RELATIONSHIP OF SYSTEMATICS TO BIOLOGICAL CONTROL

Notes

I. The Problem of Identification

A. Identification of both the pest and known associated natural enemies is the first step in a biological control effort.

1. A correct name provides a link with the work carried out in the past and represents a key to information in the scientific literature on faunistics, ethology, and ecology of a species.
2. Species identification is usually first based on dead specimens (Morphological Species Concept) submitted to a professional taxonomist whose main activity concerns identification and classification of organisms. Generally, the professional taxonomist works in a museum, is a specialist in a relatively high systematic category, and has a good knowledge of the order containing that category. Until the 1990's, ID's were provided free, but not anymore.
3. Identification of all organisms associated with a problem (pests and natural enemies) is part of the initial evaluation of available information (Fig. 3.1) in the overall scheme of foreign exploratoin program (classical biological control).

B. Determination of native habitats of the target species (pest).

1. The search for natual enemies of a pest species in the pest's native habitat is a first priority matter in biological control.
2. Correct identification may help direct biological control workers to the area of origin of a pest.

   a. The successful search for natural enemies of the cottony cushion scale, *Icerya purchasi* Maskell, was initiated in Australia (1888) based on the systematic work of W. M. Maskell which suggested that Australia was the native home of the scale.
   b. Misidentifications of the California red scale, *Aonidiella aurantii* (Maskell), as belonging to the the genus *Chrysomphalus* (believed to originated in South America) led to importations of South American parasitoids of scale species other than *A. aurantii* which did not attack the pest.
   c. Misidentification of the coffee mealybug, *Planococcus kenyae* (LePelley), in Kenya (Africa) resulted in unsuccessful searches for natural enemies on 4 continents until it was realized the pest was an undescribed species from East Africa. Following, natural enemies were found in the neighboring countries of Uganda and Tanzania (Tanganyika).
   d. Misidentification of the citriculus mealybug, *Pseudococcus citriculus* Green, a citrus pest in Israel, as the Comstock mealybug, *Pseudococcus comstocki* (Kuwana), resulted in foreign exploration being carried out in the Japan where the citriculus mealybug did not originate. Luckily. natural enemies were found by accident on the Comstock mealybug in Japan.
   e. Locating the area of origin of a pest is not always easy, especially if it has widely dispersed.

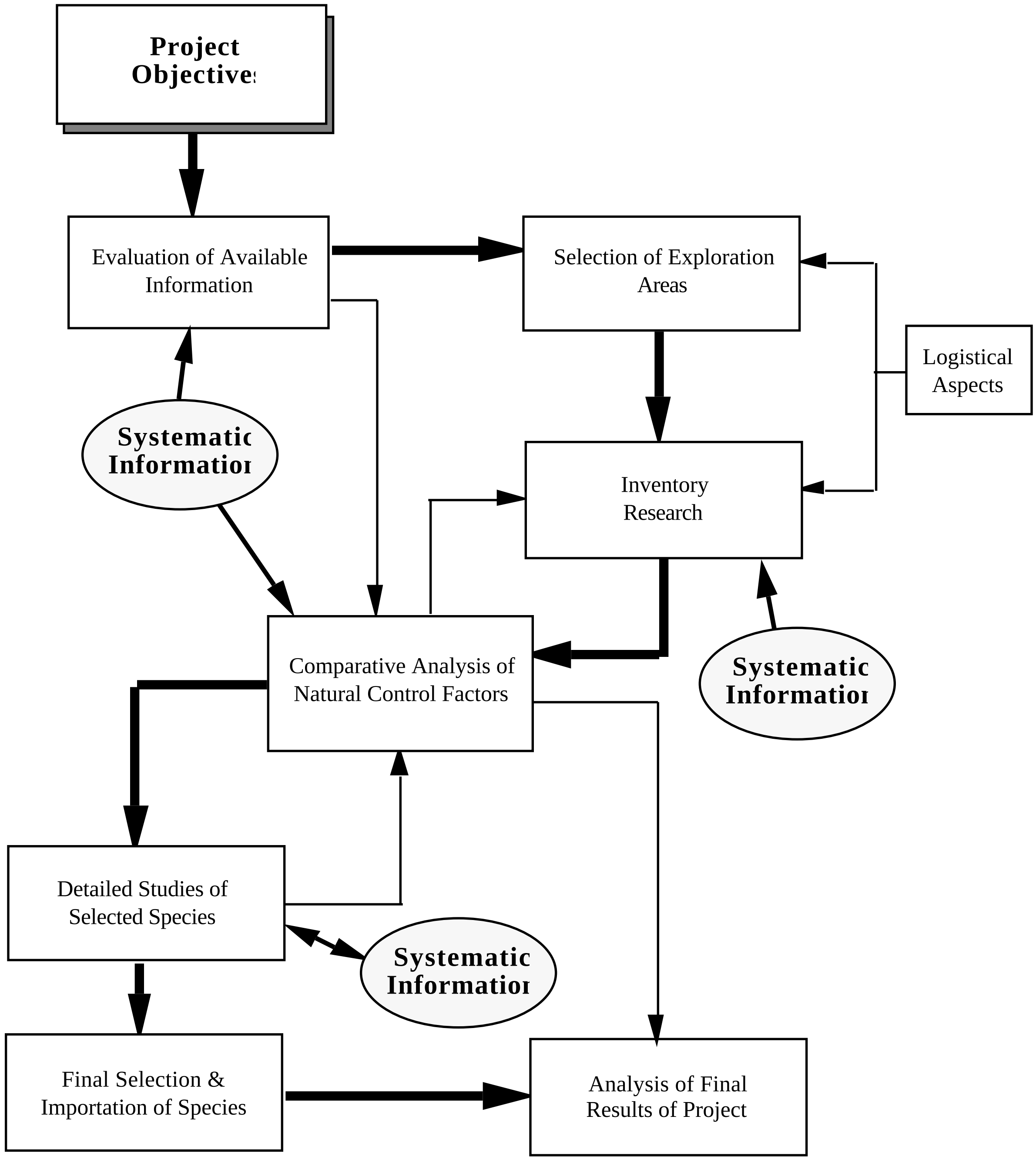

Fig. 3.1. Information flow in foreign exploration programs (modified from Zwölfer et al. 1976).

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3. In the future, researchers may use molecular biology techniques (see Chapter 14, Hoy 1994) to determine the origin of the pest species they are targeting for control, but it may be an expensive endeavor with plenty of logistical problems. If specimens of the pest can be obtained from museums or by routine collecting from various locations, then comparison of DNA sequences from the targeted pest population and the collections outside the newly infested area, may reveal where the new pest population originated. Molecular biology work by Judith Brown, University of Arizona, Tucson, on *Bemisia*

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tabaci (Biotye A. B. *et al.*) populations provided insights into where the whitefly some call the silverleaf whitefly (*Bemisia argentifolii* or *Bemisia tabaci* Biotype B) orginated.

C. Identification of natural enemies.

1. Taxonomists of entomophagous species are relatively rare, and are becoming more rare as time passes due to the reluctance of many academic institutions (e.g., University of Hawaii at Manoa) to maintain a strong systematics research program. A 1992 survey by Daly (1995) indicated that there were 28% fewer systematic doctoral students in 1992 compared with 1982. If the trend continues, by the year 2017, there would be no students being trained in systematics.
2. With the initiation of many biological control projects, taxonomic problems have extended beyond the pest and natural enemy species concerned (little known about species or confusion exists).

    a. Classical examples of these problems include the efforts to utilize natural enemies in the genus *Aphytis* (scale parasitoids) and *Trichogramma* (parasitoids of lepidoptera eggs).
    b. Potential success in biological control of California red scale in California was delayed >50 years because the effective natural enemies *Aphytis lingnanensis* and *A. melinus* were not introduced because they were thought to be *A. chrysomphali* which existed in California.

3. Once natural enemies and pests are established in cultures, it is important that species identification be monitored to insure that contaminants have not entered the cultures.

    a. Some natural enemy species may be highly competitive in culture, but highly ineffective natural enemies in the field.
    b. During a biological control project for the San Jose scale, *Quadraspidiotus perniciosus* (Comstock) (Homoptera: Diaspididae) in Europe, 4 million individuals of the ineffective parasitoid *Prospaltella fasciata* Malenotti (Aphelinidae) where accidentally released because they were though to be the effective parasitoid *Prospaltella perniciosi* Tower (Aphelinidae). *P. fasciata* never became established where it was released.
    c. Molecular markers are now developed in some projects so that different species and strains (e.g., *Encarsia*) can be tracked in culture and contaminates more easily discovered via a routine monitoring program (see Chapter 14, Hoy 1994).

II. Limitations of the Morphological Species Concept

A. Definitions.

1. Morphological Species Concept (Typological Species Concept): the concept that two species may be differentiated based on morphological and chromatic characters. The assumption is made that the characters are static in time (no change) and species display little variation.
2. Biological Species Concept (BSC): the concept that species consist of groups of actually or potentially interbreeding populations that are

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reproductively isolated from other groups. Species have been described as the largest and most inclusive reproductive community of sexual and cross fertilizing individuals sharing a common gene pool. Populations may be assumed to be the same species when one population interbreeds with another population and the resulting offspring are of normal number, viable and fertile.

B. Reference collections and descriptions of dead adult stages.

1. The professional insect and mite taxonomist deals mainly with reference collections and keys based on morphological characters of dead specimens.
2. Systematic research has suffered from the lack of appreciation of intraspecific variation in morphological characters.

   a. No allowance is made for the natural range of variation. Specimens exhibiting insignificant morphological variation may be assumed to be distinct species. Example: Individuals within a species of the genus *Aphytis* exhibiting differences in the number and relative lengths of certain setae (which varies with specimens) were thought to represent more than one species, but did not in reality.
   b. If intraspecific variation is not thoroughly understood, valid diagnostic characters may be overlooked. Example: In the genus *Aphytis*, it was eventually discovered that the pattern of pigmentation could be an important species diagnostic characteristic.

3. New techniques in molecular biology are contributing to the systematics of entomophagus species. Using techniques such as the Polymerase Chain Reaction (PCR) and Randomly Amplified Polymorphic DNA (RAPD), researchers can get a better idea of what constitutes a species and strains of organisms. These techniques are now being used to verify speciman identifications.

C. More definitions.

1. Systematics: the field of biology which includes a) biosystematics which is concerned with speciation and phylogeny; and b) classification of organisms.
2. Biosystematics: the investigational field of systematics based on any scientific information that can be brought to bear on the problems of the evolution of species, whether they concern speciation or phylogeny. Aids used in biosystematics to differentiate species include data on biology, physiology, habits, sound–production, pheromone production, host or prey relationships, host plants, and micro–habitat preferences.
3. Alpha–taxonomy: the description of new species based on morphological characteristics within an already existing classication (framework).

D. Problems with identifications based on morphological parameters alone.

1. Identifications based on morphological traits do not allow one to differentiate *sibling species* and *cryptic species.*

   a. Sibling species: sister species arising from the same ancestral species. Differentiation may be possible by conventional means.

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b. Cryptic species: those species that cannot be differentiated from each other by conventional means. They may not be *sibling species*.

2. Biological parameters used to differentiate *sibling species* and *cryptic species* include host and habitat specificty; number of generations within a given area; diapause habitat; and different tolerances to climatic factors.
3. The validity of a species must be verified by reproductive isolation.
4. Molecular biology tecnhiques are helping to address these problems now, but the answers are not always 100% clear cut. Use of different makers may indicate different lines of phylogeny.

E. Below the species level: *strains* & *semispecies.*

1. Morphologically identical populations of a given species may represent a set of strains or semispecies.
2. Some strains of a given natural enemy may be biparental, others uniparental (e.g., some *Encarsia* spp.) One strain may be a more effective natural enemy than another strain within the same species.
3. Semispecies represent conspecific populations of an organism which exhibit only partial reproductive isolation. Work on *Aphytis lingnanensis* provides an illustration of this reproductive isolation (Fig. 3.2).
4. Some semispecies possess distinct host preferences and other biological characteristics which may be of utmost importance in biological control projects.

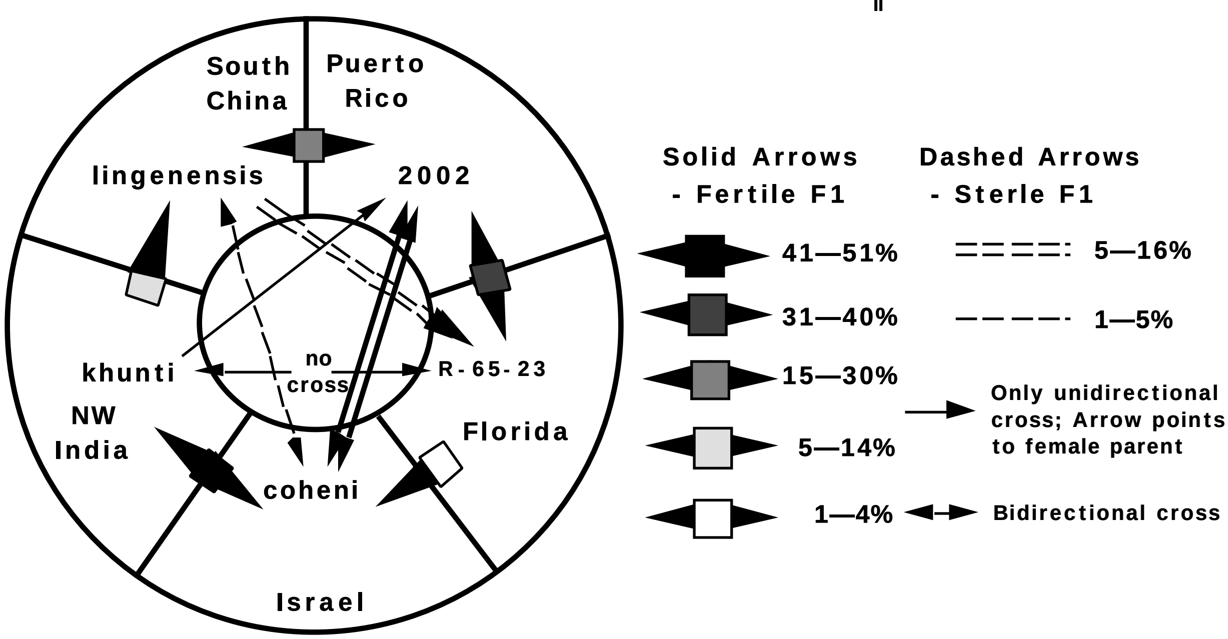

Fig. 3.2. The crossing relationships of some geographical forms of the *Aphytis lingnanensis* complex. These forms are indistinguishable on a morphological basis one from another, yet all degrees of reproductive isolation are evident (modified from Rao & DeBach 1969).

QUESTIONS

1. What is the Morphological Species Concept and what are its limitations?
2. In what ways is systematics important to the science of biological control?
3. What is the Biological Species Concept and what are its limitations?
4. What are sibling species? How do they differ from cryptic species?
5. How have the advances in molecular biology contributed to the solving challenges in biological control?

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