COMMENTS ON BIOLOGICAL CONTROL IN TAIWAN

PART I

By

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During November 6-16, 1984, Agricultural Research Institute, Experiment Stations and Universities in Taiwan were visited. In addition reports on various biological control projects were reviewed at TARI. The following are some general and specific comments.

GENERAL COMMENTS

Researchers: There is a great deal of enthusiasm and motivation to do good work among researchers. They are eager to learn and to accept new ideas. Perhaps because the program is new in many cases, the work done appears to be in the preliminary stages. Excellence can be ephemeral; don't let it fade away.

Administration: There are at least three approaches to research administration: (1) Administrators taking a strong leadership in deciding the direction of the projects, (2) researchers taking the leadership in deciding the direction of research projects, and (3) both administrators and researchers taking the leadership.

Evidently Taiwan has, though not entirely, taken the first approach. It seems to be working out exceedingly well. The administrative work is excellent; the goals are clearly spelled out. Because of this there appears to be a strong cooperative effort in attaining the goals of crop protection by use of biological control agents.

Objectives of This Report: Because of the renewed emphasis on biological control in Taiwan there is much research to be done and much of the work at present, except that on sugarcane, appears to be in preliminary stages. The main goal is to develop biological control methods that are suitable for the Taiwan cropping systems. Listed below are some suggestions.

MAPPING PEST DISTRIBUTION

Taiwan, a relatively big island, is an area of great ecological diversity. This is reflected in the diversity of crops and pests. It would be helpful for researchers and administrators if there was a map showing the incidence of the major pests in Taiwan. Biological control inputs can be intensified in areas of serious pest problems and reduced in other areas. The idea of Dr. Chiou-nan Chen of

establishing satellite mass-rearing laboratories in areas of high pest incidence is an excellent one and pest maps would be helpful in locating suitable sites.

It may be also helpful to map distribution of pests within fields. Due to cultural and ecological factors some pests tend to be abundant in one part of the field but not in others. It might save monitoring and "treatment" costs if distributional patterns were known.

TRICHOGRAMMA PROGRAM

The mass-rearing of *Trichogramma* at Hsing-ying was impressive. The program is well organized and the facilities are good. However, I would like to comment on four areas: (1) host rearing, (2) quality control, (3) field releases, and (4) economic threshold.

Host Rearing: In the existing procedure the immature stages of *Corcyra* develop in the rearing medium and the adults emerge directly into the rearing room where they are captured by net when needed.

It is suggested that attempts be made to separate fully grown larvae (or pupae) from the rearing medium. To do this it is necessary to start with eggs of uniform age and to separate fully grown larvae from the medium a day or so before pupation. They can be counted and placed in a series of oviposition cages (perhaps 1 x 1 x 1 m). Eggs to be used for *Trichogramma* parasitization can be obtained from adults that emerged in these cages. When oviposition rates of *Corcyra* begin to decline they should be destroyed and replaced by new stock.

The time to separate fully grown *Corcyra* larvae from the rearing medium must be determined. The day-degree method can be used if the member of day-degrees required for the development of eggs and larvae were known. Day-degrees can be calculated by different ways, but perhaps summation from thermograph charts of the rearing room would be the simplest. If constant temperature rooms are used, the number of days can be used to determine the time of separation of larvae from the rearing medium.

This procedure would make it possible to handle the adults easily and to identify and discard non-productive stock early.

Quality Control: The importance of the quality of *Trichogramma* reared and released can not be over estimated. To assure quality it is necessary to monitor periodically the quality of parasites produced. The method of determining quality must be worked out. Some of the indicators of quality (or lack of it) are: (1) population parameters, (2) longevity, (3) fecundity and (4) flight or dispersal capabilities. Using some of these parameters it might also be possible to select out and mass-rear superior strains of *Trichogramma.*

Field Releases: For the control of the sugarcane borer the *Trichogramma* release interval was reported to be once every two weeks. Considering the continuous egg-laying behavior of *Ostrinia*, short life span, and dispersal capacity of *Trichogramma*, this interval appears to be too long. This interval when used in corn fields would result in periods in which there would be insufficient number of parasites. Theoretically, the life span and release interval should be related; i.e., the shorter the life span the shorter the release interval.

The number of release points per unit area as well as the number of parasites to be released in corn fields should be more critically determined in areas of high and low *Ostrinia* egg densities.

The excellent report of Dr. H. C. Chiang should be helpful in determining number of release points per unit area as well as the number of parasites to be released. The benefit/cost ratios are involved here and should be taken into consideration; the higher the release efforts, the higher the cost of control.

Economic Threshold: Tentative economic threshold based on egg density of *Ostrinia* should be established. *Trichogramma* releases can be made according to the estimated threshold. Determination of precise threshold values is not necessary; for practical work estimated values are adequate. Some aspects of this work are done by Dr. Shui-chen Chiu and co-workers at TARI. It is hoped that they continue their work.

BIOLOGICAL CONTROL OF MISCELLANEOUS CROPS

Coconut Beetle (*Brontispa longissima*): This project seems to be making excellent progress in certain areas. There are evidences that coconut trees are recovering from *Brontispa* attack following the release of *Tetrastichus brontispae*, especially in areas where coconut trees are in mixed forests. Further efforts should be made to introduce *Tetrastichus* and other parasites from as many areas as possible and to release them in different ecological areas.

Other Crops: Efforts should be made to determine the key pests of different crops. Key parasites of the different pests should also be determined. If necessary foreign introductions of natural enemies should be made.

CATALOGUE

As suggested by others, efforts should be made to make a list of natural enemies and their hosts in Taiwan. Such a catalogue would be useful in importation, evaluation, and international exchange of natural enemies. Cooperative work with taxonomists would be desirable.

WORKSHOP

There appears to be a need for a more balanced research program between laboratory and field work. A short workshop on commonly used field techniques should be helpful.

PART II

By

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SOME CONSIDERATIONS IN IMPLEMENTATION OF BIOLOGICAL CONTROL PROGRAMS

Implementation: The scope of the current importation program in Taiwan has already produced very significant results. The international liaison maintained is impressive and undoubtedly will lead to further exchanges of both natural enemies and biological control information. The current achievements include: (1) The establishment of a quarantine facility which meets the current needs and provides the opportunity to train personnel in quarantine procedures. (2) The building of a full scale quarantine facility to be completed in 1985 reflects a long term view in planning and development. (3) The organization of a committee to review the requests for importing and utilizing natural enemies is crucial and its establishment again reflects excellent planning. Relative to the last item, the committee will need a satellite group of scientists to help in particular pest and/or natural enemy situations.

Another aspect may be suggested related to record keeping. The Beneficial Insect Introduction Laboratory of the USDA has started the ROBO program. It is aimed at streamlining records on the importation, movement, release, establishment, recolonization, dispersal and culture of exotic beneficial organisms in the U.S. (BIIL material enclosed). A comparable system is needed in Taiwan and should be initiated as importation is just at its beginning. If Taiwan adopted a similar system, there would be the possibility to interface the two systems in the future.

Mass Production of *Trichogramma*: I was much impressed by the planning and operation of the *Trichogramma* production Center at Wu-shu-lin, Hsing-ying. It utilizes existing expertise by transferring personnel and utilizes existing facilities by remodeling vacant buildings. This approach saved both money and time, and made it possible to start production with a very short lead time. It is a "crash program" planning at its best.

After viewing the actual operation, additional opportunities for increasing efficiency could be explored. (1) To lower the ceiling of the rearing room (or place a false ceiling) to reduce the height workers have to reach upward. (2) To add a cloth screen inside of the door to reduce moth escape. (3) To provide to the worker collecting moths a face mask which is connected by a plastic hose to air outside of the rearing room, to reduce inhaling scales. (4) Another method as suggested by Dr. Nishida is to sort out pupae and let moth emergence take place in a cage, and place fresh egg cards in the same cage and let oviposition take place.

The process of preparing egg cards is an important step. There are also opportunities for exploring modifications. (1) Test industrially manufactured sticky surfaces (such as the airline tags enclosed or similar products) to see if it is sticky enough to catch eggs. If it works and if large pieces can be purchased cheaply, much labor can be saved. (2) Test glues which can be applied and stored without losing stickiness. In both above cases, the effect on egg viability must be tested.

Mass Production in General: Successful mass production starts with knowledge on biology of the agents involved (as pointed out in my Symposium presentation). A few more aspects could be explored.

(1) Selection and breeding of the stock. This process could be a aimed at (a) faster developing and more prolific lines (as in my manuscript), (b) resistance to pesticides (as in predacious mites), (c) dispersal capability by designing the oviposition chamber so that only the parasites which can fly a distance will reach the host eggs and propagate (as I mentioned during the question and answer sessions).

(2) Finding surrogate hosts which can be easily and economically produced, and developing *in vitro* rearing methods.

(3) Quality control as pointed out by Dr. Nishida.

Storage: The needs of parasitoids in the field at a particular time depends on the weather conditions and crop and pest development. Advanced planning and projection are crucial, yet they are not infallable. Thus methods of storing an extra supply need to be fully explored, involving knowledge on physical ecological conditions under which parasite viability can be maintained for a lengthy period. Temperature, humidity and photoperiod are factors to be considered.

Field Dispensing: My Symposium manuscript provides a theoretical basis of determining the minimum number of release sites to produce desired degree of parasitism. This point will not be crucial if parasites can be broadcasted by mechanical means or if human labor is plentiful. Still, some aspects need to be explored. (1) Appropriate containers in which parasites are protected from natural elements and predation. Both shape and color are factors to be studied. (2) Determining the most appropriate period of aging of parasites before release. (3) Finding kairomones which can increase search efficiency of parasites. (4) Use a high release rate first in order to establish the effectiveness, later may use reduced rates to establish the minimum effective rate.

International Aspects: A number of natural enemies have been imported from abroad, such as Indonesia, Guam and Hawaii. With the rich fauna in Taiwan there must be many biological control agents unique to Taiwan and useful to other countries. Several aspects could be explored in enhancing the exchange of material and information in biological control on a global scale.

1. **To Initiate An Inventory of Agricultural Pests and Their Natural Enemies.** This information will be the basic data for exchanges. Prof. T. H. Su of the National Chung Hsing University discussed this idea with Dr. Nishida and me. Taiwan already has the organization and expertise for this undertaking. Taxonomic identification can be provided by scientists in universities and institutes and the field survey can be performed by personnel of the six District Agricultural Improvement Stations, search of literature on world distribution of agricultural pests and availability of biological control agents could also be initiated. The Parasite Catalogue by Thompson of the Commonwealth Institute of Biological Control could serve as the starting point of this search.

2. **Contacts with Foreign Institutions and Scientists.** A beginning can be made through personal contacts. Taiwan already is sending scientists to international congresses and conferences and foreign scientists have also been invited to visit Taiwan. This program could be expanded. Additionally, key personnel of COA may be encouraged, even supported, to become members of professional societies abroad, such as the International Organization of Biological Control, the Entomological Society of America. Through such memberships, scientists in Taiwan will receive information on

current activities in biological control on the international scene. They can also submit information on activities in Taiwan to the societies' publications such as newsletter and bulletins, to bring Taiwan achievements to international awareness.

Epilogue: In my Biological Control Symposium presentation I mentioned as possibilities and need for further research in application of biological control; (1) selection and breeding of parasite lines of particular characteristics, (2) developing *in vitro* rearing or more economical surrogate host eggs, (3) finding kairomones to increase searching efficiency, (4) improving dispensing technology and (5) improving forecasting strategic timing of dispensing. It is interesting that an article by Greany, Vinson and Lewis appeared in the December 1984 issue of Bioscience mentioned three of the five items. Under selection and breeding, that article emphasized host preference while I emphasized developmental and reproductive rates. In fact, resistance to pesticides and dispersal capacity are also possibilities. One point needs to be emphasized is that any of the above requires research in basic ecology and biochemistry of the parasitoids and their hosts. I was impressed by the fact that cooperation between scientists of different disciplines and in different institutions exists, or is potentially feasible.