NOTAS CIENTIFICAS

INTERNATIONAL ASPECTS OF BIOLOGICAL CONTROL OF INSECT PESTS (*)

By CURTIS P. CLAUSEN (**)

The biological control of insect pests of agricultural crops involves the utilization of their natural enemies to reduce the infestations below a destructive level. Its development necessitates, more than any other method of control, a close cooperation between entomological organizations of the different countries in order to obtain the most effective results. In any country, the pest that it is desired to control by this method are almost all of foreign origin, and consequently the first step in the program is to obtain living colonies of the different natural enemies from the region or country in which the pest insects originated. This is accomplished either by sending specialists to the country of origin to make the collections, in which case the cooperation of local entomologists is often very valuable, or by arranging with an entomological organization in that country to collect and forward the parasites and predators that may be available. In either case, international cooperation is involved, and it is only by the fullest use of these opportunities that maximum results can be obtained.

The emphasis on biological control of pests of foreign origin, as against those which are native, is based on the fact that the latter are already attacked by a full series of natural enemies, and if these are not able to bring about control there is little possibility that imported species, having the same general habits, would be any more effective. The situation with respect to introduced pests is markedly different. When these become established in a new country, the natural enemies which attack them in the country of origin usually have been left behind. As a result, the pest insects are freed from their natural controls and are able to increase to a level at which they are often much more destructive than in the country of origin. Biological control represents

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(**) Bureau of Entomology and Plant Quarantine, Agricultural Research Administration. United States Departament of Agriculture, Washington, D. C.

an effort, through the importation of the natural enemies, to establish the equilibrium at the low level that usually exists in the country of origin. The possibilities of biological control in any country are therefore correlated with the number of foreign pests that have become established there in destructive numbers. Of these, only a portion can be fully controlled; some will be subject only to partial control, while with others the attempt will be entirely unsuccessful.

The control of insect pests by the biological method is a development of the last fifty-five years. While several previous efforts to transport beneficial insects from one country to another had been made and a parasite of the cabbage worm obtained from England had been established in the United States some years previously, yet the real beginning is found in the work on the cottony-cushion scale, *Icerya purchasi* Mask., during 1888-1889. It was this problem and the spectacular success that followed establishment of the Vedalia beetle, *Rodolia cardinalis* (Muls.) that quickly led to the realization that control of insect pests was possible by means other than the application of chemicals.

The cottony-cushion scale, a pest of citrus and native of Australia, was first found in California in 1868, and during the following twenty years it increased and spread to such an extent that the welfare of the citrus industry was seriously threatened. Every possible method of control was investigated and, following receipt of information from Australia that natural enemies had been observed to attack the pest there, Albert Koebele was sent to that country in 1888 to study problem an to ship to the United States such natural enemies as appeared to be promising. His investigations revealed that the Vedalia beetle apparently was responsible for holding the pest in check in Australia and, accordingly, several shipments were dispatched to the United States. Within less than two years after the arrival of the first shipments the beetle had increased so greatly, and had been so widely distributed, that the pest was under complete control throughout southern California, and that condition has persisted up to the present day.

Knowledge of the spectacular outcome of this problem in California quickly spread to other countries where the cottony-cushion scale had become established, and very soon the further distribution of the beetle, which was to take it eventually into practically every citrus growing country in the world, began. Shipments were made to Hawaii and Mexico in 1890, to South Africa in 1891-92, and to Egypt and New Zealand in 1892. Up to the present time it has been imported into at least 26 countries and is now established and effective in almost all of them. It was colonized in Chile in 1931 and 1933 and is reported to be established. In addition to Chile, other South American countries that have benefited through introduction of this beetle are Argentina, Brazil, Ecuador, Peru, Uruguay, and Venezuela.

The international movement of several other beneficial insects of almost equal value has taken place on a comparable scale. Thus, *Cryptolaemus montrouzieri* Muls., a valuable Australian predator upon mealybugs, has been imported into 41 different countries since its initial colonization in California in 1891, and *Aphelinus mali* Hald., a North American parasite of the woolly apple aphid, *Eriosoma lanigerun* (Hausm.), has been imported into 44 countries since 1920. Both of these have been colonized in Chile, but *Cryptolaemus* apparently has not become established. Several other species that have shown a high degree of effectiveness against cosmopolitan pests are now being distributed on a comparable scale.

The wide distribution of the well-known parasites and predators that have just been mentioned was accomplished almost entirely by cooperative efforts. The material was assembled by entomologists in the countries where the particular species was already established and was forwarded by mail or express. The care with which this was done, both at the shipping end and in the rearing and colonization work at the receiving end, is reflected in the very high percentage of instances in which establishment was attained.

Since the beginning of biological control work in the United States more than half a century ago, interest in that method of combating crop pests has steadily mounted, and large-scale projects have been developed in Hawaii, Australia, New Zealand, Fiji, Canada, Puerto Rico, and elsewhere. More than twenty-five pest insects heve been fully controlled in one or more countries by this means. The outstanding examples have been in Hawaii on sugarcane insects and in Fiji on a series of pests attacking coconut. Thus far the most consistent results have been obtained in island areas in the tropics and subtropics, where climatic conditions are most favorable for the establishment and increase of the introduced natural enemies. The winter period in temperate regions is often a severe handicap to species imported from a milder climate, and the need, in frequent instances, for an alternate host to bridge this period has prevented the establishment, or the attainment of an effective status of a considerable number of very promising species. Notable successes have nevertheless been achieved in temperate regions, for example, on the oriental fruit moth, *Grapholitha molesta* (Busck), and the Comstock mealybug, *Pseudococcus comstocki* (Kuw.) in the United States, and on the woolly apple aphid, and the white peach scale, *Pseudaulacaspis pentagona* (Targ.), in a number of countries, mainly in Europe and South America.

Much interest has been shown in biological control work in South America, and practically every country has attempted to combat one or more pests by this means. However, no country in South America has yet included biological control as an integral part of a consistent long-time program for the solution of its entomological problems. Such an approach is essential in order that properly trained men may be available and the imported material handled with the greatest efficiency. Many present problems are much more complex than those mentioned in the preceding paragraphs, and much ingenuity and resourcefulness, in addition to knowledge of the insects themselves, is essential. Specialists are now being trained for this line of work in Chile and several other countries of South America, and a great advance in biological control may be anticipated within the near future.

A review of the insect-pest problems in Chile and elsewhere in South America indicates that there are a number of pests against which the importation of natural enemies may be expected to result in commercial control, or at least in a marked reduction in the injury inflicted upon the crops which they attack. It was pointed out in a preceding paragraph that native insects are not generally amenable to control by the biological method. However, a considerable number of important pests in South America are of foreing origin, especially those attacking fruits and fruit trees, and the introduction of their natural enemies might be of great value in controlling them. The cottony cushion scale, woolly apple aphid, and white peach scale are of widespread occurrence, and their natural enemies have already been established in many countries. Where this has not been done it would be well worth while to colonize them as soon as possible. The black scale. *Saissetia oleae* (Bern.), is now of almost cosmopolitan distribution and is one of the most important pests in Chile. For many

years the California State Experiment Station has been engaged in an attempt to control it by the biological method, and a large number of parasites and predators were imported from various countries. A series of these became established and abundant, but satisfactory control was attained only during the last few years, as a result of the introduction of *Metaphycus helvolus* Comp. from South Africa in 1937. This parasite has not yet been imported into South America, but it affords an exceptional opportunity for accomplishing the control of a very troublesome pest.

The mealybugs of the genus *Pseudococcus* are often very injurious to fruit and ornamental trees, and a number of species have become widely distributed. Fortunately they appear to be especially subject to biological control, and effective parasites are available against *P. citri* (Risso), *P. gahani* Green, *P. adonidum* (L.), and *P. comstocki* (Kuw.). There is an excellent possibility that infestations of any of these species can be fully controlled by the introduction of their parasites from the United States, where many of them are established, or from the countries in which they are native.

The oriental fruit moth, a destructive pest of peaches and of Asiatic origin, is now established in Argentina, Brazil, and Uruguay and will in all probability spread to all peach-growing regions of the continent within a relatively short period of time. This insect has come to be the most important pest of this fruit in the United States since its discovery less than twenty years ago and it is now distributed over more than half of the country. Chemical control has proved to be exceedingly difficult and unsatisfactory, but fortunately a native parasite, *Macrocentrus ancylivorus* Roh., the normal host of which is the strawberry leaf roller, *Ancylis comptana fragariae* (Walsh and Riley), has adapted itself to the new pest, and an extensive colonization program has resulted in satisfactory control of the oriental fruit moth in the greater portion of its present range. There are, however, a number of places in which, for reasons not yet clearly understood, the parasite is ineffective. In view of this situation there is not the same assurance of a successful outcome in other countries that may be expected with the pests previously discussed. *M. ancylivorus* and several other parasites of the oriental fruit moth have already been imported into Argentina and Uruguay, and establishment has been attained in the latter country. No detailed report is yet available regarding their field effectiveness. The seriousness of this problem warrants the undertaking of biological control measures as soon as possible after the occurrence of the pest in any country has been determined.

Many inquiries have been received from South American regarding the possibility of controlling the codling moth, *Carpocapsa pomonella* (L.), by the introduction of its natural enemies. This pest now occurs in practically all apple-growing regions of the world with the exception of the Far East. A considerable number of parasites attack its different stages in both Europe and North America. All these, however, appear to be relatively ineffective and, as a result, there is little reason for hope that this pest can be controlled to any practicable extent through the introduction of natural enemies.

The control of the citrus blackfly, *Aleurocanthus woglumi* Ashby, in the West Indies and Central America is an excellent example of what can be accomplished by cooperative efforts. This pest is native to tropical Asia and first appeared in the America in 1913, when it was found in Jamaica. It quickly spread to other island of the West Indies and to Central America, and in every country it became a very destructive pest, not only of citrus but of mango, coffee, and many other plants. Because of the danger of its introduction into

the United States, it was felt that every effort should be made to control the infestations in the countries in which it occurred and thus to reduce in some measure the likelihood of its entry into this country. Accordingly, a cooperative project for its control by the biological method was undertaken in 1928 by the United States Department of Agriculture and the Department of Agriculture, Commerce and Labor of Cuba. The parasites were obtained in Malaya during 1929-31, and their colonization in Cuba resulted in complete control of the pest within a very short time. The parasites, principally *Eretmocerus serius* Silv., have since been colonized in other countries in which the pest is established, with equally satisfactory results. A cooperative project with the Mexican Department of Agriculture for the establishment of the parasites in infestations on the west coast of Mexico has recently been completed.

The grubs of the coleopterous family Scarabaeidae are major pests of agricultural crops in practically all parts of the world, and cause serious injury by feeding upon the roots of grasses, grains, etc. while the adult beetles are often destructive feeders upon a wide range of foliage and fruits. In some instances a considerable measure of control has been attained through the introduction of parasites of the grub stage, but these parasites are usually limited in their host range to a single genus, for which reason the species found to be of value in Hawaii, the United States, and elsewhere probably would be of little value against the pest species occurring in South America. In recent years, however, a considerable degree of success has been attained against the Japanese beetle, *Popillia japonica* Newm., in the United States through the widespread distribution of *Bacillus popilliae* Dutky, a disease-producing organism that attacks the grubs in the soil. Reductions of eighty percent or more in heavy field infestations have been attained within one year after inoculation of the soil with this organism. It is the most effective of the natural enemies of the Japanese beetle now established in the United States. Experiments have shown that it is able to develop in a wide range of scarabeid grubs, and consequently its introduction into any country in which these insects are destructive would be well worth while.

The Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture is at present especially interested in problems that are common to North and South America. As a result of the closing, in 1939, of the parasite station that had been maintained in Europe for twenty years, it was possible to undertake a study of a number of pests in South America. A headquarters Station was established at Montevideo, Uruguay, to which the personel from the European station was assigned, and work was begun inmediately upon a number of important problems, especially the search for natural enemies of the cotton boll weevil. *Anthonomus grandis* Boh., and cotton stainers, *Dysdercus* spp., in Peru; the pink bollworm, *Pectinophora gossypiella* (Saund.), the sugarcane borer, *Diatraes saccharalis* (F.), and plant feeding Coccinellidae in Brazil; the vegetable weevil, *Listroderes obliquus* Klug, in Argentina; and the white-fringed beetle, *Pantomorus leucoloma* (Boh.), in Argentina, Uruguay, and Chile. Parasites of all these, with the exception of the last, are being collected or reared in large numbers for shipment to the United States. The white-fringed beetle, which was found to be generally distributed in Argentina, Uruguay, and the more temperate parts of Chile, has been a most difficult problem, and a search of these countries, covering a period of about two years, has failed to reveal the occurrence of a single parasitic enemy and has revealed no predators of any importance. In these countries the insect is evidently held

down to the status of a relatively minor pest through the operation of limiting factors other than natural enemies.

It may be well to mention briefly the increased possibilities in the international movement of beneficial insects that have come about as a result of changes in transportation facilities. In the past, one of the most difficult problems in biological control work was that of transporting the parasites and predators in the living condition from the country of origin to the one in which they were to be colonized. Ship transportation was slow, often requiring up to six weeks in transit, and delay in making connections at intermediate ports frequently resulted in extending the time even further. Many parasites and predators pass through their complete life cycles in two or there weeks or even less and cannot be retarded in any stage by reduced temperatures, so it is obvious that the only practicable procedure was to condut rearing work en route. This necessitated the shipment of plants in Wardian or other cages, upon which the insects could be reared, and involved close personal attention throughout the voyage. This situation has been radically changed since the advent of international airplane transportation. After the termination of the present war, air routes will undoubtedly extend to virtually every country in the world, so that this method of shipment will be used almost exclusively for the forwarding of living insects. The time in transit will be sufficiently short, seldom requiring as much as one week from any part of the world, so that almost any species may be shipped successfully in the pupal or adult stage and without need for any attention en route. Parcels containing pure colonies of parasites and predators may now be forwarded by international air mail, while the more bulky consignments, which may contain living host stages, will need to be shipped by air express. Utilization of these means of shipment will greatly reduce, the cost of the importation program and will shorten appreciably the time required to make the initial colonies available for field release.

In conclusion, the principal lines along which international cooperation in biological control can be advanced may be pointed out. First there is need for a freer exchange of information concerning the occurrence of natural enemies of the more important crop pests, and their relative importance in control. This may be by publitations or by personal contacts between entomologists of the may be achieved by publications or by personal contacts between entomologists of the different countries. The latter is particularly fruitful, and the visits of entomologists to other countries, or exchanges for study purposes, should be encouraged. Second, when parasites and predators of a given pest are introduced into any country and prove exceptionally effective, a special effort should be made to distribute this information as soon as posible to countries having the same problem, and full cooperation should be extended in forwarding colonies of the natural enemies, if they are requested. Third, there is opportunity for the much greater development of actual cooperative projects between countries confronted with the same problems. By sharing costs, the completion of the program can be expedited and accomplished on a much more economical basis for each of the contries concerned than if done independently. The example of the work on the citrus blackfly by the United States, Cuba, and Mexico illustrates what may be accomplished in this way.

RESUMEN

En control biológico de los insectos perjudiciales consiste en la utilización de sus enemigos naturales, para reducir la infestación de aquellos a limites

que ya no sean de consideración económica. Esta labor, más que ninguna otra semejante, implica una estrecha cooperación internacional. Tal cooperación debe referirse a un intercambio de informaciones sobre la presencia de enemigos naturales de las importantes plagas de los cultivos; información que, cuando un parásito o predator ha demostrado una excepcional efectividad, debe ser particularmente amplia para aquellos países que padecen de la misma plaga. Esta cooperación internacional puede incluir además la estructuración de programas o planes comunes de control, posibilitando una mayor efectividad y economía en la realización de estos.

"LOS HONGOS CHILENOS Y LOS BOTANICOS EXTRANJEROS" (*)

por JOHN R. STEVENSON (**) y FERNANDO MUJICA (***)

Al iniciar el estudio de los hongos chilenos puede apreciarse de inmediato que, al igual que otras naciones del Nuevo Mundo, una parte considerable del trabajo de recolección y estudio de estos importantes organismos ha sido realizada por botánicos extranjeros (en su mayoría europeos). Por supuesto ésto significa que los especímenes recolectados por ellos y en particular los tipos (colecciones originales) han sido depositados en museos extranjeros y que las publicaciones relativas a estos temas se encuentran esparcidas en la voluminosa literatura botánica de tres continentes.

En la preparación de un índice de los hongos chilenos se ha hecho, como medida necesaria, una revisión de la literatura extranjera para suplementar las referencias chilenas sobre el particular. Este estudio ha traído a la luz una lista de títulos que se acerca a doscientos, los cuales se refieren en forma exclusiva o en parte al tema en consideración y revelan que en los últimos 100 años, un número sorprendentemente elevado de micólogos europeos y norteamericanos han contribuído a dar a conocer los hongos chilenos.

La primera mención conocida sobre el tema, se cree, es una breve nota de Philibert Commerson, botánico francés que acompañó a Luis de Bougainville como físico y naturalista en su viaje alrededor del mundo en 1766-1769. Este colectó y depositó en el Museo de París un specimen de la que más tarde fué descrita como *Cyttaria darwinii*. Este hongo es miembro de un género único que por largo espacio de tiempo ha intrigado al mundo micológico. Algunas de sus especies, fueron por lo menos en los tiempos primitivos, usadas como alimento por los indios aborígenes del Sur de Chile, Tierra del Fuego y áreas vecinas de Argentina, donde estos hongos, en un número de especies, crecen naturalmente en las ramas del haya antarctica (*Nothofagus sp.*).

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(**) Micólogo Jefe a cargo de las colecciones micológicas, Bureau of Plan Industry, Soils and Agricultural Engineering, Agricultural Research Administration, Departamento de Agricultura de los EE. UU.

(***) Ingeniero Agrónomo Jefe de la Sección Fitopatología del Departamento de Sanidad Vegetal.