

AN HISTORICAL ACCOUNT OF BIOLOGICAL CONTROL IN ISRAEL

A. The Pioneers (1905 - 1915)

The first entomological activity related to biological control, recorded in Palestine early this century was that of a visiting entomologist. This may seem strange, but one should remember that during the first decade of this century, the country was under Turkish rule and there were no government professional agriculturists, let alone entomologists.

Thus the earliest record of activity in the field of biological control in Israel was the collection of predators and parasites to be shipped to the U. S. After the decisive success in the control of the cottony cushion scale, Icerya purchasi Mask, on citrus in California with the aid of its enemy the Coccinellid Rodolia cardinalis Muls. which had been imported from Australia for this purpose, interest in foreign predators and parasites in America increased. Further efforts were made to scout for and ship beneficial insects from abroad. In 1905 George Compere was sent on such a mission to the Far East (H. Compere, 1961). On his way there, and it may be surmised that while his boat was stationed for a few days in Port Said, he made a short detour to Palestine. He surveyed the pests in the citrus groves in the neighbourhood of Jaffa and there found certain parasites, such as Scutellista cyanea Motch., a parasite of soft scale insects. He also collected predators. Among these, Chilocorus bipustulatus L, a predator on Diaspinae apparently looked promising to him and he sent live specimens to Australia and California as tentative control agents for the red scale. From what we understand this beetle established itself with favourable results in Australia (Compere 1961).

At this time, during the latter half of the first decade of this century, new citrus groves were being planted in Palestine on a large scale, particularly in the neighbourhood of Petach Tikvah. No pest problems confronted the new citrus farmers until 1910 when some of these groves became infested with the notorious cottony cushion scale, Icerya purchasi, mentioned above. The state of the infested groves soon became such as to fit the description given for the infested groves in California about 30 years earlier. The situation was grave and all the more threatening since there were no entomologists in the country who could offer help or advice. In their desperation the citrus farmers solicited the help of the Turkish governor of Jaffa. He summoned a meeting of notables and citrus farmers to discuss the matter. One of the participants of that meeting was the Agronomist Meir Apfelbaum of Petach Tikvah. In those days there was no narrow specialization of sciences and an agronomist was supposed to know everything pertaining to agriculture. Apfelbaum was acquainted with citrus pests and knew how to control them.

As told in more detail in the chapter dealing with I. purchasi, the lady beetle Rodolia cardinalis was introduced into the country by Apfelbaum and a desirable balance between host and predator was established.

During the second decade of this century another outstanding agronomist worked in Israel (then Palestine) - namely, Aaron Aaronson. His degree from the French schools in which he studied was "Agronome", but Aaronson was more than that. He was a distinguished scholar and scientist who had, by that time, several important accomplishments to his credit. He carried out surveys in geology, zoology and in particular in botany, and contributed a great deal to our knowledge of the country. In addition he carried out research in plant genetics. However, he was not opposed to visit groves and vineyards and offer advice to inquiring farmers.

To relieve the infestation of olive trees by the scale insect Saissetia oleae (Bern), Aaronson suggested the adoption of the Tunisian practice, namely, the planting of fig trees in between the olives. The fig trees harbour the fig wax scale Ceroplastes rusci L which is parasitized by the Pteromalid Scutellista cyanea; this also parasitizes Saissetia oleae on olives. The fig trees may thus serve, as a reservoir of the parasite which attacks the pest on the olive whenever suitable.

Aaronson was appointed by the Turkish general Gamal Pacha, (during the First World War when Palestine was under a military government) as the chief commander to organize the activities against the desert locust Schistocerca gregaria Forsk. which had invaded the Middle Eastern countries in 1915. Among others, Aaronson did not overlook the possibilities of biological control by bacteria. With the assistance of Dr. Goldberg, a noted bacteriologist, he carried out certain experiments which failed. In spite of this, in his report to the Turkish authorities, (Aaronson 1915) he proposed improvements in this method and its application to the adults before they reach cultivated sites. Nowadays locusts are controlled by different methods, but the use of bacteria as an agent to control insects has received a renewed interest in view of the indiscriminative use of synthetic insecticides, whereby beneficial insects are killed along with the pests.

B. Early Research (1925 - 1935)

One of the members of the newly established Research Station at Tel-Aviv was Dr. F. S. Bodenheimer. Zionist motives moved him to leave Germany and settle in Palestine in 1922.

He became aware that he came to a country where practically nothing was known about its insect fauna in general and its pest problems in particular. He began therefore with what he later called an inventory of the pests of the various crops. He knew also that Palestine with its arid subtropical climate could offer different problems in entomology than northern countries. Accordingly he directed his attention to the relationship between climate and biology.

The problem of biological control of insects was broached to him by the citrus farmers themselves. One of them, Mr. Perez Pascal, a brother-in-law of

Mr. M. Apfelbaum mentioned above, was still under the impressions of the wonderful accomplishments of the lady beetle R. cardinalis Muls. He suggested that Bodenheimer import more of such beneficial insect species against other pests. He also organized funds through the Farmers Federation for a special insectary at Petach Tikvah, where those imported insects could be taken care of.

One of the most troublesome pests in the citrus industry was the Mediterranean fruit fly, Ceratitis capitata Wied. Work carried out in Hawaii had already gained reputation and Bodenheimer thought that the introduction of parasites from Hawaii would make a good start. At his request, Willard from Hawaii sent a shipment of Opius humilis Silv. to Alexandria in a cool room of a mail steamer. From there it was sent by ordinary mail to Tel Aviv. In all, the shipment took 44 days en route before it reached its destination. Upon its arrival, it became apparent that 17 specimens had emerged and died during the long journey. None emerged after this. Further shipments were promised but they were not sent probably because of the long duration of the journey from Hawaii to Palestine in which the chances of survival were very small. No one dreamed then, in 1926, of Air Mail service. (Bodenheimer 1951).

Another pest which caused much worry to the citrus farmers was the fruit drop, which according to observations presumably was caused by the mealbug Planococcus citri Risso. In this connection the beetle Cryptolaemus montrouzieri Muls. had become popular. Following the publication by Smith and Armitage (1931) on the method of mass breeding of this beetle, it was introduced in many countries in the Mediterranean zone. Also Bodenheimer thought to introduce it in Palestine against the citrus mealbug. At his request two shipments were sent to him, one from France by Mr. Poutier, and one from Egypt by Efflatoun Bey. The beetles of the first shipment did not survive the journey. Those of the second arrived in good order and were bred in the Insectary at Petach Tikvah. As revealed later, the beetles failed from the practical point of view, but Bodenheimer, as a result of his study, was able to explain the reasons for this failure (Bodenheimer & Gutfeld 1929).

His attention was thus directed toward the study and the mass breeding of local predators of P. citri. About two years later he was able to issue, what he considered practical recommendation for the control of P. citri, namely the breeding and release of local predators.

The insects recommended, which included Symphorobius sanctus Bo-Tjeder and Scymnus spp., were bred in larger numbers in the insectary established at Petach Tikvah, and were distributed in the infested citrus groves. After the alleged success of these breedings and liberations, other insectaries were established, in Hedera, Ramataim and Rehovot. These were housed in wooden shacks with cracks in the walls, or in old buildings not tightly closed. They were poorly equipped. Outside of a thermometer, test tubes, jars, some primitive cages and boxes for raising the potato sprouts there was not much else. This description is given to show under what conditions this kind of work was carried out then in comparison with conditions today.

As mentioned earlier, these insectaries were established and maintained by the Farmers Federation. In 1938, L. Cohen was appointed administrator to these insectaries. During his administration the working conditions improved; among others, the mass breeding was taken out from the cages and test tubes, and established in larger rooms.

In 1929 an outbreak of Icerya purchasi occurred in Hedera. The alarmed farmers raised funds for Bodenheimer to study this problem. As mentioned before the predator of this pest, Rodolia cardinalis, had already been introduced. Bodenheimer therefore made a special study about the inter-relationship of host and predator under the climatic conditions of the coastal plain of this country (Bodenheimer 1932, Bodenheimer et al. 1933).

During the third decade of the century large scale planting of new citrus groves was again accomplished in Palestine. Towards the end of the decade there were many young groves - 4-5-6 - years old. Thereby another pest gained importance, namely the California Red Scale Aonidiella aurantii mask, which was more troublesome in young groves than in old ones. Oil sprays were not used yet and various "remedies" were recommended by some agronomists and entomologists as well. Among others natural control was mentioned. Farmers knew that the coccinellid beetles in the grove were beneficial in eradicating a great part of the scale population. This is illustrated by the following: As early as 1921, when an inquiry arrived from Lebanon about a remedy against scale insects on citrus, M. Smilansky, a writer and a farmer of merit, wrote that the previous year, upon the advice of Aharoni the Zoologist, a few hundred of the beetles (Probably Ch. bipustulatus) were collected and liberated in an infested citrus grove in the neighbourhood of Gaza, and a few weeks afterwards the pest had been checked (Smilansky 1921).

Late in the twenties, when the red scale was ravaging the young groves, other agronomists wrote about this beetle. Thus Pascal (1930) in discussing certain citrus pests, wrote that the chief enemy of the red scale was Ch. bipustulatus L. At that time, Saitzov (1930), too, wrote that "while this beetle cannot be relied upon in checking the pest entirely, it must be protected because it helps us in controlling it."

A different opinion was held by the entomologists of that period. Bodenheimer (1930b) reported the presence of another predator, namely Conwentzia psociformis, Curt. but states that both this and Ch. bipustulatus were of little value in controlling the pest. In this statement he meant to warn farmers against an exaggerated confidence in these predators which might cause negligence in taking other measures of control. Klein (1935) also stated that, although the beetle in its various stages devoured many individuals of the red scale, its activity was not sufficient to check the pest.

The issue of this beetle was taken up in sound argument by Mendes-Sachs (1935). Having had a citricultural training in California, he was well acquainted with citrus pests and their control. He thought that the attention given

to the possibilities of exploiting Ch. bipustulatus was not sufficient. Bodenheimer replied that to his knowledge the climatic conditions of the country were not suitable for this species; nevertheless, he proposed an investigation on the ecology of this coccinellid in the country. This was undertaken by Hecht who at the end of two years, supported the views of Bodenheimer. But Hecht himself considered his work incomplete, and he thought that further study was needed before final conclusions could be reached regarding the potentialities of the beetle and its exploitation for biological control. (A lengthier discussion on this subject will be found in the Chapter on Ch. bipustulatus).

During that period a survey on the possibilities of biological control of the red scale was made by Dr. J. Carmin and his wife Dr. Dina Scheinkin (1934, 1939). The Carmins, finding no possibilities to work within the frame of existing institutes, founded a scientific laboratory of their own, the so-called "Independent Laboratories". Much of their time was devoted to biological control work. In addition to the lady beetle Ch. bipustulatus, they found the parasite Aphytis chrysomphali Mercet which they considered more important and claimed that on one occasion it parasitised 50% of the scale population; they discovered also entomophagous fungi. The two latter, the wasp and the fungi, would be, they thought, the proper agents of controlling the scale insect if distributed in large numbers in the groves. However, the premature death of Dina and lack of funds brought a quick end to this enterprise.

C. A New Pest Invades the Country. (1936 - 1945)

In 1937 a severe outbreak of an unknown mealybug occurred in some citrus groves in the coastal plain of Israel. It may have been present before, but no serious attention was paid to it until it became extremely conspicuous and harmful. The first observed focus of infestation in August 1937 was in the Mikveh Israel grove, where only 15 trees appeared to be infested. Early in the summer of 1938 an outbreak occurred in groves 10-12 kms. east and south of the first observed focus, (Klein and Perzelan 1940).

The farmers applied for help to the agricultural officials of the mandatory government. A meeting was summoned in which representatives of various bodies of the citrus industry were invited. In addition to the chief fruit inspector and the government entomologist there were members of the insecticide firms, some citrus farmers, the representative of the Federation of Farmers, the entomologists and the citriculturist of the Experiment Station at Rehovot.

At the meeting, held in May 1939, the grave situation of the citrus groves and the concern of the farmers found its expression in the words of the citrus farmer B. Raab who said: "The intensity of the damage caused and the apparent rapidity of spread threaten to annihilate the citrus industry", (Minutes of meeting).

During these meetings it was agreed by all that a study of the pest must be pursued, and that spray experiments should be carried out with the hope that partial and temporary relief might be found. However, the major issue, as stressed by all, was the biological control which would begin at once by introducing parasites from the countries native to the pest.

In the special chapter dealing with this mealybug, the story of its identification will be told at more length. Here mention will be made only that specimens were sent by I. Cohen to various specialists in the United States and the British Museum, that the pest was identified as Pseudococcus comstocki Kuwana, and in accordance with advice from the U. S., Japan was pointed out as the source from where parasites could be obtained.

It so happened that I. Carmon, the citriculturist of the Station at Rehovot was about to make a journey to the United States. Cohen suggested that he route his return trip via Japan and search for parasites there. I. Cohen later raised funds to cover the extra expenditures and contacted U. S. entomologists in order to solicit help and guidance for Dr. Carmon. Upon his return, Dr. I. Carmon mentioned with appreciation the help offered by C. P. Clausen of Washington, H. S. Smith and H. Compere of Riverside, California.

Two shipments of live parasites were sent by I. Carmon from Japan by air mail. The writer is not aware of parasites having been sent by air earlier than this date - the end of 1939. In addition, Carmon brought with him by boat many pupae of this parasite.

The shipments of parasites sent and brought by I. Carmon from Japan were handed over to Rivnay for study. Towards the end of the year, in September 1940, after Clausenia purpurea, one of the parasites sent from Japan, was liberated by Rivnay and had become established, mass breeding and its liberation began by the Division of Entomology of the Mandatory Dept. of Agriculture. In the autumn of 1940 some 10,000 were liberated and in the spring 1941 another 14,000 were reared and liberated (letter of Hardy, Govt. entomologist, of 28. IV. 1941).

Parallel with the breeding of Clausenia, Cryptolaemus montrouzieri was also tried. In 1940 Rivnay contacted some Spanish entomologists who sent from Valencia a cage containing some 40 adults. They were reared in the laboratory and it was found that they fed willingly on the Pseudococcus.

Early in March 1941, at Mikveh Israel, some beetles were liberated on a small citrus tree under a tent heavily infested with the mealybug. The tree was cleaned of the pest, whereupon the predaceous larvae devoured each other. However, when beetles were liberated by E. Rivnay at Rishon-le-Zion in May 1941, they all disappeared very soon before accomplishing anything.

D. Enter the Synthetic Insecticides (1946 - 1955)

A drastic negative change in the status of many insects had taken place late in the forties and early fifties with the increased application of synthetic insecticides. At first every one was happy. At last, the longed-for solution against the Mediterranean fruit fly had been found it was thought. Until then apricots could not be cultivated, peaches had to be bagged, figs were always wormy, while more Valencia orange fruit was ruined than marketed. With the introduction of the synthetic insecticides even apricots, the most susceptible of all, could be guarded against the fly if properly treated with one of the insecticides. This brought about an increase in the planting of apricots and peaches. Cover sprays with synthetic insecticides were introduced also against other pests on deciduous fruit trees and, finally, cover sprays were introduced into the citrus groves to protect Valencia oranges from the fly.

However, it did not take long before the other aspects of this practice came to notice. One of the insecticides, methoxychlor, as it became known later, was the most toxic to lady beetles; the two others, DDT and dieldrin, which were used lavishly in the groves and in deciduous plantations against the fruit fly, were toxic to a wide range of insects, including many beneficial hymenoptera.

In addition to direct sprays, the situation became aggravated late in the fifties by insecticide drifts from the air. During that decade, areas under irrigation increased and the planting of cotton was reintroduced; insecticidal air applications became the common practice and affected many of the plantations in the immediate neighbourhood.

Mites became conspicuous in peanut fields as a result of a spraying program against Spodoptera littoralis (Boisd.) and on fruit trees as a result of spraying against the codling moth, Carpocapsa pomonella L. Various scale insects became numerous, and on citrus trees the soft scales became difficult to control and the red scale gained prominence.

However, of all these the most trouble and damage was caused by Chrysomphalus aonidium L. the so-called Egyptian Black Scale.

The story of the spread of Ch. aonidium will be told at more length in the special chapter on this insect; here it will be noted that ever since this pest reached the main citrus area south of Jaffa early in the forties, its populations grew extremely dense and, already in 1945, it assumed the role of the most injurious pest of citrus.

Farmers were worried while spray equipment became burdensome and oil imports grew steadily. It was felt that biological control would have saved the situation had the proper parasite been found.

In June 1945, just about at the end of the Second World War, Rivnay had the opportunity to make a trip to New York and Washington, U. S. A. He

thought that this would serve as a good opportunity to visit Riverside, California where he could inquire about possible parasites against the black scale and, at the same time, learn about the methods of parasite breedings at Riverside.* There Rivnay met H. S. Smith, H. Compere and S. Flanders, all most ready to offer whatever assistance was desired. As to parasites against the Ch. aonidium, the name of Casca smithi Comp. was mentioned as a possible successful insect as well as Comperiella bifasciata How. Cultures of the latter only were available, and some specimens were offered to Rivnay. Earlier, in 1936, specimens of this parasite had been sent in reply to a request from the Entomological Division of the Mandatory Government of Palestine. Also in 1939, Rappaport, at the request of I. Cohen, brought over some specimens. But, at that time, shipping conditions being as they were, the insects on both occasions arrived in bad condition, unsuitable for propagation (Gruenberg 1956).

This time, in order to insure the successful transfer, Rivnay took along with the parasite also host specimens for propagation. Adults which emerged during the journey oviposited in this material. Thus, at the end of the journey, which then lasted 35 days, live and active material was available.

Breedings on the local Egyptian Black Scale at Rehovot were unsuccessful as this parasite did not oviposit in the black scale. Further material was imported by the Department of Agriculture and Fisheries of the Mandatory Government only to confirm these findings (Gruenberg 1956).

In the meantime, as mentioned above, with the introduction of the synthetic insecticides the situation with the black scale, bad as it was, deteriorated still more. In many groves the conventional oil applications did not always bring relief. The ill effects of the cover sprays with synthetic insecticides against the Mediterranean Fruit Fly became conspicuous on the scale within one season. Trees sprayed with synthetic insecticides in March were heavily infested in August and the oil application did not give relief, while adjacent trees which had not been sprayed in March, being less infested, could be cleaned by the oil applications.

E. Recent Research

(1956 - 1965)

This decade saw a change of approach in the field of applied entomology. As mentioned above in addition to the extermination of desirable insects, the lavish applications of the synthetic pesticides had other negative aspects, namely the development of resistant strains of some insects. Some pests became "hard to kill" by dosages of insecticides which formerly brought about the desirable control. This fact resulted in an increase in the dosages and an introduction of

* This journey was in part sponsored by the Farmers' Federation through its president Joseph Jacobson.

stronger, more toxic pesticides, which in turn accentuated the ill effects of their applications. Doubts were then expressed in the literature as to whether this was the proper technique, and whether there should not be a change in the approach to pest control.

Other negative aspects of the chemicals were discovered - namely the ill effects of residues and their accumulation both in the tissue of man and animals who consumed contaminated food, and in the soil.

Responsible entomologists became more reserved in their advice about the use of pesticides and restrictions in the timing of applications began to accompany the recommendations. In the mind of entomologists it became certain that while the farmer could not continue without the use of the necessary pesticides, their lavish application often caused more harm than benefit and should be restricted.

The idea ripened that a middle road must be found, a kind of balance in the employment of control methods whereby the ill effects of one should be ameliorated by the employ of methods, other than pesticides. A group of entomologists in California who summed up this approach, coined the term of "Integrated control methods" (Vanden Bosch 1958). In brief, this method advocated restraint in the employ of insecticides; - these should be used only when absolutely necessary, they should be properly selected for each occasion; selective substances should be used when possible; their application should be properly timed, and localized only where absolutely necessary. This method advocated biological control where possible and a striving to maintain the existing favourable balance; it recommended the exploitation of some physiological properties of the pest leading to its destruction, and finally it encouraged the development of resistant plant varieties and the employ of cultural methods of control.

In Israel, restrictions in the employ of synthetic insecticides were practised before the coinage of the term "Integrated control", but the foreign literature on this subject stimulated studies in this direction, especially in relation with citrus pests.

L. Cohen contacted the various entomologists in the United States as well as the Ministries of Agriculture in Japan and Hong Kong. Subsequently, many replies were received, only a few of which will be mentioned here (not in chronological order). Compere was skeptic (see his letter page 22). De Bach, l. VIII, 55, wrote about the prospects of Aphytis spp. and Prospaltella aurantii (How.) in the control of Diaspinae. Christensen expressed his readiness to send Opius spp. against the Mediterranean Fruit Fly; Fleshner (on behalf of Boyce,) wrote 7. XI, 55, about Stethorus against Acarina, and finally Flanders wrote 8. IX. 55 about Casca smithi Comp. and Aphytis lingnanensis Comp. as potential parasites against the Black Scale. As may be seen from his letter (see page 23) he was full of hope about the possibilities of these two species.

He also suggested and intimidated that shipments of these parasites could be obtained directly from Hong Kong through Mr. Shih Kwen Cheng, the

manager of the Chisum Horticultural Company who was trained by him to collect parasites. Cohen contacted Cheng; after coming to an agreement Cheng promised in his letter of Jan. 16, 1956 that he would start shipping the parasites in February. Coehn then contacted Rivnay, of the Rehovot Research Station with the request: "Would he be willing to receive and handle the parasites sent by Cheng". Although burdened with other duties, and quite skeptical of the outcome, Rivnay consented. A lengthier account of the two parasites and the efforts to establish them in Israel will be given in the chapter on the Egyptian Black Scale.

Activity of the Agrotechnical Division - C. M. B.

D. Nadel of the citrus marketing board took over the work from Rivnay. He diverted his attention towards the development of mass breeding methods of the black scale. The conventional methods of rearing the scale on blue squash was employed, but the main difficulties were the low relative humidity prevailing in the rooms. Nadel employed a simple device for raising the humidity conditions, whereupon the mass breeding of the black scale progressed satisfactorily.

Cheng continued to send parasites to Nadel, but they all arrived dead as were the last shipments received by Rivnay. It was decided to infest fruit at Rehovot with black scale, and ship them to Hong Kong to be parasitized there and returned to Israel. It was hoped the parasites in the larval stage would survive where the adults could not.

This activity was interrupted since, in the meantime, the Aphytis was recovered by Nadel in Sept. 1957. In other words, it took about eight months before the population of the parasites first distributed by Rivnay became conspicuous in the groves. Upon this, at the directives of Cohen, Nadel and his associates undertook a survey to find the extent of the distribution of these parasites. Mass breeding of the introduced Aphytis began with the purpose of distributing it in groves where it had not yet reached or where it was still scarce.

In addition to the work on the black scale, Nadel began to develop a method for mass breeding in the Mediterranean Fruit Fly, flies were needed also for testing the various bait substances which were proposed for the control of the fly in the groves.

Efforts were also exerted at this laboratory to try again to acclimatize Cryptolaemus montronzieri against Planococcus citri Risso. Mass breedings of this beetle were carried out from a second stock obtained by E. Rivnay from Spain through the courtesy of G. del Rivero from that country.

With the transfer of the laboratory to the new building in 1960, and the increase of the staff, the work of the Agrotechnical Division expanded, and several projects were treated simultaneously. This work was summed up by Cohen and Nadel (1962) as follows:

- 1) Mass breeding of A. holoxanthus and its release in areas where needed was in progress.

- 2) Parasites of the red scale were imported from California, bred in the laboratory and released. These included: Aphytis lingnaensis (Comp.), Aphytis melinus De Bach, Comperiella bifasciata Howard, and Prospaltella perniciosi (Tower). In addition A. coheni De Bach was reared in mass for release.
- 3) Metaphycus helvolus (Comp.), a parasite of the soft Olive Scale Saissetia oleae, was introduced, bred and released.
- 4) Parasites of the Florida Wax Scale Ceroplastes floridensis were introduced from Japan and released. These included: Anicetus beneficus Ishii et Yasumatsu; Anicetus ceroplastes ishii; Microterys clausenii Comp.; Cocophagus hawaiiensis Timb. and the lady beetle Chilocorus kuwanae Silvestri.
- 5) Predator mites were introduced from the Far East. These were reared and studied, in collaboration with Swirski of the Volcani Institute. The mites included: Typhlodromus (Amblyseius) largoensis (Muma) and Phytoseius spp.
- 6) Of the various parasites against the Fruit Fly, Dirhinus giffardi Silvestri alone was reared and tested in the grove.

In addition to this and application of bait, the work against this fly was lately diverged in different directions, namely release of sterile males to create a male vacuum. A method was developed where 1,000,000 flies were reared daily; sterilization was done by Cobalt radiation while chemosterilants were being studied.

At the beginning the laboratory of the Agrotechnical Division was housed in the prefabricated concrete plate building. Simple devices were arranged to meet the requirements of the various breedings. Thus, to prevent the temperature from rising too high in the rooms, a burlap tent was spread over the roof and sprinklers installed (see Plate).

The humidity was kept at the desired percentage by slipping a small bag over a tap and tying it. The moisture from the inflated bag was diffused with the aid of a ventilator.

At the beginning some of the instruments such as stereoscopic and compound microscopes were borrowed, but gradually this laboratory obtained all the necessary tools.

I. Cohen felt that the achievements so far, the increasing scope of work and the prospect for the future justified a permanent, well-equipped building. He broached the idea to the management of the Citrus Marketing Board who found it plausible and were ready to finance it. The building was complete in June 1961 when the staff moved into it.

Research at other Institutions.

At the Faculty of Agriculture, the Hebrew University, Rehovot, members of the staff as well as graduate students began to devote more of their attention to the study of various aspects of biological control and natural balance.

Rosen (1964) carried out a four year general survey of hymenopterous parasites of citrus pests. The biology of some of them was studied by himself and other students. The ecology of Chilocorus bipustulatus in the grove was followed up by Yinon (1964) and Rosen et Gerson (1965). A survey on the various Parlatoria spp. and their biology was studied by Applebaum et Rosen (1964) and Gerson (1964), while a survey of predator Cecidomyiidae in the citrus grove was made by Harpaz & Gerson (1966).

The ill effects of pesticides upon the beneficial insects were given due attention. Avidov and Rosen (1964) studied the extent of ill effects upon parasites by the Mediterranean Fruit Fly bait; air application was compared with that of ground application of the same material. The hymenopterous parasites Aphytis holoxanthus was used as the test animal. The effects of applications of synthetic pesticides upon the Combined population of the red scale enemies in the citrus grove was followed up by Ben Dov (1963).

Not only citrus pests and their parasites occupied the attention of the members of the faculty, Harpaz (1953) made a survey on parasites of aphids, while the limiting factors of some coccinellidae were also analyzed (1956). Together with Peleg the study of Microphanurus and its limiting factors was carried out (Peleg 1959). The possible exploration of pathogenic viruses against Lepidopterous larvae was given much attention, in particular the one associated with the polyhedral disease of the notorious Spodoptera littoralis (Boisd.) Harpaz et al 1965).

At the Volcani Institute of Agricultural Research, Swirski, who had been devoting much of his time to the study of mites and their control, began to concentrate his attention on the biological control aspects. A survey of local predator mites was undertaken, and a restraint in the use of acaricides was advocated in order to prevent their destruction. Swirski also made a trip to the Far East from where he sent predatory mites which were received and bred here by his coworker S. Amitai (1961). They were liberated in the grove and the effects were followed up.

A general survey on predatory mites was carried out by those workers (1961 and 1965), while a similar survey in the citrus grove was made by Porat and Swirski (1965).

Kehat and Swirski (1964) also undertook the study of the date Parlatoria in the Arid Zone of the Arava, and together studied its natural enemies and the possibilities of its biological control, or preserving its natural balance. Kehat undertook also a taxonomical and biological survey of the Coccinellidae associated with palms (1966).