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Some Practical Aspects of Biological Control*

by
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Introduction: In recent years, considerable interest has been evoked all over the world in the application of biological methods of controlling crop pests. Three of the major reasons for this have been: (1) the rapid development of resistance in insect and mite pests to many chemical pesticides, (2) the hazards that many of the recently developod organo-phosphorous and other toxic compounds pose to human and wild life and (3) the development of serious outbreaks subsequent to the use of a chemical pesticide, resulting from annihilation of existing natural enemy populations. Whatever other reasons there may be, it is gratifying to note that greater interest is now being taken in biological control and measures being taken to prevent further serious upsets in the balance of nature.

Need for a scientific and systematic approach: To many of us, biological control may not mean much more than obtaining natural enemies, either indigenous or exotic, multiplying them in large numbers in the laboratory and releasing them in the field against a pest species. We know from experience that experiments which have been based on such flimsy foundations have invariably ended in failure and consequent disillusionment in the biological control method. A serious study of the most outstanding successful cases of biological control, however, has shown that most of such attempts have been based on a thorough understanding of the ecology of the pest as well as the natural enemy involved. The natural enemy has been carefully selected and concerted efforts made to give it all possible opportunities to become established in the country of introduction. It must therefore be stressed that the need for approaching any biological control problem scientifically and systematically is utmost and hence also the need for well-trained personnel.

Problems in selecting an exotic natural enemy: A review of successful cases of biological control has brought to light the fact that the introduction of an exotic natural enemy of either the same pest or an allied species from its native home offers greater possibilities than the mere mass-rearing and liberation of an indigenous species. In tackling any biological control problem therefore, a preliminary survey for existing natural enemy species

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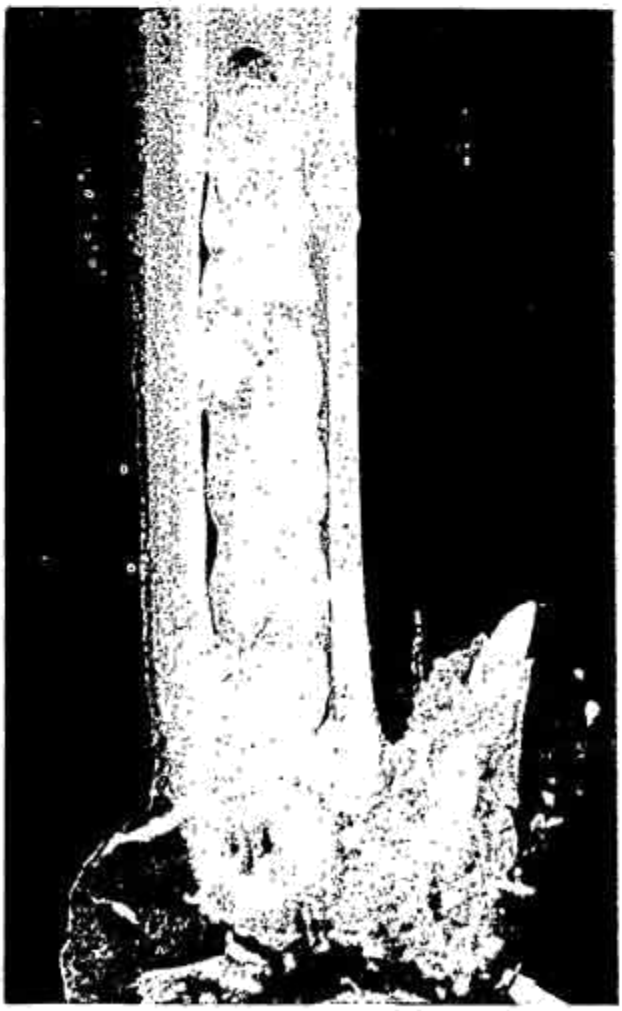
is very important. This helps in the subsequent selection of exotic natural enemies of the pest. The next step is foreign exploration for natural enemies of the pest in its native home. From experience, certain basic tenets have been established for purposes of selection of a natural enemy: (1) It is generally advisable to look for a natural enemy in a region with similar climatic conditions, as it is most likely to become established in the new home of the pest. (2) A host-specific, monophagous parasite or predator is likely to give immediate and obvious results and thereafter hold the host population at a low level. Nevertheless, the presence of alternate hosts as in the case of a more polyphagous species can at times be of help in maintaining populations of the natural enemy even when the major host species is in abeyance. (3) It must be understood that the most predominant natural enemy occurring in the native home at low host densities generally offers the greatest promise for introduction. One must, however, take care to see that the host is not an accidental one. (4) Genetic races of a given natural enemy may be involved, so that one race has bio-ecological adaptations better suited to the host and the area of introduction than another. (5) Since the natural enemy may even show preference for hosts on a particular species of host-plant, the host-plant preference must also be taken into consideration.

Transportation to country of introduction and laboratory propagation of the natural enemy: Shipment of natural enemies from one country to another or even within a country for redistribution is one of the most critical phases in biological control. The C. I. B. C. as well as some other institution in Western countries have developed special types of shipping containers which can provide for maximum survival of the natural enemy in transit. Specially insulated wooden boxes with provision for food and maintenance of adequate humidity have been designed to prevent dessication which is a major cause of mortality during shipment. Depending on the stage of the natural enemy that is to be shipped, necessary modifications can be made. Fortunately, in many cases, the inactive pupal stage can be shipped, reducing the chances of mortality.

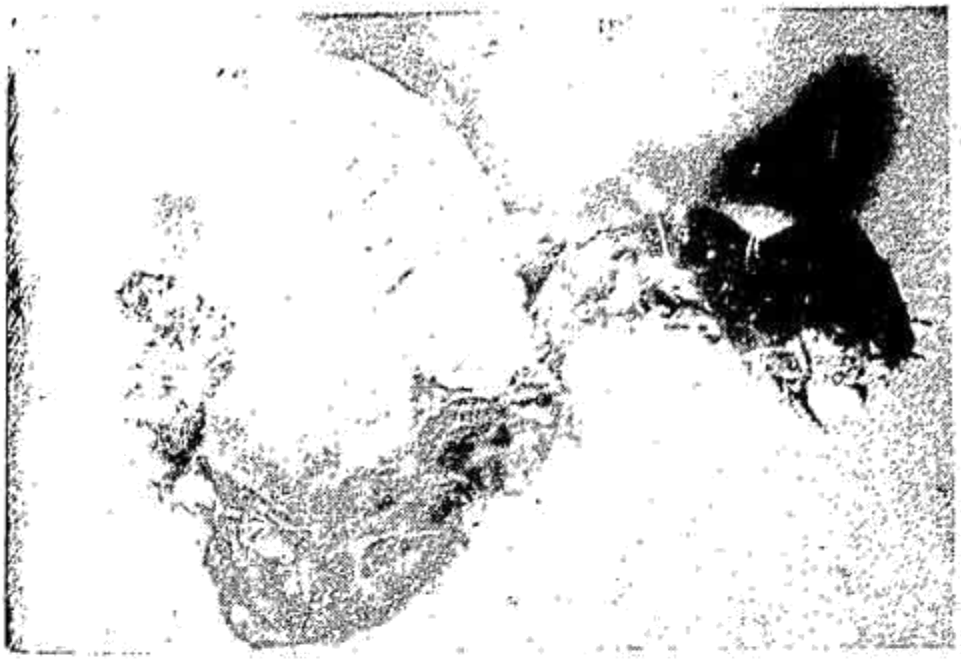
With the development of rapid air transport and pressurized aircraft, shipping natural enemies from one country to another has become much easier. Nevertheless postal delays and rough handling can often result in a high degree of mortality en route.

Laboratory propagation of natural enemies: Quarantine facilities are very essential in any laboratory handling importation of natural enemies in a biological control programme. Often, the man in charge of foreign exploration may not have facilities for rearing the natural enemy in a laboratory

A group of larvae of the parasitic wasp, *Goniozus indicus*, feeding on a top borer of sugarcane.



A parasite larva feeding on the paddy stem-borer, *Tryporyza incertulas*. Several species of parasites of different paddy stem-borers have been recorded by the Indian Station of the CIBC.



Full-grown larva of the parasitic fly, *Spoggosia (Stomatomyia) bezziana* emerging out of the Black headed caterpillar, *Nephantis serinopa*. Note that the body contents of the host caterpillar, which has shrivelled up, have completely been eaten up by the parasite larva.

Full-grown maggot of the Cuban fly emerging out from the parasitized early shoot borer of sugarcane.

and may therefore be forced to ship field-collected material. Since field-collected material is likely to be contaminated with hyperparasites (or parasites of beneficial predators) and other undesirable material, the shipment boxes must be opened only in well protected quarantine rooms by specially qualified technicians. Careful screening and identification of the natural enemy individuals should be made and all undesirable material destroyed in an incinerator. It is generally advisable to rear at least one or two generations of the natural enemy in quarantine, to confirm that only pure cultures of primary parasites (or predators) are present.

The culture of entomophagous species requires special skill and training. One of the most serious problems often encountered is getting the adults to mate. Alternate exposure to bright sunlight and shade, exposure to wind, use of large insect cages or small vials with restricted space, are only some of the measures which may have to be implemented to induce mating. The sex-ratio of adults released in a cage for mating may have to be controlled, particularly in some *Hymenoptera* to prevent excessive mating, resulting in the ejection of the numerous spermatophores and subsequent production of all male progeny.

The selection of a suitable laboratory host that can be reared easily and economically on a large scale may often be problematical. Moreover, it should be possible to rear the host insect on a host plant that can be easily obtained all through the year at a low cost, be able to provide all nutritional requirements of the host insect; it should be amenable to insectory handling and techniques as well as be suitable for storage over long periods. The potato and banana squash are perhaps the best examples of such host plants. The development of artificial (synthetic) media for rearing host insects on a large scale in the laboratory is a relatively new area of research.

Colonization of natural enemies: The next step in a biological control programme is field liberation of the laboratory reared natural enemies. It is always best to release the natural enemy at a time of the year when the climatic conditions are optimal and when the host stage available in the field is that preferred by the parasite or predator. The colonization site should be carefully selected, so that it is not exposed to deterrents such as toxic chemicals which will hinder establishment. The adult stage is usually best suited for release. Adults should be fed well prior to release. Also, care should be taken to see that the females have mated, to ensure a favourable sex-ratio. It is usually considered best to release adults in the field either early in the morning or late in the afternoon and prevent their being exposed to excessive mid-day heat. Air-conditioned automobiles are ideal for transporting the natural enemies to release sites.

It is difficult to specify the number of individuals of a natural enemy that should be released in a given area. If the natural enemy has a high host searching capacity as in the case of *Rodolia cardinalis*, as few as 10 mated females may be sufficient to effect establishment. More individuals may be required in other cases. The natural enemy may be released in confined sleeve cages, or in the open field. Often, releases in sleeve cages can be of help in the initial establishment of a natural enemy, as the cages can be made to provide some degree of protection from competitors, secondary parasites, *etc.*

The need for continuing field releases varies with the ability of the natural enemy. In some cases the effect of the natural enemy may not become apparent until several years later, while in others, it may be almost immediate. Dispersal of the natural enemy may on occasion have to be aided by redistribution of individuals from the initial establishment site to adjacent areas. It must be stressed that a given natural enemy should not be abandoned as being worthless merely because it has not become established easily, unless adequate numbers have been released at a suitable time of the year so as to synchronize with the preferred stages of the pest. However, if serious attempts to establish the natural enemy have been made and no success has been achieved for three years or so, it is unlikely that the natural enemy will ever become established.

Recovery and Sampling: The phase dealing with recovery and sampling of a natural enemy and evaluating its effectiveness is the most difficult one in biological control, nevertheless the most rewarding. Satisfactory quantitative methods of evaluation are still in the process of being developed and are at present being made (1) by correlating population changes of the host and natural enemy to show the effect of the latter on the host or (2) by analyzing life-table mortality data.

In addition, experimental methods of evaluation have been developed by workers in California. These methods involve a comparison of plots with and without the natural enemy. Exclusion of the natural enemy by using mechanical and/or chemical barriers, deliberate hand removal of the natural enemy and use of ants to inhibit the natural enemy, are methods suggested for creating "check" or "control" plots for comparison with "test" plots accessible to the natural enemy. Ecologists and Entomologists in the U. S. A. and Canada and particularly in the latter country are concentrating on this aspect of biological control.

Conclusion: It is hardly possible in a talk such as this, to describe all the complexities and aspects of biological control. I have therefore made no reference to the use of insect pathogens and weed control. Instead, I have tried to draw your attention to various procedures involved in what we might call classical biological control.

An analysis of successful cases and the factors responsible for these successes have proved without doubt that success has always been in proportion to the effort spent on tackling a problem. In general, the amount of money spent on biological control hitherto has been relatively very little. A recent investigation in the state of California has revealed amongst others the fact that in a period of about 36 years, the returns with respect to biological control were $ 30·00 for each dollar invested, while in the case of chemical control, the nationally accepted figure was $ 5·00 for each dollar invested. This should be sufficient inducement for any developing nation to divert more funds and attention for research in biological control. I do not mean to say that chemical control should be entirely abandoned, because considering the extent and type of agriculture that we have in the world today, it would be ridiculous to suggest such an idea. Rather, attempts must be made to combine or integrate the two methods judiciously and with long-range effects in mind and an ecological approach to pest control be pursued. A country such as ours certainly has the potential to do this, if only we can find dedicated scientific workers trained adequately in the fields of ecology and biological control.

A Study of Variation Pattern in the Progenies of an Amphiploid of *Pennisetum* *

by

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Introduction: The study of cytogenetical behaviour of the natural polyploids and the evaluation of the breeding behaviour of their derivatives have been of particular interest to the geneticists and breeders in crops like *Sorghum, Allium, Triticum, etc.* The evaluation of the amphiploid progenies also throw much light on the nature of true genetic relationships (Grant, 1956). In this paper an account of morphological variation of the progenies of a colchicine induced amphiploid of F_1 of *P. typhoides* x *P. purpureum* is presented and the genetic segregation has been interpreted. The scope for the use of amphiploid progenies is indicated.

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