

# MODERN TRENDS IN BIOLOGICAL CONTROL OF PESTS

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In our present day society man is confronted with ever increasing problems bearing on his survival. One of these, insects has been with us since biblical days. But all insects are not harmful. We also find that pests are kept in check by their natural enemies which are mostly insects and we call it biological control. Thus biological control is mainly the introduction, encouragement and artificial increase of the natural enemies of the pest viz. parasites and predators. It had its true inception about 90 years ago although references to this type of control date back to 12th Century. It is now considered by many to be the most important phase of applied control. Although it does not effect immediate reduction in pest population as do some of our latest pesticides it is the most economical and has the least side effects. They do not contribute to environmental pollution.

## ROLE OF BIOLOGICAL CONTROL IN "PEST MANAGEMENT"—ITS SCOPE

Basically biological and chemical control are incompatible. But they can be brought together by using the "integrated control" approach whereby chemicals are used only when necessary, at the lowest effective rates, so as to minimize possible damage to beneficial organisms. Biological control thus contribute a major part of what is now referred to as "pest management". Biological control may be defined as the artificial manipulation of natural biological phenomena for the purpose of checkmating destructive population of insects, other animals and plants. It includes the use of resistant strains or varieties of plants and animals that have been developed through extensive research programmes taking advantage of our knowledge of genetics. It also implies the introduction, mass rearing and liberation of large numbers of predaceous and parasitic animals or disease producing organisms. In other words it may be termed "biological warfare" against the enemies of man. Though in the strictest sense of the term biological control is mainly the use of parasites, predators and

pathogens, some sophisticated methods like male sterile technique, cytoplasmic incompatibility and chromosome translocation may also be included if a broad view is taken.

*History of biological control:* Biological control had its inception in the United States in 1888 with the introduction of the vedalia beetle, *Rodolia cardinalis* (Muls) from Australia for the control of the scale insect *Icerya purchasi* on citrus in California. Success in this programme laid the foundation for continued research. While some biological control programmes have been highly successful and have eliminated the need for intervention by other control methods, others have yielded only partial success and still others have produced no tangible benefits.

*Present efforts and prospects:* Biological control in the restricted sense of pest suppression through the action of parasites, predators and diseases, usually implies some manipulation of these agents by man. Such manipulation is commonly of two types (1) importation and colonisation of foreign species (2) management practices designed to increase the effectiveness of beneficial species. At the present time biological control programmes are being conducted on a number of crop pests and noxious weeds, in different parts of the world. Comprehensive and effective programmes of establishing *Spoggosia heziana* the exotic tachinid parasite of *Nephantis seri-nopa*, a caterpillar pest of coconut and *Platymeris laevicollis*, the exotic reduvid predator of *Oryctes rhinoceros* the most ubiquitous pest of the same crop, are in progress in India. Other pests viz. borers of mealy bugs, scale insects, the pea aphid and cotton boll worms and some leaf eating caterpillars have received research emphasis in recent years.

Insects like man are susceptible to pathogenic agents like bacteria, viruses, fungi, protozoa, rickettsiae and

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nematodes. More than a thousand pathogens are associated with arthropod pests. Insect pathogens as agents of control of insect pests, have also received increasing research emphasis. Pathogens show tremendous promise as microbial insecticides although commercial availability at present is limited to two, developed from bacteria. Current and past research work with various diseases of cabbage looper and cotton boll worm in U.S.A. is very encouraging. In fact two bacterial diseases were developed into commercial microbial insecticides. The milky disease *Bacillus popilliae* of the Japanese beetle, developed in U.S.A., is still sold and effectively used to control grubs in lawns and golf greens under various trade names including Japidemic or Doom. Another commercial microbial insecticide is formulated from another bacterium *Bacillus thuringiensis* and are sold under the trade names Dipel, Thuricide etc. In India this is being tested against a host of caterpillars, including leaf-eating caterpillar of coconut *Nephantis serinopa*, with varying degrees of success. Viruses also offer the greatest potential for development into microbial insecticides. They are both specific and potent. Recently two companies were granted temporary permits in U.S.A. to sell a specific virus which is used to control cotton boll worms under trade names Biotrol and Viron. If the propagation of the virus is technically successful it could replace the use of more than 2 million pounds worth of chemical pesticides per year on cotton alone. *Rhabdionvirus oryctes* is being tested in India against rhinoceros beetle of coconut.

The possibilities of using insect killing fungi were first considered in the latter part of nineteenth century. Since then many attempts were made and some of them were successful indicating that fungus disease could be used to advantage. The factors that regulate effectiveness of a fungus in biological control are weather conditions, population density of the host, resistance of the host, virulence of the fungus etc. In India *Metarrhizium anisopliae* is being tested against *Oryctes rhinoceros* for its control. In the majority of cases the fungus pathogens infect the insect hosts by penetration into body cavity through integument. In proper humidity spore germinates, proliferates, invades the tissues and finally penetrate outside. Microbial insecticides thus fit ideally into pest management concepts and offer excellent alternatives to current chemical methods of control. Protozoa have been used against aphids, leaf hoppers, scale insects and beetles. Problems of production and poor field stability have seriously restricted the use. Nematodes have been successfully used in field tests to reduce population of beetles and caterpillars. Lack of economical mass culture method is a limiting factor to the commercial utilization of nematodes. Nematode DD-136 *Neoalectana carpocapsae* and the associated bacterium *Achromobacter nematophilus* have been successfully tested against grubs of *Oryctes* at Central Plantation Crops Research Institute, Kayangulam.

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Among vertebrates that are predatory upon insects, the birds are doubtless most effective. More than half of the food of this most abundant and most mobile group of terrestrial vertebrates is insects. They considerably delimit insect population from crops. But except in a few instances birds are not made use of in biological control work. *Acridothorus tristis* (the common Mynah of South India) has been recommended to be introduced for the control of Bombay locust, a pest of coconut in Laccadive Islands. In rice fields in South India infested by swarming caterpillars ducklings are used to control the pest. They devour the caterpillars. Ducks are also used for the control of paddy bug *Menida histrio* in Tiruchirappalli and Tanjore rice belts in Tamil Nadu. Among various aspects of economic ornithology the role of individual bird species particularly insect pest predation from various crops is little known. The black Drongo or King crow (*Dicrurus adsimilis albirictus*) is a known insectivore. The common owl of South India *Arthena brumma brumma* is a good predator on rats and other destructive rodents. Some fishes are made use of for destroying mosquito larvae. *Haplochilus*, *Rasbora* and *Ophiocephalus* are some of the important ones. The giant toad of Mexico, Central America and South America has been introduced into the Hawaiian Islands, Philippines and West Indies and is said to have brought under control the white grubs destructive to sugarcane. The reptilian predator *Uromastix* sp. has been found to be a voracious feeder on locust hoppers in North India. Even man may be considered a predator in those countries where certain insect species serve as food. For example the larvae of popilio butterfly attacking magury plant in Mexico are often eaten by the natives. Locusts and termites are eaten in some middle east countries and grubs of red palm weevil in certain parts of Burma. The distribution of the giant fish killer bug *Lethocerus indicus* ranges from China and India to Australia and forms a regular article of food among some tribes. In Europe, till some years back, foxes, the main carriers of rabies, were kept down in number by wolves, lynxes and eagles. But a change in ecological set up has upset this balance. These natural enemies have been decimated and it is now reported that the foxes reign supreme carrying the dreadful disease to the length and breadth of Europe at a faster rate, particularly since the second world war.

#### SUCCESS IN BIOLOGICAL CONTROL—CLASSICAL EXAMPLES

Some of the most spectacularly successful examples of biological control have been achieved by the use of

predacious species of insects. In this regard there immediately springs to mind the control of cottony-cushion scale by the vedalia beetle in California, the reduction of coconut scale insect by *Cryptognatha nodiceps* in Fiji and the suppression of sugarcane leaf-hopper by *Cyrtorhinus mundulus* in Hawaii. The predators which tend to inhabit a rather restricted niche and yet may be somewhat general feeders can be very important in the suppression of agricultural pests.

#### BIOLOGICAL CONTROL OF SOME NON-INSECTAN PESTS—SNAILS

Fresh water snails act as first intermediate hosts for many of the digenetic trematode parasites of animals. Several methods of snail control are in practice. Among them biological control has an important place. Their natural enemies include aquatic arthropods, molluscs, fishes, birds etc. Larvae of firefly *Lamprophorus fenestrosus* was found to be an effective agent for snail control. The giant water bug of the family Belostomatidae attack snails *Limnaea luteola*, *Endoplanorbis* etc. It is also known that aquatic beetles *Hydrophilus* and *Dytiscus* serve this purpose.

An important finding during studies on integrated control of giant African snail *Achatina fullica* was the principle of using predatory millipedes. This pest is also seen to be controlled by predatory snails *Euglantina* sp., a native of Bermuda and *Gonaxys* sp. belonging to East Africa. In an integrated method of control using the predatory hermit crab and the chemical metaldehyde 5 per cent dust the latter is selective in action adversely affecting on the molluscan snail and doing no harm to the arthropodan predator. In Andamans pigs are seen to feed on eggs and young ones of this snail upto a shell length of 30 mm. Certain residents in snail affected parts of Kerala keep ducks to get rid of this pest.

Many fishes feed on snails. *Macropodus* feeds on *Melanoides* sp. of snails. *Clarias* has been observed to feed on *Physopsis globosa*. The cat fish *Pangasius* feeds mainly on gastropods. Hora found that *Tunica* feeds on vivipara. *Gourami* feeds on young snails.

#### SOPHISTICATED METHODS

##### *Sterile male technique*

As in other fields of biology there are pest control problems in which application of nuclear radiation and radio isotopes can be used. The use of sterilized insects is a form of biological control. But this cannot be offered as a panacea or as a replacement for

conventional control practices. However, the gratifying success with sterilized screw worm flies (*Callitroga hominivorax*) should encourage entomologists to think about the possibility of applying sterilization technique to some other species. The phenomenal success of eradication programme of screw worm pest of sheep and cattle in USA, by the release of males sterilized by irradiation, has already become an entomological classic in its own right. The laboratory bred, sterilized insects are capable of competing for mates with the normal insects in the population. By overwhelming the natural population with sterile insects and by continuing their release for several generations, the declining number of fertile individuals in the natural population experience progressively greater difficulty in encountering fertile males until the chances of successful mating reaches zero. For the sterile male technique to be effective in the control of an insect, Knippling the pioneer worker in this field, listed five conditions which should prevail: (1) Method of mass rearing of the insect must be available, (2) Adequate dispersal of the released sterile males must be obtained, (3) The sterilization procedure must not adversely affect the mating behaviour of males, (4) The female of the insect to be controlled must normally mate only once, or if more frequent mating occurs the sperms from the gamma irradiated males must compete with those of fertile males, (5) The population density of the insect must be inherently lower or the population must be reduced by other means to a level which will make it economically feasible to release a dominant population of sterile males over an extended period of time.

This method does not seem feasible for application to the huge population of many economic pests that exist over widespread areas. It also is not applicable where the released males would themselves constitute a pest (as in the case of adults of *Oryctes rhinoceros* L., a major pest of coconut). It seems best adapted to those species that are reduced rapidly, but that fact should not eliminate consideration of insect with an annual life-cycle. For those species that produce only one or a few generations per year in nature but which develop more rapidly in the artificial climate of the laboratory, control must be easier because, although insect breeding is retarded out of doors, unlimited population of males might be reared in the insectary, sterilized and released at the beginning of a season. The area from which the pest is to be eradicated should be so situated that reinfestation can be kept to a negligible level or completely excluded. The number of sterile males released per unit area has to be several times higher than the population of normal ones. When sterile male technique is to be employed as a part of integrated control it is more efficient at low population levels. Population should first be brought down by chemical and other means and then sterile male technique applied. This method can be very effective if applied against univoltine grass hoppers and the internal feeders with definite broods. This system of insect control will be of great value in the elimination of new incipient infestation in preventing the spread of insects and for use in conjunction with other methods to eliminate population of well established pest species. Other sterility method of in-

sect control which is still largely under development, involves sterilization of the required proportion of individuals of the natural population by exposing them to chemosterilants in essentially the same manner that insects are exposed to insecticides. They cannot reproduce and they become biological agents capable of reducing reproduction in the normal population.

In Kerala the sterile male technique was tested by the Entomology Division, Central Plantation Crops Research Institute, Kayangulam in collaboration with Bhabha Atomic Research Centre, Trombay against red weevil, the deadly enemy of coconut. Sterilized males were liberated in a red weevil infested area of 400 hectares and the viability of eggs laid by natural population was found reduced to some extent. However, large scale attempts were abandoned considering adverse factors particularly the impracticability of execution in the large and contiguous coconut growing tracts of India.

#### *Cytoplasmic incompatibility*

Strains of insects from different regions are found mutually incompatible. When males of a strain incompatible to local strains are released in sufficient numbers, they induce sterility in the local wild females. *Chromosomal translocation*: Insects can be irradiated and their chromosomes altered by breaking and recombination. Strains developed with such translocation can mate with local strains and induce sterility in the local wild populations.

*Problems of biological control*: Hyper-parasitism occurs when a parasite attacks and develops on another parasite and is a serious problem in biological control. So when an exotic parasite is introduced extreme care should be taken to prevent the introduction of hyper-parasites from the native land of the parasite. The common mechanism by which pest upsets are provoked with contact and stomach poison insecticides, is predominantly through direct destruction of natural-enemy adults. The insecticides selected for the control of a pest should be selective, less persistent and should be so timed as to cause the least adverse side effects on the beneficial parasite population. The complete elimination of natural enemies through disruption of their food chains is not uncommonly the cause of pest outbreaks following insecticide treatment.

*Future possibilities*: Success is a relative term and invariably we measure it in an economic sense. Hence outstanding successes refer to biological control projects against a major pest of a major crop, over a fairly extensive area, so that insecticidal treatment becomes rarely necessary. Partial success are those where chemical control measures are also necessary, but need be done less frequently when the same is integrated with biological control. On a careful scrutiny it may be seen that the number of successes attained will be proportional to the amount of research and importation work carried out. Work should be directed along lines which appear to be most suitable both biologically and ecologically. The idea of international cooperation in biological control work is a long felt need and is soon becoming a reality.