effectiveness

   a. It has been shown that percentage parasitization <u>cannot be equated</u> with level of control exerted (see Fig. 18.2)

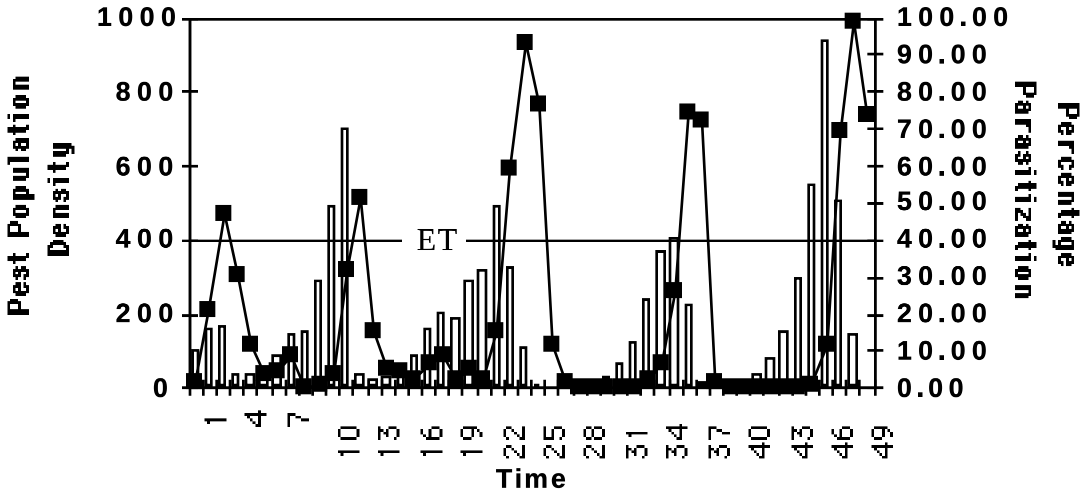

Fig. 18.2. In the above graph, the pest density (–■–) [left axis] and percentage parasitization (bars) [right axis] is shown. Note that if a economic threshold (ET) were set at a density of 400 pests, then all pest populations would be above the ET even though as much as 70% parasitization had been achieved.

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b. It is the number (not the percentage) of survivors that escape natural enemy action that determines subsequent pest density

D. Legner (1969) stated that the "ultimate and probably only reliable method for judging a parasite's effectiveness is the reduction in host equilibrium position following liberation". This requires an evaluation of a parasite's effectiveness by using "before" and "after" introduction density comparisons.

E. Hassell and Varley (1969) state that "laboratory studies can go some way to predict which species (among several introduced) may be successful, but an introduction provides the only real test".

F. Experimental (comparison) methods of evaluation - most of these methods can be employed with either newly introduced, exotic natural enemies or indigenous natural enemies. These include:

1. Addition Method
2. Exclusion Method
3. Interference Method

V. Addition Method

A. This is essentially a "before" and "after" comparison. Set up a number of plots (e.g., 20) and introduce natural enemies into 10 plots and leave others as controls. Check them at a later time to see the impact.

B. Plots must be set up prior to introductions of natural enemies. Plots must be distant from each other to prevent invasion of check plots by introduced natural enemies.

VI. Exclusion Method (also known as Subtraction Method)

A. This technique involves the elimination and subsequent exclusion of resident natural enemies from a number of plots which can then be

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compared with a like number of otherwise comparable plots where the natural enemies are not disturbed.

B. Significantly different "before and after" pest population densities indicating different equilibrium levels for the two groups of plots serve as a direct measure of the control and regulating effectiveness of the natural enemies.

C. Experiments must be designed to be biologically realistic. One should not alter parameters such as temperature and dispersal area which may exert an appreciable influence on the results. The techniques work best with insects with low powers of dispersal.

D. Natural enemies are mechanically excluded from hosts by use of exclusion cages (this is often referred to as the "paired cage" technique). These take several different forms. The general process is:

1. Select sites for the studies.
2. Clean up sites with insecticides or by hand removal of pests and parasitoids.
3. Re-introduce pests into cages.
4. Close cages up and let pests become established
5. Open one cage up to natural enemies
6. Take census counts during the study

VII. Interference Method

A. This method involves greatly reducing the efficiency of natural enemies in one set of plots as contrasted to another set having natural enemies undisturbed.

B. Any increases in pest density in the interference plots, relative to the normal biological control plots, demostrates the effectiveness of the natural enemies.

C. Such comparisons reveal only a part of the total extent of host population control because the natural enemies are not entirely removed and may be producing some limiting effect.

D. The percentage parasitism may commonly be as great in the interference plots as in the normal activity plots. The density of the pest population at equilibrium is determined by the rate at which premature mortality of a pest increases with pest density. If the rate of parasitization increases rapidly as the host population starts to increase, the host equilibrium density will be low. If it increases slowly, the density will be high. Because the equilibrium mortality level (mortality = natality) is reached quickly at low levels in the unexcluded plots and not in the latter, this illustrates the difference between an effective and ineffective natural enemy.

E. The above explanation also explains why pesticides (an interference measure) can cause pest upsets when effective natural enemies are inhibited and why parasitoids may be even more abundant in a chemically treated habitat and yet unable to control the pest, or maintain it at a low density.

F. The various techniques in the Interference Method include:

1. Insecticide check method
2. Hand-removal method
3. Biological check method
4. Trap method

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G. Insecticide Check Method: Selective toxic materials are used to interfere with the natural enemies. Usually these are insecticides such as DDT, Methomyl, or Carbaryl. Can also be substances such as talc or road dust. However, some compounds induce the condition of hormoligosis which is the stimulation of an insect to produce more eggs by sublethal doses of insecticides.

H. Hand-Removal Method: Natural enemies are periodically removed from area. Intensive labor required and time consuming. Used in studies on regulation of spider mite mite densities by natural enemies on foliage of strawberries and papaya. Too expensive with respect to "manpower".

I. Biological Check Method: Interference with ants that naturally interfere with natural enemies which attack honeydew producing insects. Ants may be eliminated by insecticides (e.g., Amdro®) or barriers such as "Tack Trap". Restriction of the Argentine ant, *Iridomyrmex humilis* Mayr, resulted in control of California red scale. In Hawaii, suppression of the big-headed ant, *Pheidole megacephala*, in pineapple plantings led to reductions in pineapple mealybug densities.

J. The Trap Method: A large area is selected as the test site. Insecticides are applied around the outside borders thus creating a wide band of insecticide treated foliage which must be crossed by organisms either leaving or entering the test site. Nothing is modified directly in the test area, thus natural enemies are not inhibited. This technique is most successful with fairly sessile pests which have rather mobile natural enemies. By use of several different selective chemicals applied at required intervals one could make this a fairly sophisticated technique.

VIII. Life Tables and Population Models

A. The techniques discussed above only tell us how effective are natural enemies, but they do not tell us why they are effective nor how we can change the system to improve their effectiveness.

B. The use of life tables and population modeling allows one to break apart the systems in which we are interested and to analyze the components.

C. Comparison methods tell us if natural enemies are effective whereas population modeling can tell why they are effective.

IX. Cost / Benefit Analyses

A. Financial evaluation is beneficial to a program to view the economic benefits of biological control and should be implemented after establishment, implementation, and adoption of the natural enemies as a control factor.

B. Typically, classical biological control has a much better return on the financial investment (as much as $30 to every $1 invested) than chemical control, and often it keeps on providing benefits without additional inputs.

C. Consult notes on economics of biological control for more information.

QUESTIONS

1. Why is "quarantine" an important and necessary part of any biological control introduction program?
2. How does one obtain an importaion permit?

3. How does establishment of a species differ from colonization? What factors interfere in attempts to successfully colonize and establish a natural enemy?
4. Why do we evaluate the effectiveness of a natural enemy?
5. What are the three major experimental (comparison) methods used to evaluate natural enemy effectiveness in a habitat?
6. How would one do a paired cage technique?
7. How would one conduct the pesticide check method?
8. Few biological control programs are adequately evaluated. Why?

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