Israel Journal of Entomology Vol. VI, 1971

# ON SOME BIOLOGICAL CONTROL PROBLEMS IN JAPAN

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## The Comstock Mealybug

The first topic is the development of a biotic insecticide against the Comstock mealybug which occurs also in Israeli, and is there controlled by a parasite, Clausenia purpurea, introduced from Japan many years ago.
Since the introduction of organic synthetic chemicals the comstock mealybug has become a serious pest of apple trees in the northern part of Japan. The new persistant chemicals have almost eliminated the natural enemies of the mealybug. In apple groves the growers apply insecticides and fungicides more than 20 times per year. It is thus our urgent need to reduce the number of applications, so as to prevent the development of resistant strains of insect pests and the chemical pollution problem, and also to conserve the natural enemies as much as possible.

The Takeda Chemical and Industrial Company has paid great attention to the control of this mealybug and began to develop a biotic insecticide against this pest. Dr. Morimoto, the entomologist of the company, has conducted fundamental and technical studies on Pseudaphycus malinus under my guidance. This parasite was shipped to the USA many years ago, and from the USA was sent to Canada and the USSR. In Japan, this parasite occurs only in the Chita and Fukuoka Prefectures, located in the Southern part, but never uccurs in the colder Northern region, where apple is one of the main crops.
If the temperatue falls below a minimum the parasite cannot overwinter.
Thus a biotic insecticide like Pseudaphycus malinus can be used annually on a commercial basis.

In the spring of 1970, the Takeda Chemical and Industrial Company was able to establish a method of mass rearing and storage of the parasitized mummies by inducing diapause, and the parasite was registered as a biotic insecticide by the Ministry of Agriculture and Forestry. This is certainly the first biotic insecticide ever made in Japan.

This parasite has the following advantages. The Oviposition period is short, 4 to 10 days, whereas it lasts 16 to 20 days in Clausenia pupurea, So, we can use it easily, between two insecticide applications. This parasite has an excellent searching ability for the hosts, which are located in places as difficult to reach with insecticides. The female oviposits in every stage of the nymphs and in adults; and it is poly-parasitic when it parasitizes the older stages of the host. On the other hand, Clausenia purpurea attacks only the first and second instar nymph of the host, and never attacks the 3rd instar or the adult, furthermore it is monoparasitic. The duration of one generation at 25$^{o}$ Cis more than 41 days both in Clausenia purpurea and its meallybug host, whereas it is only more than 21 days in Pseudaphycus malinus. Thus, one liberation of the parasite well corresponds to two applications of insecticides. In other words the parasite completes two generations in a single host generation. This parasite has a biotic potential more than 30 times that of the host mealybug. Two or three hours after emergence, the adult female begins ovipositing, and within 5 to 7 days more than 90% of the eggs are deposited in the host. The average number of eggs, deposited per female, is about 100. The number laid in a host individual depends upon its seize. An average of 1.3 in the 1st instar host nymph, 1.9 in the 2nd, 12.5 in the 3rd, and 16.7 in the host adult.

The live material is sent to the apple growers by the Takeda Chemical and Industrial Company in a special box. The box contains 50 sheets of papers each harboring about 2000 parasitized mealybug mummies. On an average, three sheets are enough for a single apple tree. The sheets are fixed to a tree trunk.

It is estimated that one sheet may control more than fourteen thousand host mealybugs. It is desirable to control the ants in advance. Most effective results are obtainable in June, when the parasite is used against the second or third instar nymph of the overwintering generation of the host.

At the moment, the cost of mass production of this biotic insecticide is still fairly high, but Dr. Morimoto is making every effort to reduce it. The capacity of producing this biotic insecticide is still limited, but in the near future the company will be able to fulfill the urgent demand of the apple growers.

## Rice Stem Borers

The second topic is the finding of the alternate host of Trichogramma japonicum, an egg-parasite of the rice stem borer, Chilo suppressalis, and also the discovery of Chilo hylax in Japan.

Trichogramma japonicum is an effective egg parasite of the rice stem borer of the first generation in early summer, when the percentage of parasitism may rise to 909 . But in the case of second generation eggs the percentage of parasitism is almost zero. One reason of this difference in parasitism is the habit of host preference of the parasite. In early summer the foliage of rice plants is not dense and the egg masses of the rice stem borer are deposited on the surface of the leaves and are well exposed to the parasite. On the other hand, from late August through early September, the foliage of rice plants is very dense and the egg masses are found exclusively in the sheath of leaves and are difficult to be noticed by the parasite. In the paddy fields or nearby, the alternate hosts of Trichograma are very few and they are not enough to support the large numbers of Trichogramma of the second and the following generations. Generally the rice stem borer has two generations a year, but the egg parasite *Trichogramma* has at least eleven or tweleve generations in the warmer parts of Japan. Nevertheless, the percentage of parasitism in the early summer of the next year is very high. This phenomenon has long been a mystery and no one knew the causes to this situation.

Back in 1965, during our survey of natural enemies for rice stem borers including five species in southern and eastern Asia, we discovered the egg of a Sciomyzid, *Sepedon santeri*, as an important alternate host of *Trichogramma japonicum*. This fly is very common in paddy field or in swampy areas, the adult occurs almost all the year round and the generations overlap. So, we can find its egg masses in any season except in the winter. The eggs are deposited side by side in masses on the foliage of any kind of grasses grown in swampy places. Large numbers of *Trichogramma japonicum* were reared from the eggs of *Sepedon santeri* which had been regarded as having no connection to rice cultivation. But our discovery revealed that the eggs of *Sepedon santeri* are contributing much to the maintenance of the *Trichogramma japonicum* population. The larva of this Sciomyzid fly is a predator of the aquatic snail, *Lymnaea*, which transmits disease. Several years ago, this fly was introduced to Hawail to control *Lymnaea* there. Now, the fly is well established all over the Hawaiian Islands. Recently *Trichogramma japonicum* was also reared from the egg of this fly on the island Mani of Hawaii. Our finding would suggest that the higher the population of *Sepedon* flies in the paddy field the lower the infestation of the rice stem borer in early summer. The presence of *Sepedon* is most important to bridge over the population of *Trichogramma japonicum* from one *Chilo* generation to another and at the same time to control the aquatic snail.

Two species of rice stem borers have been know in Japan, namely *Chilo suppressalis* and *Tryporyza incertulas*. The former occurs all over, Japan along the Pacific coast. For more than 80 years, many of the Japanese entomologists have been engaged in the study of *C. suppressalis*, which has long been the major insect pest of the rice plant. While studying the material of moths of *Chilo suppressalis* which were attracted to the light traps of the Agricultural Experiment Stations in various provinces, we came across specimens of a different species. After a careful taxonomic study, we identified the species as *Chilo hylax*, which was originally described from China and Manchuria and has been unrecorded from Japan. As the two species, *Chilo suppressalis* and *Chilo hylax*, are so similar in appearance to each other, the distinction is very difficult. We have before us tremendous volumes of knowledge on *Chilo suppressalis* hitherto accumulated in Japan. Unfortunately, however, it became clear from our discovery that this knowledge contains mixed data on *Chilo suppressalis* and *Chilo hylax* and the former voluminous data has become entirely unreliable from the taxonomic standpoint. We are now trying to find the food plants and the larvae and pupae of *Chilo hylax*. Our finding shows the importance of taxonomic work concerning the most common and popular species of economic importance in the field of applied entomology.

## Integrated Control of Citrus Pests.

The third and last topic is the successful trial of integrated control of some citrus pests in the Hagi District of Japan. In this area some of the citrus growers are getting fruit without applying any insecticides and in these groves the natural enemies are very abundant. On the other hand, in the citrus groves receiving frequent applications of insecticides, natural enemies are very few and the citrus growers are always threatened by infestation of several insect pests and citrus mites.

Nine years ago Dr. Nohara, one of our research team members, started investigations under my guidance on the possibility of control of citrus pests by harmonizing biological and chemical or physical control. Finally, he succeeded to establish an integrated control program of citrus pests in 1969, and his recommendations were approved by the Control Committee of the Provincial Department of Agriculture and are included in the commercial programme of citrus pest control. The most important pests of the Hagi district are a scale insect, Unaspis yanonensis, which was introduced into France some years ago and the citrus red mite, Panonychus citri. Among the predators of these pests, Saula japonica and Chilocorus kuwanae are the most important. The former belongs to the Endomychidae and the latter to the Coccinellidae. The effect of insecticides upon these predators was investigated both in the laboratory and under field conditions. The result was quite different in the two series of experiments and shows the necessity of an experiment in the citrus groves where the behaviour of each species of predator is closely watched.

The data also suggest that the results obtained in the vial or in the laboratory are not applicable to the grove conditions.

In Nohara's experiment, alternate rows of citrus trees were sprayed against Unaspis yanonensis during June, September and December. As a result the populations of insect pests in experimental plots were below the economic threshold, and large numbers of predators were found in the citrus groves after about three years. The expenditure in the experimental groves was far less than that in the groves receiving applications of such insecticides as fussol. phenkapton or dicofol. He also found that the spraying of water under high pressure against the Citrus red mite is very effective and many of the washed down mites could not crawl up to the tree again. If this method is applied to the citrus groves two or three times before the outbreak of the red citrus mite that pest will remain below the economic level by the activity of predators mentioned above.

Most interesting and important in the finding of Mr. Nohara is the behaviour and biology of Saula japonica. Generally, Endomychid beetles are fungivorous. Saula japonica was always seen resting quietly under the leaves of Citrus trees, so one was able to observe the activity and food habits of this beetle. According to the study of Nohara, both the larva adult of Saula japonica feed on all stages of Unaspic yanonesis, Pulvinaria awantii, Icerya purchasi, Pasnonychus citri, larva of a Flattid and several species of fungi including sooty molds. The beetle has two or three generations a year. The feeding activity of Saula japonica is confined only to the period after darkness and the female also prefers to oviposti on the underside of leaves at night. About eight eggs are deposited in a mass. Most important is the fact that Saula japonica has no natural enemies and the egg is not attacked by Coccinellid beetles and no cannibalistic behaviour was observed within the species. The number of eggs deposited per female is over 100. Oviposition ceases during the warmest season. Over-wintering commences at the end of September, gregariously, within the dead and curled leaves of citrus trees. This beetle is most convenient in having the habits of both predator and fungivore . We can rear the larvae and adults not only on insect pests but also exclusively on fungi. So the beetle completes its life cycle and reproduces very well event in the absence of insect prey. We are now studying the method of mass production of this beetles using various kinds of fungi.

Chilocorus kuwanae, the other important predator of the citrus yanone-scale, has three generations a year. During the larval period, one larva period, one larva consumes 98 individuals of yanone - scales in May and 1117 in August. During its life span one adult beetle destroys 44 yanone-scales in July and 392 scales in August until its death. As many as 1085 scales are fed upon by the overwintering adult.

This beetle overwinters in the adult stage and small mass assemblages are commonly found in places where the fluctuation of temperature is light, the wind is not strong and the prey is easy to find. They prefer small twigs or branches of citrus trees. Even in the winter time, they become active and crawl about outside the hibernacula when the maximum daily temperature rises up to 10°C and begin to feed Yanon-scale when the temperature rises to 12°C.

Actually many of the beetle move to other places outside citrus groves to find appropriate overwintering sites and the delay in returning to citrus groves in the next spring may cause an increase of population of yanone-sclae. To prevent the outward movement of the beetle, we recommend to provide overwintering sites to the beetle on the trunk or branch of Citrus in the form of cloth girdles.

One of the disadvantages of this coccinellid is the presence of its parasites, Homalotylus flaminius and a species of Tetrastichus. When this Coccinellid is free from the severe attack of these Encyrtid and, Eulophid, it may play an important role in the control of Yanone-scale.

Anyway, in the citrus groves of the Hagi district, citrus pests are controlled below the economic level by combining the 1.5 applications of chemicals per tree and many predators including Saula japonica and Chilocorus kuwanae.