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A REVIEW

Different means of biological control against insect-pests in Indian sub-continent

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ABSTRACT

Biological control may be defined as the use of natural enemies to suppress the pest species. The term natural enemy refers principally to the parasites and predators (mostly other insects) but may also include disease organisms. The high potential rate of increase of insects counters balanced most of the time by high mortality. The two broad groups of natural mortality factors are associated with physical aspects of the environment and those that are due to activities of other living organisms.

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INTRODUCTION

In older times, Chinese used Pharaoh's ant, *Monomorium pharouis* for the control of pests of stored grain. Another predaceous ant, *Oecophyllasmaragdina* was used in Olina in citrus groves to control the foliage feeders. The same species was also used in Yemen to control insect pests in date palm fruit. In more recent times, the Indian Mynah (*Acridotherstristis*) was introduced in Mauritius in 1962 to control the red locust. In 1873, Riley introduced predaceous mite, *Tyrogiyphusphylloxerae* from US to Europe to control the grape phylloxera, *Phylloxera vitifoliae*.

Biological control agents :

There are three different type of agents used for suppression of pests in a crop. These are insect predators, parasites and diseases of insects induced by microorganisms.

Predators :

Predators of insects are animals which capture and consume them as a source of food. Many are other insects, but some other animals also feed on insects, either exclusively or a component of a more mixed diet.

Biological control, insect pest, parasites and predators :

***Insect predators and their prey* :**

Several families of beetles are largely predatory in habit. Among these, the lady birds are important as they attack mainly aphids, scale insects, and mealy bugs, many of which are serious pests of plants. The ground beetles, rove beetles and tiger beetles are predators of a diverse range of ground dwelling insects. A few orders of insects such as Neuroptera are exclusively predatory. Oily few flies, ants, bees and wasps are predatory. Spiders which are closed relatives to insects are exclusively predatory. The predatory habit is also quite common in mites. The major groups of insect predators are given in Table 1 along with their preys.

Parasites :

Insect parasites are those whose larvae feed internally or externally on the body of another insect. The attacked insect is referred to as host and sustains parasitic larvae throughout its development. Insect parasites are always smaller than their hosts, while in predators insects are always bigger than the prey. Insect parasites invariably kill their host by the time their own development is completed.The main families under these orders are listed in Table 2 along with their principal hosts.

Parasites themselves are not immune from other parasite attack. They may be affected by other species and referred to as secondary parasites (hyperparasites). These may also in turn be attacked by tertiary parasites. Such are the inbuilt checks and balances of the nature.

Life cycle of a parasite :

The adults are entirely free living. They may imbibe nectar, but do not normally feed on the host insect. Both the sexes usually occur, but parthenogenesis is common and sometimes males may be few or absent. Eggs are laid by the female into the appropriate stage of a suitable host insect, usually by insertion of ovipositor and deposition of eggs into the body cavity. Sometimes eggs are simply stuck outside of the host or deposited near by (in case of parasitic flies). Once established inside (or externally) on the host, the parasite larva feed and develop, consuming non-essential parts first and then essential parts of the host insects. Eventually, however, as the parasite larvae reaches maturity, virtually the insect host is completely killed, and consumed. Once mature larvae of many parasite species (especially Ichneumonoids) emerge and spin a silken cocoon along the side of the dead host insect. Other parasite species however pupate within the dead body of the host insects. The adults emergence from the pupal stage is usually considerably delayed to synchronize adults of parasite with appropriate stage of the host insect. There may be one or several generations of a parasite each season depending on species.

Pathogenic micro-organisms :

This group comprises bacteria, fungi, viruses, protozoa and nematodes, but their relative importance is rather different with insects. For instance, diseases caused by fungi are relatively much more common in insects, than they are in vertebrates. It should be noted that diseases of insects do not always rapidly kill the affected individuals. The larvae of Japanese beetle infected with milky disease may progress through all the three stages before they finally succumb. In the case of the nematode which affects sirex (steel blue wood wasp), there is no mortality at all but adult female wasps are effectively sterilized so that suppression of the following generation occurs rather than directly infected. However, with many other insects diseases high and rapid mortality takes place. This is particularly true for the insect diseases caused by viruses. The insect pathogenic micro-organisms are listed in Table 3 with examples and symptoms.

Table 1 : The major groups of insect predators and their prey

Sr.No.	Group	Stages which is predatory	Main prey
1.	Lady bird beetles	Larvae and adults	Aphids, Scale insects Mealy bugs
2.	Ground beetles	Larvae and adults	Various soil dwelling insects
3.	Rove beetles	Larvae and adults	Various soil dwelling insects
4.	Tiger beetles	Larvae and adults	Various insects on ground surface
5.	Lace wings	Larvae and adults	Aphids
6.	Hover flies	Larvae only	Aphids
7.	Robber flies	Adults and also larvae in some areas	Various insects
8.	Many species of wasps and ants	Adults but prey fed to larvae	Various insects
9.	Predatory bugs from several families	Nymphs and adults	Various soft bodied insects
10.	Arachnid spiders	Juveniles and adults	Plant feeding mites
11.	Vertebrate birds		Various soil inhibiting insects

Table 2: The main parasitic families of insects and their principal hosts

Sr. No.	Order	Family	Principal hosts
1.	Hymenoptera	Ichneumonide	Larvae of holometabolous insects, specially Lepidoptera (in this case hyper-parasites)
		Braconidae	Larvae of holometabolous insects also aphids
		Encyrtidae	Larvae and pupae of Lepidoptera
		Eulophidae	Scale insects and mealy bugs
		Aphelinidae	Aphids and scale insects
		Pteromalide	Larvae and pupae of Lepidoptera and coleoptera
		Trichogrammatidae	Insects eggs of various orders
2.	Diptera	Tachinidae	Larvae of lepidoptera, Coleoptera, some hemiptera

Specificity :

Most of the insects are rather specific in that they affect only a group of insects or even a single series. Some of them however are considerably broader in activity.

Inoculation (introduction) :

This involves the introduction of new species of parasites, predators or micro-organisms into areas where they did not exist. Once introduced and established they are left to spread and maintain themselves though dispersal which may be assisted initially by artificial means. Introduction is the classical biological control procedure and has been employed in most examples of successful biological control cases over past 100 years. This also involves selection, handling and release of a suitable parasite or predators. If the pest to be controlled has gained entry to the country or area of some other parts, probably the natural enemies are unlikely to have come with it. The biological control in such cases involves the search of natural enemies in the area of origin of the pest and introduces it in the new areas. Strict quarantine is essential to ensure that other unwanted organisms or hyper-parasites are not introduced. Before introducing a parasite in a locality, the three most important points are to be seriously considered, (i) the insect to be introduced should be a parasite on a particular insect, it is not desired to control other plant feeding species, (ii) it is never by any chance a plant feeder, (iii) and it should not attack some of the primary parasites already present in the locality. In Table 4 important exotic natural enemies of pests established and used in India are listed.

Commercially available biological control agents:

Ready availability of the required quantities of healthy natural

Table 3: The main groups of insect pathogenic micro-organism

Sr.No.	Group	Example	Symptoms
1.	Bacteria	Milky disease (*Bacillus popilliate*) of Japanese beetle	Larvae develop a milky white appearance, become sluggish and die. Slow action
2.	Fungi	*Entomophthora* spp. of aphids	Aphids become stuck to leaf surfaces and surrounded by a white halo of spores
3.	Viruses	Granulosis virus of white butterfly	Larvae become water-soaked and blackened in appearance; after death, the body disintegrates releasing fluid loaded with virus
4.	Protozoa	*Nosenia* spp. of grass grub	Growth of larvae is retarded; body later becomes abnormally grey and flecked with dark spots due to pathogen development in the fat body
5.	Nematodes	Deladenussiricidicola of steel blue wood wasp.	Adult female wasps are sterilized by concentrations of nematodes in the developing ovaries. Males are also infected but are not sterilised

Table 4: Important exotic enemies of pests introduced in India

Sr.No.	Enemy	Origin	Pest	Crops	Result
1.	Apantelessubandinus	S. America	Phthorimaeaopercuklla	Potato	E
2.	Apantelesunicoloratia	S. America	*P .operculella*	Potato	E
3.	Aphelinusmali	N. America	Eriosomalanigerum	Apple	E
4.	Chelonusblackburni	Hawaii	*P. operenlella*	Potato	R
5.	Copidosomakoehleri	S.America	*P. operculella*	Potato	S
6.	Cryptolaemusmontrouzieris	Australia	*Planococcu* spp. and other mealy bugs	Citrus, guava, custard, apple, grapes	S S
7.	Curinuscoerules	Mexico	Heteropsyllacubana	Subabul	E
8.	Diadegmaturcator	S.America	*P. operculella*	Potato	E
9.	Encarsiaperniciosi	California, Illinois, Chinese, Russian, strains	Quadraspidiotusperniciosus	Apple	S
10.	Leptomastixdactylopii	West Indies	*Planococcus citri*	Citrus, coffee, guava,	E
11.	Platymeruslaevicollis	Zanzibar	*Oryctes rhinoceros*	Coconut	E
12.	Telenomusalecto	Colombia	Borer	Sugarcane	E
13.	*T.remus*	New Guinea	*Spodoptera litura*	Tobacco	S
14.	*Trichogramma brasiliensis*	S.America	*Helicoverpa armigera*	Cotton	R

enemies for timely releases is an essential pre-requisites for undertaking practical biological control. This requires for establishment of insectaries. It is reported that there are some 40 commercial insectaries in U.S.A, 7 regional laboratories in U.S.S.R. and a number of production units in China, which annually produce millions of parasitiodes and predators for control of a variety of pests. In India, a beginning was made by Pest Control (India) Ltd. by establishing "Biological Research Laboratories" (BCPL) in Bangalore in 1981. In India attempts were first made in 1930, 1960 and in 1970's to use egg parasitoids, *Trichogramma* spp. against the sugarcane borers Chilo species, to control it biologically. But the first commercial production of parasites and predators was only possible during the last 20 years. Now in India, Gorakhapur is another centre which is supplying commercial parasites cards to the farmers for the control of borers. Tamil Nadu Cooperative Sugar Federation has also established a main bio-control research laboratory at Chengelpettu. A large number of progressive sugar factories in North and South India, have also established commercial laboratories to rear the parasites and predators, with the help of sugar development fund.Some of the important biological agents commercially available are listed below.

Trichogramma to control sugarcane borers, cotton boll worms, and apple codling moth, etc. *Trichogramma* (spp.) are most important and widely used parasitoids for control of variety of lepidopterous pests throughout the world. It is used for sugarcane (early shoot, internode, stalk and top borers etc.), cotton bollworms (*i.e.*, spotted, pink ballworms, *Heliothis armigera*) and apple codling moth etc.

Trichogramma is an egg parasitoids. The tiny adults parasitoids remain active in field, locate the host eggs and parasites them, *i.e.* the parasitoid lays its own eggs within the eggs of the pest. On hatching, the parasitoid larvae feeds on the host eggs and completes its development within. The parasitoid egg turns black, and invaluable dignostic character in 3 to 4 days and adult parasitoids emerge in 7 to 9 days. A single parasitoid can thus destroy over 100 eggs of the pest. *Trichogramma* kills the pest in egg stage itself before the pest could cause any damage to the crop. It is purely beneficial insect.Release of 40,000 to 1,00,000 parasitoids/acre are recommended. The parasitoids are supplied by BCRL in the form of "Tricho Card", each card carries 20,000 *Trichogramma* parasitoids.Worldwide, over 32 million ha of agricultural crops and forests are treated annually with *Trichogramma* spp. in 19 countries, mostly in China and Republics of the former Soviet Union (Li, 1994). Parasitoids for coconut black headed caterpillar. The coconut black-headed caterpillar is a serious pest of coconut palms. The caterpillars feed on green portions on the underside of leaves, mostly lower fronts. They remain concealed in form of silken webs and excrete. Two larval parasitoids namely, *Gonizusnephentidis* and *Braconbrevicornis* have been found promising for controlling the pest.When parasitoids are released, they go in search of caterpillar feeding on coconut leaves. The parasitoid paralyses caterpillar by stinging and lays up to 12 eggs on it. The eggs hatch in 2 days. The parasitoid larvae feed on the paralyzed host, and after completing development in 3-4 days, form cocoons on or near the remains of host. After 7-10 days, adult parasitoids emerge and go in search of caterpillars. Releases of 1200 to 1800 parasitoids/acre/season are recommended.An example of the inoculative release method is the use of the parasitoid wasp, *Encarsiaformosa* Gahan, to suppress populations of the greenhouse whitefly, *Trialeurodesvaporariorum* (Westwood), (Parrella, 1990).

Lady bird beetles to check mealy bugs and scale insects:

Mealy bugs and scale insects are the serious pests of a number of agricultural and horticultural crops. These insects hardly move, build up thick colonies on leaves, stems, fruits etc. and suck sap from the plants. Besides this, they secrete a sticky substance known as "honey dew" on which "Sooty moulds" fungus develops, consequently the infested surface become black, and reduces market value of the crop.The species of ladybird beetles, namely, *Cryptolaemusmontrouzieri Symnus coccivora* and *Nephus* spp. can give effective control of mealy bugs infesting coffee, citrus, grape vine, mango etc.Similarly, other two species of beetles, *Chilocorusnigritus* and *Pharoscymnushomi* destroys scale insects of sugarcane, coffee, sapota and other crops.

The adult ladybird beetles, being winged, searched for mealy bugs or scale insects and feed on them through out their life. They live for about 45 days. They lay their tiny eggs in the colony of the pest. Each female can lay 100-250 eggs or more depending on species. Eggs hatch in 5 to 6 days and grubs voraciously feed on all the stages of mealy bugs and scale insects, preferring egg sacs and gravid females. They enter the pupal stage, and the pupae release adult beetles in 8- 10 days. They met again and start feeding and breeding. A minimum release of 600 ladybird beetles/acre is recommended. The releases are made at the first visible sign of infestation.

Parasitoids to control citrus/coffee mealy bug :

An exotic parasitoid namely, *Leptomastrixdactylopii* has given good results controlling mealy bug, *Planococcus-citrii*. It is a specific parasitoid which actively searches for mealy bugs in the fields and lays its eggs in the mealy bugs. On hatching, larva feeds and develops on the mealy bug. It completes it development in 16-18 days and emerges as adult. The adult can live 30-40 days and each female can lay up to 200 eggs. A minimum release of 2000 parasitoids/acre/season is required.

Parasitoids to control housefly and other filth flies:

The pupal parasitoids namely, *Spalangia* spp. and *Pachycrepoideus vindermmiae* have been found to be

promising and are being mass multiplied, and released in sufficient numbers to suppress fly populations in poultry, dairies, piggery, dumping yards etc.European corn borer larvae in corn field edges near these types of habitats are parasitized at two to three times, the rate of those in field interiors (up to 40%) (Landis and Haas, 1992).

Advantages of biological control :

- Biological control has its permanent effect.
- Biological control agents are non-poisonous hence they do not have any toxic residual effect on crop plants.
- Some biological control agents can be produced cheaply and conveniently.
- Insects never become resistant against biological control of agents.
- Few biological control agents are sprayed along with insecticides so that the insect is certainly killed either ' through one or both.
- Beneficial insects do not have any adverse affect as in case of chemical control.
- Biological control agents fit into the ecosystem without disrupting any other components.
- The natural enemies are capable of self-dispersing and self-propagating, so that control is obtained over an entire area.
- The parasitoids and predators have the natural ability to search for their hosts and attack them.

Biological control problems :

- Biological control involves living organisms; hence a qualified person is required for it.
- Have narrow spectrum as they chiefly kills insects of a particular species.
- They are slow in action, so it requires sufficient time to build up, and should be available in large numbers.
- It requires sufficient money and time.
- Few biological agents are effective in particular environmental conditions. So one has to wait for conditions.
- Exotic biological control agents requires favourable climatic conditions, hence sometimes a problem for their survival.
- Sometimes the level of biological control may not be effective.

Conclusions :

Biological control has an important role to play in modem pest control programmes but can never provide a complete solution to all pest problems. Indigenous pests are rarely be controlled by the introduction of dew species of parasites or predators. Further degree of control is inadequate. Horticultural products must be blemish free for market value, which is rarely possible in biological control. But due to some advantages, renewed impetus has been given to biological control in recent years, as an important component of pest management systems.1n such systems, biological control is supplemented by other methods. There is little doubt that the potential for biological control of many pests has not yet been fully explored and further advances may be expected both in situations where it is to be used alone and in conjunction with others.

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