ANALYSIS OF BC SUCCESSES AND CASE HISTORIES

Notes

I. Successes in Classical Biological Control

A. Successes may be divided into 3 categories based on an economic scale:

1. Complete BC: biological control obtained and maintained against a major pest of a major crop over a fairly extensive area so that insecticidal treatment becomes rarely, if ever, necessary.

   Example: Cottony cushion scale, *Icerya purchasi*, controlled by the vedalia beetle, *Rodolia cardinalis*, in Hawaii.

2. Substantial BC: cases where economic savings are somewhat less pronounced by reason of the pest or crop being less important, by the crop area being restricted (such as a small island), or by the control being such that occassional insecticidal treatment is indicated.

   Example: *Liriomyza* leafminers on watermelon controlled by various natural enemies introduced into Hawaii

3. Partial BC: cases where chemical control measures remain commonly necessary but either the intervals between applications are lengthened or results are improved when the same treatments are used or outbreaks occur less frequently.

   Example: Lebbeck mealybug, *Nipaecoccus vastator*, on various plants controlled by *Anagyrus dactylopii* (hymenopterous parasitoid) imported into Hawaii from Hong Kong.

B. Analysis of worldwide attempts at biological control of insect pests shows:

1. More than 1,300 cases of BC have resulted in either partial, substantial or complete control of target species
2. More than 135 species of insect pests and weeds have been substantially to completely controlled by introduced natural enemies
3. During the last 100 years there has been 1.4 BC successes per year
4. Ranking of insect orders with regards to successes in BC

1st - Homoptera	5th - Hymenoptera
2nd - Lepidoptera	6th - Orthoptera
3rd - Coleoptera	7th - Heteroptera
4th - Diptera	8th - Dermaptera

Table 20.1. Success in biological control of arthropods and weeds in Hawaii.

Pest Organism	Number of projects	Projects with substantial to complete control
Weeds	9	6
Scales	3	3 (Homoptera)
Mealybugs/Whiteflies	6	4 (Homoptera)
Aphids	1	1 (Homoptera)
Leaf- and Planthoppers	3	3 (Homoptera)
Heteroptera	1	1
Orthoptera	5	3
Lepidoptera	5	2
Diptera	4	3
Coleoptera	4	2
Thysanoptera	1	1
Spiders	1	1
Snails	1	1
TOTAL	44	30

Notes

C. Rough analysis of BC successes in Hawaii (Substantial to Complete)

With respect to biological control in Hawaii:

1. Most of the successes have occurred in the Homoptera (11)
2. Successes with introduced weeds have been high
3. California and Hawaii lead the world in the number of complete BC successes. The world leaders in BC are:

1st - California	27 successes
2nd - Hawaii	25
3rd - Rest of U.S.A.	23
4th - Canada	17
4th - Australia	17
5th - New Zealand	10
6th - Fiji	7
6th - Chilie	7
6th - South Africa	7
6th - Peru	7

D. Correlations with successful BC projects:

1. Over a period of time, the number of successes attained will be proportional to the amount of research and importation work carried out
2. Worldwide there are 4 times as many successes with parasitoids as with predators
3. Majority of the successes have been with scale insects
4. In the biological control of weeds, there has been a great number of successes against *Opuntia* sp.

Notes

II. Case Histories - See supplements provided and reading material

The following case histories will be examined in lecture:

Sugarcane Leafhopper in Hawaii - 1920
Citrus Whitefly - 1967
Spiny Blackfly (Orange Spiny Whitefly) - 1925
Coconut Scale - 1928
Citrophilus Mealybug - 1928
Citrus Blackfly - 1930
Citriculus Mealybug - 1940
Citrus Blackfly - 1948
Rhodesgrass Scale - 1957
Dictyospermum Scale - 1962
Green Vegetable Bug - 1963

Prickly Pear Catus - 1925
Klamath Weeds - 1944

Students will be responsible for additional case histories discussed and summarized in handouts which were covered in previous lectures.

SIGNIFICANT EVENTS OF CASE HISTORIES OF BIOLOGICAL CONTROL PROJECTS

Sugar-cane Leafhopper, *Perkinsiella saccharicida*

Use of an insect predator belonging to an insect family predominantly composed of plant feeding species.

Citrus whitefly, *Dialeurodes citri*

Biological control projects should be carried on when there is any chance of success. This project was terminated due to difficulties in importation of natural enemies. Fifty-five years later, importations of natural enemies were resumed.

Spiny blackfly (**Orange spiny whitefly**), *Aleurocanthus spiniferus*

Costs of biological control importations can be extremely low when there is good cooperation among research scientists.

Prickly pear cactus, *Opuntia* spp.

Outstanding successes throughout the world. Analogous to the successes with the cottony cushion scale.

Notes

***Eucalyptus* snout beetle**, *Gonipterus scutellatus*

1) Project showed that an egg parasitoid can be an effective biological control agent.

2) Effective natural enemies will become established within 3 years at or near the release sites, but it may take many years to obtain complete biological control throughout the pest's ecological range.

Coconut scale, *Aspidiotus destructor*

Parasitoids may not always be the most effective natural enemies. This pest was controlled by a predatory coccinellid within nine months following its release.

Citrophilus mealybug, *Pseudococcus fragilis*

Ranks second only to the cottony cushion scale in success in California.

Citrus blackfly, *Aleurocanthus woglumi*

1) Work in Cuba showed that *Eretmocerus serius* was the best parasitoid for this pest in the Caribbean area.

2) Work in Mexico showed that *Amitus hesperidum* was a generally effective parasitoid in dry areas but it did not work well when it was hot. *Prospaltella opulenta* was dominant in hot areas and *Prospaltella clypealis* was good in humid areas.

3) For many situations, there may be no one "best" natural enemy. In order to obtain complete biological control in some areas, one may need a complex of parasitoids, each with different ecological requirements.

Citriculus mealybug, *Pseudococcus citriculus*

1) Identification of the pest species targeted for biological control is just as important as accurate identifications for the natural ememies. Misidentification can result in foreign exploration being carried out in the areas where suitable natural enemies are lacking.

2) Personal initiative is extremely important in carrying out biological control projects. Two of the main participants in this project were not professional entomologists.

Klamath weed (**St. Johnswort weed**), *Hypericum perforatum*

Some problems may arise when bringing insects from one hemisphere to the other (insects have to make adjustments in yearly cycles).

Rhodesgrass scale, *Antomina graminis*

1) Parasitoids which control a pest in one location may not be suitable in a second location with significantly different ecological parameters.

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2) A parasitoid with low dispersal abilities may be effective as a biological control agent, especially when aided by Man (parasitoids distributed by plane).

California red scale, *Aonidiella aurantii*

1) Longest active project against a pest (since 1889).

2) Classical example of competitive displacement among parasitoids.

3) The search continues for parasitoids to control this pest in the harsher inland areas of the San Joaquin Valley, California.

Dictyospermum scale, *Chrysomphalus dictyospermi*

1) Project completed for a few hundred dollars.

2) Natural enemies transported from near Los Angeles, CA, to Athens, Greece, in 24 hours.

3) Fastest dispersal of *Aphytus melinus* recorded in a year's time: 124 miles (remember *A. melinus* is ca. 1 mm in length).

Green vegetable bug (**Southern green stink bug**), *Nezara viridula*

1) Good evaluations are important to the science of biological control.

2) The introduced natural enemy may not always be the one reducing the pest numbers.

Walnut aphid, *Chromaphis juglandicola*

1) More than one strain of the same natural enemy species may be required for complete biological control over a widely varying ecological area.

2) Complete control of an aphid species (aphids were originally thought to be uncontrolable by natural enemies due to their high reproductive capacities).

QUESTIONS

1. Differentiate "complete", "substantial", and "partial" biological control.
2. What order of insects tends to have the greatest successes in classical biological control? Why?
3. What was significant about the project against the prickly pear cactus?
4. What was significant about the project against the *Eucalyptus* snout beetle?

REFERENCES

DeBach, Paul. 1964. Successes, trends, and future possibilities. *In* Biological Control of Insect Pests and Weeds (P. DeBach, editor), Chapman and Hall Ltd., London. 844 pp.

DeBach, Paul. 1974. Biological control by natural enemies. Cambridge University Press, London. 323 pp.

van den Bosch, R., P. S. Messenger & A. P. Gutierrez. 1982. An introduction to biological control. Plenum Press, New York. 247 pp.

READING ASSIGNMENT:

pp. 106–189. **DeBach, Paul. 1974.** Biological control by natural enemies. Cambridge University Press, London. 323 pp. **[see handout]**