FOREIGN EXPLORATION AND IMPORTATION OF BC AGENTS

Notes

I. Introduction

A. In classical biological control there are several steps involved from the initiation of the search for natural enemies to the final evaluation of BC agents in the area of release. These may be divided into:

1. Foreign exploration
2. Quarantine handling
3. Colonization
4. Establishment
5. Evaluation.

B. Foreign exploration is most often inacted when outbreaks of exotic pests occur due to the lack of their natural enemies to control them. The importation of beneficial insects is the most widely practiced and potentially the most rewarding approach to biological control.

C. The objective of foreign exploration is to detect, select, and export natural enemies which show promise as biological control agents and to provide information facilitating their establishment in the country of introduction.

D. The selected agents should be imported in:

1. Healthy condition
2. Suitable stages
3. Sufficient quantities

to insure safe arrival at their destination.

E. The foreign explorer should also collect data for later comparative evaluations of the natural enemies in their original and adopted ecosystems (improve understanding of biological control itself).

F. Organization of a foreign exploration program is dictated by the objectives of the project. It is necessary that these objectives be well defined. Needed information to define objectives includes:

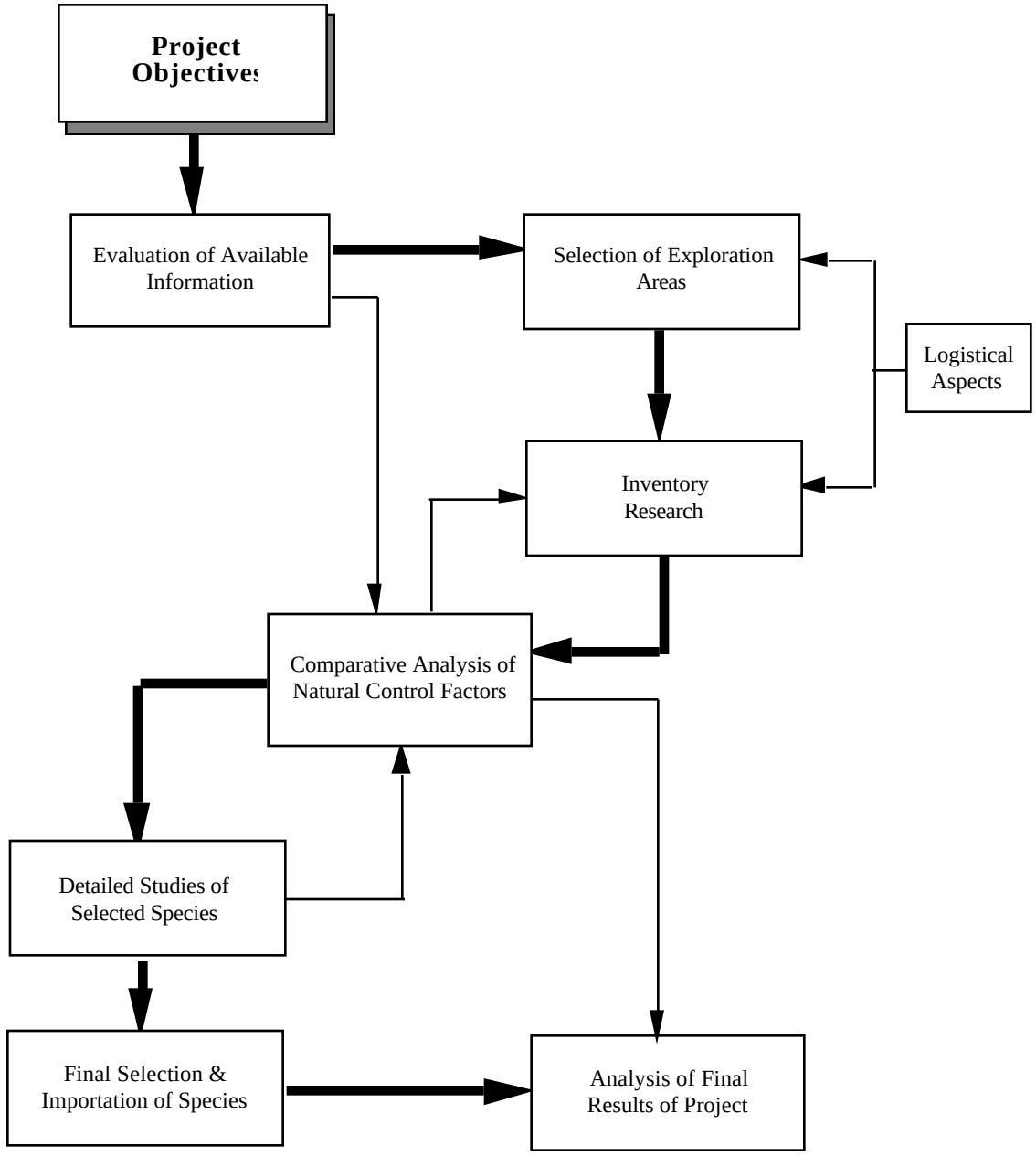
1. Type of target organisms (plant or animal)
2. The organism's noxious status worldwide
3. Results of previous attempts at BC, if any
4. The quantity and quality of information available on its natural enemies
5. The level of financial, collaborative, and logistical support available

These factors will determine the scope and depth of the program.

G. Various phases of a foreign exploration program (pioneer type) are diagrammed on next page. They may be organized in the following manner:

1. Planning and preparation of the program

a. Accumulation and evaluation of available information
b. Selection of target organisms and exploration areas



Information flow in foreign exploration programs (modified from Zwölfer et al. 1976).

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2. Inventory research and investigations on selected species

   a. Inventory research
   b. Comparative analysis of natural control factors
   c. Detailed studies on selected species

3. Importation of natural enemies

   a. Final selection of agents for introduction
   b. Preparation of the material for shipment

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4. Analysis of final results of project

H. Under actual conditions several phases usually proceed concurrently. Information obtained in one phase can be extremely useful in other phases.

II. Accumulation and Evaluation of Available Information

A. This information should be obtained prior to the actual search for natural enemies:

1. Taxonomic position, life history, and economic importance in country of origin
2. Native geographical distribution
3. Total present distribution
4. Host plant distribution
5. Probable center of origin of the organism and its close relatives
6. Coextensive occurrence of related species
7. Occurrence and distribution of related and ecologically similar species in regions where the target organism does not occur but where exploration for an enemy agent seems desirable because of climatic similarities to infested areas of country of introduction
8. Available records of natural enemies and other mortality factors.

B. Correct identifications of pests and natural enemies cannot be stressed enough. Incorrect identifications or nomenclatural inconsistencies can greatly impede progress. Wrong identifications could result in foreign exploration in the wrong geographical areas.

III. Selection of Target Organisms and Exploration Areas

A. Logistical Aspects: several problems may be encountered which modify exploration schemes. These include:

1. Inaccessibility of a search area because of national or international considerations, unavailability of transportation, or inclement weather
2. Lack of laboratory facilities within the search area
3. Restrictive customs procedures barring importation of specialized equipment into the search areas
4. Maintenance of cultures or collections during extended research periods
5. Quarantine restrictions on material imported for testing purposes

B. Target Organisms: first choice of natural enemies should be those dominant species occurring at low densities in the native home of the pest. If no promising control agents of the target species can be found (or if control of a native species is desired) then species closely related to the target organism (pest) should be used as sources of natural enemies.

C. Exploration Areas: several criteria must be considered in selection of exploration areas:

1. Searches should initially be undertaken in areas where target species is native because chances are increased for finding rich, diversified complex of natural enemies. However, suitable control agents may be found outside native areas due to the spread of natural enemies with

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the host or new natural enemies adopted the target species as a host when it spread to new areas.

2. The climate and environmental conditions should be similar to area of intended introduction (enhances chances of natural enemy establishment).
3. At least a part of the search area should include or be as near as possible to the center of the target species and its close relatives (if climatically similar to area with pest problem) because the diversity of complexes of specialized natural enemies tends to be a function of the duration of association of an organism with a given ecosystem.
4. Faunal and floristic history, vegetation, and habitat structures should present maximal diversity in the area selected (important when cannot determine native range or origin of target species)
5. Exploration areas should be as wide and diversified as possible to maximize chances of finding numerous and ecologically differentiated natural enemies of broad genetic variability, and of acquiring information on the ecology of individual species under different conditions.

IV. Inventory Research and Investigations on Selected Species

A. Inventory Research: objectives of this phase are to provide:

1. A survey (or inventory) of the available natural enemies
2. Criteria for the selection of suitable BC agents within the foreign areas being explored. Searching for natural enemies may involve several strategies:

   a. Collecting in high host density areas where natural enemies are easy to find (not the best idea)
   b. Collecting in areas where conditions are suitable for target species but it occurs at low densities due to actions of natural enemies
   c. Artificially concentrating host densities in the field by the "exposure method"

B. Signs which assist in the recognition of areas where control of target species by natural enemies is good includes:

1. Scarcity in areas suitable for target species
2. Colonial or clumped type host distribution which is associated with highly effective natural enemies
3. Occurrence of localized outbreaks of target organisms associated with pesticide usage
4. Abnormal abundance of target species where it is protected from natural enemies by ants, dust, or litter

As much information as possible should be recorded on the habitats where natural enemies were found. Status of the target species should be observed in different localities.

C. Comparative Analysis of Natural Control Factors - has a central role in any foreign exploration program:

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1. Results in selection of species for detailed studies as candidate BC agent
2. May provide additional data and feedback on selection of exploration areas

D. Effect of natural enemies: usually determined through indepth biological studies that are impossible to conduct on exploration trips. Conventional methods may be used to determine the following parameters:

1. Host range: range of acceptable host species, estimated by the number of supraspecific systematic categories
2. Host preference: indicates the acceptance of the target host relative to other acceptable hosts
3. Constancy: the percentage occurrence of a natural enemy in all samples taken in the exploration area. Measure of frequency of association between enemy and host
4. Abundance: designates the numerical occurrence of one species within individual samples (expressed as "apparent percentage parasitism")
5. Intrinsic competitive capacity: indicates outcome of intrinsic competition with other natural enemies

E. Interactions among natural enemies: well adapted natural enemies with good searching abilities coexist with less specialized, but intrinsically superior species (often capable of both primary and secondary parasitism) has been referred to as "balanced competition". If analysis shows this to be true then the foreign explorer should recommend that species are introduced in a predetermined sequence starting with the intrinsically inferior natural enemies

F. Hyperparasites and other secondary enemies: must be eliminated from material to be shipped. These organisms can reduce the effectiveness of a natural enemy. When in an environment without these the natural enemy may be greatly improved.

G. Factors other than natural enemies affecting target species: comparative analysis may reveal important control factors in the exploration area that are not common to area of introduction

H. Detailed Studies on Selected Species - can be conducted prior to introduction

1. Reproductive capacity and impact on host: determine fecundity of natural enemies and number of hosts killed by single individual
2. Adaptation to different climates: natural enemies must be effective in climatic conditions of intended area of introduction
3. Searching ability: this parameter could be estimated by looking at parasitism at various levels of host densities
4. Host selection: can be empirically defined through field observations and laboratory tests. Most important in species imported as biological control agents of weeds, but is becoming more important in BC of arthropods (consult notes on environmental impacts) due to concerns about nontarget, endangered species. Limited host range is desired in BC agents of arthropods, and it is absolutely necessary for BC agents of weeds.

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5. Synchronization: this is a complex area, but is a must for effective colonization. Especially important when moving natural enemies between northern and southern hemispheres.
6. Genetics: investigations of genetic variability may aid in selection of enemy strains suitable for target areas

V. Importation of Natural Enemies

A. Selection of Agents for Introduction: most crucial phase in any BC project. Is entirely an empirical process. The following criteria are important:

1. The candidate species must not develop harmful effects in the country of introduction (top priority in weed control, and becoming more important for arthropod control)
2. It should possess a good searching capacity and be able to operate effectively at low and high host densities
3. It should be well adapted to the climatic conditions, host habitats, and other ecological factors in release area
4. A relatively high host specificity or the capability of developing a high host preference in the situation is desirable
5. Its life cycle should be well synchronized with its host, thus allowing exploitation of the host
6. High reproductive capacity, preferably combined with short generation time and a high "effective rate of oviposition"
7. In some instances it may prove useful that the agent is able to integrate itself into the system of mortality factors already existing in the target country.

   Remington (1968) warns against introducing material from laboratory rearings started from just a few individuals. He suggests that a large sample from a large, central, wild source population in an environment most similar to that of the region of intended establishment should be introduced. He also suggests introductions with individuals from many wild source populations is also good. Multiple species should be introduced (consult notes from lecture on Theories of BC)

B. Preparation of the Material for Shipping

1. Laboratory Propagation: If possible, it is desirable to set up a temporary lab facility for propagation of field collected material. This enables the explorer to increase the numbers of individual natural enemies for shipment.
2. Timing of Shipments: Natural enemies must be shipped so that any immediate releases to be made will be insured of potential success by the availability of the preferred host stages at the release sites. Problems of synchrony are encountered when shipping material from the southern to northern hemispheres. Those receiving natural enemies in quarantine facilities must also be ready to rear natural enemies.
3. Screening for Parasites and Diseases: Great caution must be exercised to prevent the shipping of hyperparasites and unwanted pathogens with the natural enemies. Shipping of adult natural enemies is best in

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reducing hyperparasites. The use of sterile techniques may be necessary to insure that no pathogens are transported.

C. Shipping Methods

1. Satisfactory transporting of natural enemies is considerably facilitated by air freight facilities, but still requires considerable planning and ingenuity. The optimal conditions of humidity and temperature vary with different natural enemies; hence, pilot tests should be made to determine the best shipping method for the species concerned. Food should be provided for natural enemies.
2. Shipping containers should be well insulated, sturdy, light, and easy to handle.
3. Shipment packages should bear instructions for the postal authorities as well as a importation permit. When sending shipments by air freight, affixing instructions concerning special handling, transfers, etc., may facilitate quick transportation.

QUESTIONS

1. What are the main steps involved in a classical biological control program? Briefly describe each one.
2. What factors determine the scope and depth of a biological control introduction program?
3. What logistical problems might be encountered in planning a classical biological control program that would impair the success of the project?
4. What would be the best place to search for effective natural enemies of an introduced pest?
5. Prior to introduction of a biological control agent, what studies might one conduct to estimate the potential of success of the agent?

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READING ASSIGNMENT:

Chapter 8: pp. 128–157; Chapter 9: pp. 158–172. **Van Driesche, R. G. and T. S. Bellows, Jr. 1996.** Biological control. Chapman and Hall, New York. 539 pp.