# THE ROLE OF PREDATORS IN BIOLOGICAL CONTROL OF INSECT PESTS

By Dr. K. N. Trehan
(*Professor of Entomology, College of Agriculture, Poona*)

## Introductory

Under favourable conditions of food and climate, insects multiply freely but their population is regulated automatically by the presence of their enemies or through the intrinsic limitations of the organisms themselves (Thompson, 1939). This view is also supported by Elton (1930) who emphasized that animal population is controlled by natural factors to a position of optimum density. Occasionally, however, some pests attain prominence either when they are transferred to new environments where they flourish unchecked in the absence of enemies, or in their original habitat where they establish relatively more harmonious relations with their surroundings. Under such circumstances, the economic loss is apt to increase in geometrical progression unless a speedy control is adopted. Insecticidal and mechanical methods of control are practicable when speedy control is desired, but their repeated applications always increase the cost of production since a single treatment does not ensure the crop against future attacks. Cultural methods of control have practically limited scope since they involve certain complications with respect to different varieties, date of sowing, number of irrigations and manures, etc. Biological control on the other hand, implies the application of parasites or predators, either introduced from their original home or bred artificially and liberated in the fields. Both these types of beneficial insects flourish in nature in association with the pest which is thereby kept under control. The parasites cause the death of their victims through a slow process, whereas predators destroy them directly by feeding on them. A lot of useful literature on parasites and parasitism is available but the predators on the contrary have received relatively little attention even though their efficacy has been experimentally established in certain cases.

## Origin of Predators

Insects are believed to be primarily phytophagous. In nature, therefore, some species of insects must of necessity have been established on one and the same food plant. Hence according to Sweetman (1936) a slight variation in food habits may produce a useful predatory species. Under extreme cases of restricted food however, a keen competition among individuals of one and the same species or of different species is bound to occur and some of the individuals may be forced to develop cannibalistic habits. Such deviations in feeding habits probably resulted in modification of certain useful characters which in the course of further development became functional and permanent. In most cases, however, morphological modifications are confined to the mouth parts and the grasping organs only.

Secondary differentiation in habits is met with among *Syrphid* larvæ which may be phytophagous, carnivorous or seprophagous. Similar differentiation is also noticed among *Coccinellidæ*, with characteristic modifications in the mandibles of carnivorous and herbivorous forms. It may, therefore, be believed that the predatory habit among insects is secondary in origin.

## Host-Predator Relationship

The activities of parasites are usually more appreciated than those of the predators whose specificity in the selection of hosts is often doubted. However, Thompson (1928-29) examined this factor critically and emphasized that the predators like the parasites, are equally specific in the choice of their hosts. For instance, *Hyperaspini* is said to feed exclusively on coccids; *Hippodemiini* mostly on aphids and *Microweiscini* destroy *Diaspini* scales. The genera *Rodalia* and *Novius* feed on Icerya, whereas *Scymnus, Syrphids* and *Chrysopids* prey upon aphids and white-flies. Some of the Carabids feed mainly on larger *Lepidoptera* and the *Nitidulid-Rhizophagus* feeds on wood-boring coleopterous larvæ. Of the Hemiptera, *Perillus bioculatus* confines its attack on colorado beetle—*Leptinotersa decemlineata* Say. According to Morris (1938) *Eupelmella vesicularis* Retz. confines itself exclusively to *Microplactron fuscipennis* Zett. as a host and is capable of detecting the presence of its larvæ and pupæ even within the cocoons of the Saw-fly.

The primary relation between the host and the predator is their close proximity. As a rule, both these types flourish in one and the same environment; the surroundings agreeable to one may be presumed suitable to the other, both establishing for themselves an ecological equilibrium. Food being the primary consideration, increase in pest population is normally followed by the corresponding increase in the numbers of its enemies. This statement has a bearing on the laws concerning the interaction of a predator and its prey, *vide* Volterra (1926), since it is concluded that, if the prey is given additional protection the mean values of the populations of both the species, increase. Nevertheless, a keen competition between the two rival factors ensues but usually the activities of the predacious insect predominate and ultimately it becomes a controlling factor, the effect being reproduced automatically. Since a predator multiplies at the expense of the host, the predators will also be affected adversely to some extent.

The greatest achievement, however, is brought about by the fact that predators as a rule, kill far too many individuals than are actually required as food. Thus the performance of a predator differs remarkably from that of a parasite which can kill only one host at a time. Often even this much is far from expectation, since a parasite may deposit more than one egg in one and the same host or if it be a case of superparasitism two or more species of parasites may contribute simultaneously towards the ultimate death of a single host. The capabilities of a predator, on the contrary, are well pronounced and this fact predominates even if a predator is relatively less prolific or less specific. Clausen (1916) estimated that *Hippodamia convergens* Guer. destroys on an average, 21 aphids a day during its larval stage and the number consumed by the insects of any single species during one life-cycle may go upto 624. Wildermuth (1916) observed that *Chrysopa californica* is capable of destroying 300-400 aphids during its larval life, while according to Simenton (1916) a single larva of *Hyperaspis binotata* Say. may destroy 90 adults and 3,000 coccid larvæ during the entire larval period. Burgess (1911) estimated that on an average, a single larva of *Calosoma sycophanta* L. devours 41 full-grown caterpillars of gipsy moth and the adult may kill 238-272 caterpillars during its life. Certain coccinellids, however, have been observed by various workers to destroy upto 1,000 caterpillars. Morris (1938) states that one larva of *Eupelmella* is capable of eating 20 larvæ and pupæ of *Microplectron* and finally it kills all the remaining living young ones of the host before it pupates. Similar observations support the importance of various species of predators in the control of the pest.

This fact is further strengthened by the observation that in most cases both the adults as well as the larvæ possess predacious habits; their activities, therefore, prove all the more effective in the destruction of pests. This behaviour may even compensate for the slightly lower rate of reproduction although this feature is not of common occurrence. On the contrary, some predators as in Meloidæ are rather prolific and may lay from 2,000–10,000 eggs per female.

### Hyper-Predatorism

Some of the useful predators assume the status of injurious insects as a result of which their utility is greatly handicapped since they prey upon other predators. This behaviour is allied to hyper-parasitism and as such works adversely in the control of insect pests. Henson (1937) gives a few instances of this nature and particularly mentions *Thanasimus formicarius*, a predator on bark-beetle. This predator is extremely voracious both in its adult and larval stages but unfortunately it destroys equally readily the larvæ of Rhizophagus and *Euraca* spp., both of which are quite effective predators on the same pest. Their cannibalistic habit may even be extended further when they begin to devour each other in the absence of any food. This undesirable activity interferes materially with the biological control of the pest.

An interesting instance of similar nature to that described above is cited by Morris (1938) where a chalcid *Eupelmella vesicularis* Retz. acts as a predator on another chalcid parasite, *Microplectron fuscipennis* Zett. and on saw-fly, *Diprion sertifer*, in Hungary. It has been observed that once this predator gets established, it definitely brings about an appreciable inhibitory effect upon the efficiency of the primary parasite in the control of the pest.

Such instances of hyper-predatorism or of predators on primary parasites are practically unrecorded in India. However, systematic observations will be needed before we are in a position to confirm its existence in our country.

### Application of Predators

Introduction of useful insects has actually yielded results of considerable importance and as in the case of parasites the utility of some of the predators has equally been tried by various investigators in other countries. For instance, *Novius cardinalis* (Imms, 1926) Syn. *Vedalia cardinalis* (Wardle, 1929) proved its efficacy in the control of Fluted scale *Icerya purchasi* of citrus in Hawaii. Similarly *Cyrtorhinus mundulus* (Wardle, *Cytorhinus mundulus*) effected a complete control against *Perkinsiella sacoharicida*, a very serious pest of sugarcane in Hawaii. *Calosoma sycophanta* L. was regarded one of the most important biological factors of control against the gypsy moth in New England. Results of considerable encouragement have also been obtained by the introduction of *Hyperaspis silvestrii* in Hawaii from Mexico, since it completely controlled the Avocordo Mealy-bug, *Pseudococcus nipæ*. Another instance of a perfect control by a predator was through the activity of a coccinellid beetle, *Cœlophora inacqualis* against a black aphid. A similar enterprise of outstanding nature was the control of *Citrophilus* Mealy-bug in California with the help of *Cryptolœmus* lady-bird beetle. In India, similar enterprises have not received much response. Recently, however, Rahman (1940) has contributed a valuable list of the important predators in India and added brief notes on their life-history and seasonal activities.

Husain and Trehan (1933) state that the adults of *B. gossypiperda* (*B. tabacci*), the white-fly of cotton in the Punjab, killed by the larvæ of *Chrysopa* sp. and *Brumus* sp., far exceed that which is actually required for food. Their population in the fields yielded the following results and their application in field cages practically controlled the pest:—

Table I

| Date | *Brumus* sp. per 100 plants | | *Chrysopa* sp. per 100 plants | |
|---|---|---|---|---|
| | Adults | Grubs | Adults | Grubs |
| 31- 8-29 | 52 | 212 | 396 | 1,084 |
| 5- 9-29 | 348 | 404 | 321 | 1,632 |
| 24- 9-29 | — | — | — | 380 |
| 3-10-29 | 128 | — | 108 | 240 |
| 13-10-29 | 104 | 48 | 60 | 52 |
| 20-10-29 | — | 95 | — | 56 |
| 1-11-29 | — | — | 60 | — |

Rahman (1940) also pointed out that various species of *Aleurodidœ* in the Kulu valley are kept under control through the activities of *Brumus suturalis* and *Scymnus* sp. *Eriosoma lengigerum* (woolly aphis) has quite a number of insect enemies in the Kulu valley. Its relative decrease in numbers during certain parts of the year is generally attributed to the prominence of certain predators, the commonest being *Ballia encharsis*, *Syrphus confrator*, *C. chrysopa* sp., and *Chilomenes bijugus*.

Ayyar (1940) recorded a new species *Scymnus coccivora* which has been regarded as an extremely effective natural control against the *nim* scale, *Pulvinaria maxima*, round about Coimbatore. Kapoor (1939) contributed a short note on the bionomics of *Adonia variegata* Goez., and stated that its larvæ are capable of feeding on 65 aphids during various instars. The adults, on the other hand, may feed on 35-75 aphids per day.

QUALIFICATIONS OF AN EFFECTIVE PREDATOR

Significance of biological control goes with the accurate functioning of the predators utilized for the purpose. A few primary qualifications, therefore, may be considered necessary before a final selection is made.

1. Specificity for a given host is extremely essential since a predator's efficacy depends considerably on this behaviour. A thorough study, therefore, is needed and the range of hosts studied properly. A predator showing the greatest tendency to feed on the pest under consideration should be encouraged.

2. Rate of reproduction and the capacity of preying upon the pest need special attention. A predator which multiplies rapidly and at the same time its individuals are in the habit of destroying too many insects, will prove extremely successful in controlling the pest.

3. Seasonal activity of the predator should coincide with that of the pest. Greater achievements may even be expected if a predator assumes activity slightly earlier than the pest. This will surely facilitate the control because of the superiority of the predators over the pest with respect to their numbers.

4. A predator will achieve maximum efficacy if its multiplication is not checked in any way, by its parasites or predators.

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# SOME ASPECTS OF SHARK LIVER OIL INDUSTRY IN INDIA

BY DR. C. C. JOHN
*(Department of Marine Biology and Fisheries, Travancore)*

IT is now more than three years since the manufacture of Shark Liver Oil was started on a commercial scale in India and within this short period, it has gained considerable popularity as a substitute for Cod Liver Oil. The industry was first started under the initiative of the Fisheries Departments of Travancore and Madras, but soon other maritime provinces followed the example and in due course, private enterprises also started manufacture. At present, though all these concerns are exploring every possible avenue for increasing production and though the output to-day is much greater than what it was two years ago, it can be safely asserted that, at present, the demand is much in excess of available supplies.

It is a generally accepted fact that dislocation of International trade due to conditions of war, provides opportunities for developing indigenous industries. This is well exemplified by the growth of Shark Liver Oil industry in India. Though Shark Liver Oil was known to possess high vitamin potency it was never able to find a market in competition with Norwegian Cod Liver Oil during pre-war days. But, when the supply of Cod Liver Oil was completely cut off and when the medical profession began searching for a suitable substitute, the valuable researches and propaganda conducted by the Nutrition Research Laboratory at Coonoor, assured confidence regarding the suitability of Shark Liver Oil and very soon this new product found a place on every chemist's counter in many parts of India. But this meteoric development had its disadvantages. In the midst of heavy rush of orders and efforts to increase production there was hardly any breathing space to realise the necessity for improving methods of manufacture, based on correct principles of fish oil technology. If, however, this tendency to ignore the necessity of improving quality is allowed to prevail unchecked, it may ultimately prove disastrous to the future of the industry and once more yield to the influx of foreign products when conditions return to normal. Stabilisation of the industry will be possible only if side by side with every effort to increase production, equal, if not greater, attention is concentrated on improving and standardising quality through scientific investigations.

Researches on fish oils so far undertaken in India relate to the determination of vitamin A potency and the specific chemical properties of the oils of some of the common varieties of sharks found in Indian seas. On the manufacturing side, however, no work of any importance seems to have been carried out nor any endeavour made to adopt the technical principles followed elsewhere. The disadvantages resulting from the neglect of this aspect may be summarised as follows:—

Fish oils tend to become rancid when stored for more than a limited period of time. Peroxides formed during the process, cause rapid destruction of vitamin A. If, therefore, the vitamin is to be preserved, oxidative rancidity should be prevented. The method of extraction, storage, influence of light and the degree of unsaturation, are all important factors which control the development of peroxides. In foreign countries antioxidants derived from certain seeds are used for the stabilization of fish oils but this is mostly kept as a closely guarded trade secret. It is necessary to prepare extracts of the indigenous seeds and test them so as to discover a suitable antioxidant.

The removal of sterine from Shark Liver Oil is an important process which determines the quality of oil for human consumption. At present raw oil is cooled at random. But