A. lepidosaphes is an arrhenotokous species. It is a gregarious ectoparasite, as many as 5 individuals may develop under the scale of one host.

Aphytis lingnanensis Comp.

This Aphytis was first distinguished as a distinct species by Flanders in 1947; through pupal characteristics (having black markings) which differed from those of A. chrysomphali (being entirely lemon-yellow). Subsequent breedings by Flanders also showed a different host relationship between the two species. The very close similarity between the adults of A. chrysomphali and A. lingnanensis prevented its earlier recognition, although, as Compere (1955) stated, it was collected by George Compere in 1906, by Silvestri in 1924-25 and by H. Compere in 1932; it was considered then to be one of the known species, already existing in the United States.

For this reason no attempt was made at that time to introduce and propagate it in the United States, but somehow it became established in Texas prior to the discovery by Flanders. It was introduced into Israel from California by the Biological Division of the Citrus Marketing Board, and was liberated in the citrus groves. A survey is in progress now to see to what extent it has become established here.

PSEUDOCOCCIDAE

The Citrus Mealy Bug - Planococcus citri Risso

The Economic status of P. citri

The citrus mealy bug has always been rated as a severe pest of citrus and vine crops. Its damage extends also to other fruits.

In all, the damage is manifested by the fumagine which develops on the fruit due to the excretions of the bug.

On grape vines and bananas the fruit may also be marred by the presence of the mealy bugs themselves and their sticky excretions.

As to citrus, there is, in addition, the question of fruit drop. Farmers attributed the drop of small fruit in the spring, to the mealy bug. Entomologists, however, (Bodenheimer et al. 1929, Bodenheimer 1951, Carmin 1932, Rivnay 1943 & 1961) distinguished between the early fruit drop and that which occurred later. The first, the so-called May or June drop, is due to a physiological-ecological factor complex, and it usually ceases towards the end of June.

The summer drop, however, is due to the mealy bug. In years of P. citri outbreaks, in particular when the dry Khamsene winds in the spring were not very severe, the fruit drop was prolonged till the autumn; fruit the size of walnuts and golf balls dropped, a great percentage of which were bearing specimens of P. citri or traces of it, an indication of the direct cause of this abnormal fruit drop.

In the autumn, again, there is still another physiological ecological factor complex which may be responsible for fruit drop. P. citri, which may be feeding under the sepals of large fruit, does not always cause the fruit to drop. After the fruit becomes well attached, the feeding of the pest does not affect it unless the fruit is weakened by other factors (Bodenheimer 1951, Rivnay 1961).

It was pointed out that there was no correlation between number of fruit dropped and the density of P. citri population in that grove (Rivnay 1961).

Farmers, however, believed that were it not for the mealy bug the fruit even when weakened by other factors, could remain on the tree till picking time.

The endeavour towards biological control of P. citri.

The first efforts by Bodenheimer et al. (1929) towards biological control of P. citri were by the introduction of the then so famous beetle Cryptolaemus montrouzieri Muls. into Israel. Encouragement to do this was obtained by the favourable reports from California and Nice; a shipment from France sent by Poutier was unsuccessful as the beetles did not survive the transport difficulties. Another shipment sent from Egypt by Efflatoun Bey was more successful and breedings began in the laboratory specially organized for that purpose, first at Tel-Aviv and subsequently transferred to Petach-Tikvah.

The breedings were not without fault. The cages were imperfect and another predator Sympherobius sanctus penetrated into them and fed on the host as well on the C. montrouzieri larvae. Also cannibalism reduced their own numbers (Bodenheimer et al. 1929). Nevertheless important biological data could be obtained, a resume of which is presented in later paragraphs.

Outdoors the situation was different; as soon as the beetle was liberated in the grove, its shortcomings soon became apparent, namely, that the high temperature and low humidity, prevailing during the spring in the coastal plain of Israel, were too severe for the larvae in the grove; and therefore they surely could not survive the summer either. The autumn was more favourable, but then the winter set in too soon and interrupted their development and reproduction.

In addition, the larvae were slow, and unless food was plentiful in their immediate vicinity they did not hunt for it. This factor proved the more important in view of the special cryptic habits of the host on the citrus tree.

This made Bodenheimer concentrate his attention on local predators; one of them was the above mentioned Sympherobius sanctus Tjeder (= amicus Navas).

The breedings of S. sanctus were very successful; in fact, as mentioned above, this predator penetrated into every place where the mealy bug was kept. A summary of data accumulated in the course of these breedings will be found in the special chapter on this insect page 65.

It was found that this predator could raise about ten generations a year, which is more than the host does. Its threshold of development was slightly above that of the host; it was not attacked by other parasites or predators, and finally the larvae were very active and hunted for the host. Thus Bodenheimer believed it was better suited for the purpose of biological control of the citrus mealy bug. Field trials were made in which it was claimed that the predator cleaned the infested trees. It was recommended, therefore, to breed this insect on a large scale for liberation in the grove.

In the course of mass breeding of P. citri in the Petach-Tikvah laboratory, the cages became infested with a gall midge the identity of which was not known at that time, but which was identified later as belonging to the genus Dicrodiplosis. It was thought that this insect, too, could be exploited for biological control of the citrus mealy bug. Its development was short, enabling about 16-17 generations to develop annually. Its drawbacks were, that this midge was susceptible to the cold and humid conditions during the winter. Furthermore, its breedings were more difficult to handle than those of S. sanctus Tjeder.

From breedings of mealy bugs collected outdoors, the small Encyrtid Leptomastidea abnormis Girault was obtained. It was thought that the climatic conditions in Israel were more severe than they were in California which accounted for its irregular appearance in Israel and its lesser efficiency in parasitizing the mealy bug. It was not bred because it was thought that S. sanctus would serve the purpose in controlling the mealy bug.

At the recommendation of Bodenheimer, breeding centers for S. sanctus were established by the Federation of Farmers at Hadera, Ramataim, Petach-Tikvah and Rehovot. The predator was feeding on P. citri reared on potato sprouts according to the method of Smith and Armitage (1931). With the onset of the World II War they were discontinued and have not been renewed since.

The work on biological control of Planococcus citri was resumed in 1942. Specimens of Leptomastix dactylopii Howard were received by I. Cohen from Canada, some of which were given to Rivnay for breeding and liberation.

The species was successfully reared in two-liter jars on citrus fruit infested with P. citri. (Rivnay unpublished notes). The offspring obtained were liberated on various trees infested with P. citri in the neighbourhood of Rehovot. Other specimens were concurrently liberated by Gruenberg (verbal communication) in Mikveh Israel and Benyamina.

A year later, in the course of a survey on parasites of P. citri, specimens of L. dactylopii were recovered from infested bunches of grapes taken at Benyamina (Rivnay 1960).

The number recovered was small, not more than 1% of the number of hosts. After this, no further specimens of the parasite were recovered. Rivnay expressed the opinion that the numerous hyperparasites which were recovered from the same source prevented the parasite from becoming thoroughly established.

LIST 3. Parasites recovered from P.citri (after Rivany, 1960)

Anagyrus kivuensis Comp. (= pseudococci Girault) - Primary parasite

Leptomastidea abnormis (Gir) - Primary parasite

Achrysopophagus aegyptiacus Mercet - hyperparasite

Homalotylus quaylei (Timb) parasite upon Scymnus

Leptomastix dactylopii Comp. - primary parasite (introduced)

Tropydophryne palestinensis Riv. - primary parasite

Cheiloneurus spp. hyperparasites

Tetrastichus spp.

Thysanus sp. hyperparasite

In his survey of Planococcus parasites on citrus, Rosen (1964) could add only one parasite - Allotropa ? mecrida Walk, which is very rare, and one secondary parasite Pachyneuron siculum Delucchi, found only once.

Of much interest is the survey of Planococcus parasites made by Berlinger during 1964 and 1965 in the northern part of the arid Negev. The places he surveyed include: Sa'ad, Mivtachim, Rvivim, Sde-Boker and Ein Gedi on the shores of the Dead Sea.

As soon as irrigation was established in these arid places, grape vines were planted, and quickly became infested with Planococcus citri. However, the parasites did not fail to follow their host. See list 4.

LIST 4. Parasites and predators collected from P. Citri by J. Berlinger in the Negev (unpublished notes):

Clausenia josefi Rosen	-	common
Anagyrus pseudococci Girault	-	common
Leptomastix flavus Mercet	-	common
Pauridia perigrina Timb.	-	rare
Achrysopophagus aegyptiacus Mercet	-	fairly common
Homalotylus sp. attacking Scymnus		
Thysanus sp.	-	rare
Leptomastidea abnormis Girault	-	very rare
Pachycrepoidens	-	very rare
Scymnus spp.	-	fairly common
Hyperaspis sp.	-	fairly common

Ants

Cases where ants interfere with the activity of entomophagous insects in reducing the number of pests have been observed in Israel too (Klein 1936, Rivnay 1961). However, their epidemiological importance in the citrus groves has been a subject of controversy. Bodenheimer (1951) thought the protection of insect pests by ants was not of major importance. Rivnay (1961) stated that ants were not sufficiently abundant on the citrus trees to offer protection to the citrus mealy bug, but thought further study is needed before a conclusion is made.

On the other hand, Peretz (Perzelan 1947) relying upon information from abroad, and quoting South African entomologists, believed ants were an important factor in keeping a proper balance of mealy bugs and even recommended measures against ants for the control of mealy bugs.

With the aim to appraise such an undesired interference by ants, Peretz and Peled (1964) carried out a simple test in a banana plantation in the Jordan Valley. The test consisted of treatments of banana plantations with 2.5% granulated diazinon. Thirty to forty grams of granules were strewn around the trees or in the holes of ant nests; other beds were left untreated. The comparative extent of infestation between treated and non-treated banana beds served as a criterion for assessment of the ants' inferference.

The treatment was made on August 21, and counts of ants were made 26 and 78 days later. Appraisal of the P. citri population was made about every month till February. The ants which were abundant in those localities were as follows:

LIST 5. Ants associated with P. citri (Peretz & Peled)

Nylanderia jaegerskjoeldi (Mayr)

Tapinoma simrothi var. phoenicium (Em)

Monomorium gracillilimum (Smith)

Monomorium pharaonis (L)

Tapinoma israelis (For)

Crematogaster jehovae (For)

Plagiolepis pallescens ssp. ancyrensis (Sants)

LIST 6. Entomophagous insects associated with P. citri on bananas

Scymnus suturalis (Thunberg)

" flavicollis Redtb.

" clarus

Leptomastidea abnormis Cirault

Anagyrus pseudococci Girault

The counts showed that in the non-treated plots ants remained active throughout the period of observations, whilst in the treated plots the ants disappeared.. Regarding the mealy bug population, it decreased as could be seen from the number of infested bunches. There were 47% of them entirely free of mealy bugs in the treated plots, and only 3% of them harboured more than 20 mealy bugs. In the non-treated plots only 6% of the bunches were entirely clean and 30% had over 20 mealy bugs each.

Ps. aff. citriculus Green (erroneously Ps. comstocki Kuwana)

The Economic status of Pseudococcus aff. citriculus

As previously stated, a new citrus pest, a mealy bug, then unkown in the country, was discovered at Mikveh-Israel in 1937.

Its damage was severe. "On newly infested trees it was limited to weakening of the tree and the loss of fruit, which became either black as a result of the sooty mould, or blemished, because of injury during the early states of the fruit. However, as the infestation progressed, the tree ceased to yield fruit, deteriorated slowly, leaves dropped, and the branches gradually dried up," (Rivnay & Perzelan 1943). "In cases of severe attacks, honey-dew could be seen dripping from leaves and fruit, and sooty mould gained enormous proportion," (Klein & Perzelan 1940).

The entomologists recommended various methods of control, including oil sprays, but the results were disappointing. The general feeling of the entomologists was well expressed later in the words of Gruenberg: "Before the eyes of the observers, trees were converted into skeletons of trees; the observer had the feeling of helplessness against a great force of nature. This feeling was the more accentuated when it was found that conventional methods of control do not give relief", (Gruenberg 1950).

The endeavour towards biological control of P. citriculus

a. A local survey of entomophagus insects.

As part of this endeavour, a survey of local parasites and predators of that pest was made by Rivnay et al. during 1939-40. As a result of that survey they pointed out how biotic factors had already affected the density of the pest population:

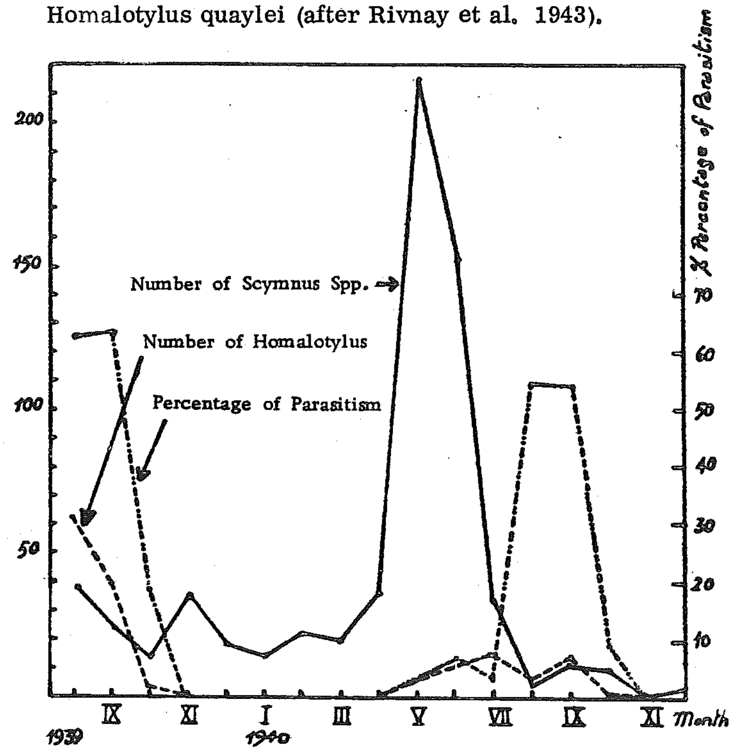
"It has been noticed repeatedly that in newly infested groves the pest may become more severe than in groves which had been infested for a few years. As soon as predator and parasites become established, the infestation is largely checked," (Rivnay et al. 1943).

Cecidomyia larvae were found among the eggs, and Chrysopa pupae were collected from the leaves infested with Pseudococcus. From these cocoons

Perilampus sp. often emerged. Larvae and pupae of Sympherobius sanctus (Tjeder) were found in larger numbers in the clusters of the pest None of these were of any importance.

The following Coccinellidae were mentioned: Scymnus suturalis Thunb., Sc. includens Kirsch., Sc. fenestratus Sahlb., Sc. quadrimaculatus Hbst. and Hyperaspis pumila Mulsant. In particular the first two were abundant, these no doubt were important in diminishing the host population. The peak in the population of the Scymnus species occurred in May. A sudden drop from 200 adult specimens per 200 leaves to about 30 took place by July and to less than 10 by August. There is no doubt that climatic factors influenced the reduction in the Scymnus population, but a biotic factor was also involved, namely, parasitization by Homalotylus quaylei Comp. This Encyrtid attacked all of the Scymnus species listed above and in any stage of the larva. Its development lasted only 16-20 days as compared to 25-30 days of the host at the same temperature. In its height of activity the wasp parasitized about 40% of the beetle population (Fig. 9). A redeeming feature in this relationship is the fact that it is active in the grove only from May, reaching its peak in August-September, thus giving the Scymnus a chance to act uninterruptedly during the early part of the summer, (Rivnay et al. 1943).

Fig. 9 - Populations of Scymnus spp. and percentage of their parasitization by Homalotylus quaylei (after Rivnay et al. 1943).



The following Encyrtidae were further reared from infested leaves brought into the laboratory: Leptomastidea abnormis, Girault, Anagyrus kivuensis Comp. (=pseudococci Girault) Leptomastix flavus Mercet, and Thysanus sp.

Leptomastidea abnormis. A small percentage in comparison with host individuals was obtained from this parasite. During the winter about 1-2% and in the summer about 6% of the hos t larvae were parasitized by this wasp, so that its role as a check in the host population was probably negligible.

Anagyrus kivuensis. The opinion was expressed that this was a recently introduced Encyrtid in the country.

It was found that Anagyrus was active only during two periods, May-July and September-November, there being an interruption in the summer and winter.

Leptomastix flavus Mercet. L. flavus was more active, it was found from May to October with a light interruption during July-August. At the height of its activity, over 35% of the host were parasitized, but only when the population was dense. This insect was in turn parasitized by a Thysanus sp., but fortunately its development period lasted longer and its reproduction was less than that of the host. When the host population was lower than it was in 1939, the combined parasitization of the three species was 30-35%. The three species played thus a role and together with the Scymnus spp. helped to bring about the reduction of the pest.

However, it was felt that perhaps the introduction of further parasites from abroad might contribute to a faster and more complete control of the pest.

b. The identity of the new mealy bug.

In connection with the introduction of parasites, the question of the real identity of the pest was raised. Specimens from Palestine were sent by Cohen, Rivnay and others to several entomologists abroad; among these were Laing of the British Museum, Silvestri, Compere, Morrison, Ferris and Rou. While some of them believed the Palestinean material was identical to the species considered in America as comstocki, others believed it was not identical to the "American" comstocki but close to it. Some of the letters are quoted below.

On February 27, 1940, Laing wrote to Rivnay:
"The species close to comstocki which has been turning up is readily distinguished by the absence of translucent pores in the hind legs; I have been treating it as new, having failed so far to link it up with any of the described species, but on account of the different characters stressed in descriptions it is not easy to form definite conclusions. For purposes of your work you should assume that you have longispinus, comstocki, and this other species 'X'".

From the United States, G. J. Rou wrote to Mr. Cohen of the Farmers Federation on May 18, 1939, as follows:

"I have now made close comparison of your preparations with Pseudococcus comstocki (Kuwana) as we accept this, and it is my present opinion that the differences which are observable are sufficient to indicate that the Palestine species is not comstocki in our sense."

After enumerating the differences between the American and Palestinian material, he concluded:

"While variation plainly exists within the species in the mealy bugs, I have no background that would indicate that it might extend so far as to include within one species showing the differences enumerated above. It seems to me that it would be much more practical and probably more nearly correct, to regard the Palestine speciments as representing a species thus far unplaced that is quite close to but definitely distinct from comstocki. In the absence of examples from Kuwana's type material, any question as to the correctness of Professor Ferris' placing of our material as this species will, of course, have to remain in abeyance."

As the work progressed, it became more apparent to Rivnay that the Palestinean species of the comstocki group was not identical with that of Japan or the United States. In 1945, Rivnay (Rivnay 1946) wrote that Ps. comstocki which is a well-known pest of apples in the U. S. did not attack these trees in Palestine although the apple trees were planted in the immediate vicinity of a badly infested citrus grove. Also Allotropa Sp. reared from Ps. comstocki brought from Japan, did not attack the Palestinean species while it did parasitize the species in the U. S. (Rivnay 1946). The footnote in that paper written a year later reads:

"Since writing this paper, the writer visited the U. S. A.. and discussed the identity of this mealy bug both with Dr. Morrison of the U. S. Department of Agriculture and with Prof. Ferris of Stanford University, California. Upon re-examination of material from Palestine, both were of the opinion that the Palestinian mealy bug is not that found in America. As to which is the proper Ps. comstocki Kuw., Prof. Ferris claims to have in his collection Kuwana's material from Japan and finds the American species to be identical with it."

The identity of the species of Pseudococcus was taken up again later. After a revision of the comstocki group by Borkhsenius (1949), the Israel material was studied by Gruenberg under the guidance of Bodenheimer (Gruenberg 1950). He found that of all the species in the comstocki group, the Israel material is closest to Ps. citriculus (Green) but not entirely identical with it. While Gruenberg decided to call it Ps. near citriculus Green, Bodenheimer called it "Ps. citriculus Green without claiming that it actually belongs to this species" but may be new. *

* According to communication by Hall to Bytinski-Salz (see Israel J Entom. I p. 30) there exist only the type slide of P. citriculus Green, at the British Museum (Nat. History). All other material in theB. M. and that of Ferris, Zimmermann and Borkhsenius described as "citriculus" is not the real P. citriculus Green, but nearly related undescribed species. This is true also for the material from Israel.

c. The introduction of foreign parasites and their liberation.

In view of these uncertainties, it was advisable to avoid specification and to refer to the comstocki group as a whole in writing, and in search for parasites.

Dr. Carmon thereupon sent parasites of Ps. comstocki directly to E. Rivnay by air mail and further specimens were brought with him by boat. During the long journey on the boat some of the live pupae were kept in a refrigerator to prevent premature emergence. As a result, some of the females which matured upon reactivation, failed to reproduce. Among this material there was a single female of an Anagyrus sp., and two females of a Leptomastix sp. which produced a few males (being unfertilized) and died subsequently.

Two other species brought by Carmon were in greater numbers, sufficient to liberate in the groves. They were bred, however, in the laboratory and their qualities were studied before liberation. One of the parasites was on Allotropa sp. (later identified by Muesebeck as A. burelli). It failed to parasitize the Palestinean "Ps. comstocki" at all stages in spite of many breedings in which parasite and host were put together. This failure called for a scrutiny of the host material. As early as that the remark was made that "from the remains of the parasitized species brought from Japan it is evident that it was an entirely different species from the Palestinean material" (Rivnay 1942).

Another species received in larger numbers was Clausenia purpurea Ishii. It was discovered that the pupal material was very much hyper-parasitized (at least 50%) by another hymenopteron, (later identified as Lygocerus sp.). Test breedings were made to ascertain which was which - as no literature was available then for their identification. Upon establishing the role of each, pure cultures of C. purpurea were bred and the entire remaining material brought from Japan was destroyed.

The parasite was then bred in large numbers and immediately liberated in the infested groves, first by Rivnay and subsequently by Gruenberg.

In discussing the potentialities of the parasite and calculating its reproductions and that of the host, Rivnay came to the conclusion that "if we start with one parasite to 100 hosts, it will overcome the host after the fourth generation, and if we start with one parasite to 100, 000 hosts, we find the host being overpowered after the ninth generation of the parasite, namely, early in the second year.

However, the efficiency of this parasite could be better illustrated by following the situation in the grove where it was liberated:

In April 1940, 100 individuals of Clausenia were liberated on a tree badly infested with Pseudococcus at Mikveh Israel. This tree was covered by a tent for five months. Counts of parasitism on this tree showed that Clausenia established itself immediately. Furthermore, the wasps escaped from the tent and in a short period it was found in trees within a radius of several rows. Liberation by the mass breeding laboratory were also made in other groves. As an example, one grove at at Rishon-le-Zion was taken, where 25 parasites per tree were liberated during 1940. Counts by the writer in March 1941 showed 1% of parasitism and by May of the same year, 4%. The percentage of paratisim increased steadily; at the end of August over 70% were counted by members of the mass-breeding laboratory staff headed by Gruenberg, and simultaneously the intensity of the pest decreased. This supports the calculations presented above by Rivnay.

d. The effects of Clausenia liberations

Five years after Clausenia purpurea had become established in Israel, Rivnay (1946) reviewed the situation, giving further examples of groves which have become infested, but which were cleaned a short period after C. purpurea was liberated there. It was also pointed out that there was a competition for host, between the various local parasites; in one grove one parasite, Anagyrus pseudococci was dominant, in another L. flavus was more prevalent. One thing was certain however, wherever C. purpurea was introduced, it became the dominant species after a short time. The reasons given for this were: C. purpurea becomes active earlier in the spring than the other species, being thelytokous it produces parthenogenetically, while the others are arrhenotokous, and C. purpurea is probably less hyperparasitized in the grove than the others.

A comparison was made also between the efficiency of C. purpurea in Israel and in the United States. Climatic factors which exist in Israel but do not exist in the area where C. purpurea is active in the United States, make it less efficient there than it is in Israel. Also Lygocerus, the hyperparasite of Clausenia which was exterminated by Rivnay in Israel and which is active in the U.S. renders Clausenia less efficient there (Rivnay 1946).

As mentioned above, A. Gruenberg was in charge of the mass breeding laboratory and he followed the spread of the pest as from 1940 and continued to liberate parasites in the newly infested groves. He summed up later (1950) the situation as follows:

"While the intensity of the infestation decreased in old infested groves, the pest spread further and gradually reached the groves at Hadera in the North, Migdal in the South, and Tulkarem in the East." As a rule the density of the population in the newly infested groves remained at low levels, and very quickly, within a year, or often within the same summer, the pest was checked and brought to below economic level.

In 1946-47, Gruenberg followed the percentage and type of parasitism of Ps. citriculus in a few groves month by month. The counting was made by bringing a standard number of infested leaves from the groves into the laboratory where all insects were allowed to develop to maturity. A summary of these counts is given in Table 6.

It is noticed that in six out of the ten groves Clausenia was more numerous than any other predator or parasite, each taken separately, while in five it was more numerous than all taken together. In two groves L. abnormis was dominant, while in the Migdal grove Scymnus spp. were dominant and the pest was overcome before Clausenia could become established.

These facts made Gruenberg state that the pest would have become subdued also without the aid of Clausenia only it would have taken more time than it actually did. He adds, however, C. purpurea is the easiest to handle and to breed and this is what makes it so important.

Table 6 - Parasitism in ten citrus groves in various localities of Israel, 6-7 years after C. purpurea was introduced into the country.

Total parasitism in the grove	Scymnus spp.		Anagyrus pseudococci		Leptomastic flavus		Leptomastidea abnormis		Clausenia purpurea	
	numb.	perct.	numb.	perct.	numb.	perct.	numb.	perct.	numb.	perct.
Sarafand 51					4	7.8	27	52.9	20	39.2
Rishon-le-Zion 203			76	34.7	30	14.8			97	47.7
Ness Ziona 245			40	16.3	106	43.2	22	8.9	77	31.9
Hadera (R) 332	21	6.3			2	0.6	48	14.4	261	78.6
Hadera (L) 204	27	13.2			8	3.9	18	8.8	151	74.0
Hadera (K) 166	10	6	3	1.8	5	3	62	37.3	86	51.8
Hadera (N) 593	1	0.2	20	3.4	58	9.9	479	80.8	35	5.9
Tulkarem 56	19	33.9	1	1.7	2	3.5	5	8.9	29	51.8
Kfar Yavets 3748	70	1.8	2	0.05	5	0.1	261	6.9	3410	91
Migdal 383	344	90.6	0		36	9.4				

Pseudococcus adonidum L

Pseudococcus adonidum has been introduced into Israel long ago, in the twenties of this century. Until 1950 it remained inconspicuous. Commercial damage to citrus was noticed at Mikveh-Israel 1952. In 1954 Gruenberg liberated there two parasites - Tetracnemus peregrinus Comp. and Anarhopus sydneyensis Timb. A year later the first was recovered but not the latter (Gruenberg 1957).

The situation in 1966-67

The imported mealy bug Ps. aff citriculus was brought entirely under control mainly by Clausenia purpurea which was imported from Japan. Colonies of this mealy bug may be found in scattered areas, but Clausenia is always within these colonies, and prevents outbreaks (Rosen 1964).

The situation is different with the citrus mealy bug - Plannococcus citri. Regardless of the efforts of the various entomologists, no changes have occurred in the biological balance of this pest. The imported predator failed because of climatic conditions, whereas the imported parasite failed probably because of hyperparasites. The various local parasites and predators keep the pest at low levels, but not sufficiently so as to prevent it from causing damage. Leptomastidea abnormis is not as efficient here as in other countries. Also other parasites are checked either by adverse climatic conditions or by hyperparasites, and the same is true with the predators.

Some relief in banana plantation may be obtained through the control of ants which repel parasites, by means of granular pesticides; direct application against the pest are made on bananas, grape vines and others. From the point of view of biological control, this problem still awaits a solution.

Biology of Sympherobius sanctus Bo-Tjeder (=amicus Navas)

The following data on the biology of S. sanctus were obtained by Bodenheimer and Guttfeld (1929)

The eggs were laid singly or in groups in the vicinity of Plannococcus colonies. The incubation period of eggs laid in November lasted 25 days. No oviposition took place during December-February. The winter was thus passed in the larval and pupal stages. The activity of the adult resumed in late April-early March. The incubation period in the summer was about 3 days.

In the coastal plain about 8-9 generations may develop in succession with no true diapause. The winter generation developed within 95-112 days. The spring and autumn generations within 40-50, and the summer generations each within 26 days, including the preoviposition period.

The development period of 34 days at 20.8°C, and that of 22 days at 26.4°C served to compute the threshold of development. It was set at 10.5°C and the thermal constant at 350 day degrees C for the fastest developing insects and 567 for the slower ones. One female laid from 300-500 eggs during the summer, but less than that during the spring or autumn; on the average 254 eggs were laid by one female.

Breeding this neuropteron on Ps. aff. citriculus, Rivnay (1943) studied the effects upon the insects of extreme degrees of temperature and humidity such as prevail on the hot Khamsene days in Israel. It was found that a high mortality of eggs took place at temperatures above 35°C. When eggs were placed at 42°C for five hours 80% of the eggs died. Of all the stages, the larvae were the least resistant to temperatures. Mortality of larvae at uncontrolled humidities was 80% at 30°C, and 100% at 33°C. At a high relative humidity 36% died at 30°C and 60% at 33°C. The pupae were less resistant at the higher relative humidity than the eggs.

Breeding outdoors showed that when low relative humidity was coupled with high temperatures such as occur on Khamsene days, the mortality was from 60- to nearly 100 per cent. The mortality was higher when the duration of the detrimental conditions was longer and more intense. High temperature prevailing during the spring and late summer shortened the life of the adult and caused a decrease in the egg production. The most favourable season for the adult, when the highest production of eggs occurred was February-March and June (Rivnay 1943).

Massbreeding of Sympherobius sanctus Bo-Tjeder

The following instructions were given by Bodenheimer and Guttfeld (1929):

Mass hatching is easily obtained in the large breeding cages. From May on, 20-60 adults may be collected in each cage every day. They are easiest caught in test tubes in the evening between 7 and 11 o'clock when they sit quietly on the gauze of the breeding cages. 20-30 adults may be caught in one test tube, into which some mealybugs have been previously introduced. The few remaining adult lacewings are easily caught the next morning. These adults are ready for liberation in the orchard, but may also be kept for 2-3 days in captivity, if desirable.

It is very important to collect as many adults as possible from the cages every day. In this way only a very small fraction of the eggs is laid on the mealy bugs in the cage and a regular development of Sympherobius is therefore secured for some months. If too much oviposition is permitted in the cage, the whole reserve of mealy bugs is quickly destroyed. Thus one obtains a mass-appearance of Sympherobius in a period when there is possible no use for them and must therefore build up the infection of the cage from the beginning.

Biology of Cryptolaemus montrouzieri Muls

The report on the excellent results in the control of mealy bugs brought about C. montrouzieri in California stimulated its introduction into Israel (Palestine). The lady beetle was reared on P. citri breedings on potato sprouts (Bodenheimer et al. 1929).

The eggs were laid singly within the egg masses, and the incubation period, depending upon the temperature, lasted from one to three weeks. The complete development period at 18°C lasted about 85 days, and at 24-26°C it was complete within 40-48days. The threshold of development was set at 9°C and the thermal constant at 645 day degrees C. Oviposition ceased in December, and was resumed in March, but larvae and pupae did develop in the winter albeit at a great percentage of mortality. The beetle thus raised six generations annually. The winter generations lasted about six months, the spring generations two months, and in the four remaining summer months 4 more generations could develop.

The biotic factors limiting development of the beetle in Israel were very negligible. Gallmidge larvae and lacewings did destroy some of the eggs of the beetle, but in very small numbers. Cannibalism occurred, but only under crowded conditions. The main limiting factors were climatic. It was noticed that the mortality of immature stages in the field was high in the winter, due to the cold wet conditions, and in the summer due to the hot, dry conditions. The favourable periods were the short early spring and autumn. The population in the autumn was suppressed by the subsequent winter cold and that of the spring was exterminated by the summer heat. A comparison of conditions in Algeria, Egypt and Israel showed that all three countries have a hot, dry spring in common. These climatic conditions when compared with those in Nice and California where the beetle was established further substantiate this limiting factor for this beetle in this part of the world (Bodenheimer et al. 1929, Bodenheimer 1951).

Notes on Scymnus suturalis Thunb.

S. suturalis was found with Ps. aff. citriculus in whose eggsacs it laid its own eggs.

The development of the stages at various temperatures is given in Table 7.

Table 7 - Data on the development of Sc. suturalis

Temperature	Length of development in days			
	Egg	Larva	Pupa	Total
29°C	5-7	6-8	4-6	14-21
25	7-9	9-10	9-10	25-29
23	9-10			35-40

At favourable temperatures the preoviposition was about one week, while at 14-18°C no egg laying took place (Rivnay and Perzelan 1943).

Notes on Scymnus includens

S. includens was found with P. citriculus and its eggs were laid in the masses of the host or in the ovisacs.

The development of the various stages is given in Table 8 (Rivnay et al. 1943).

Table 8 - Data on the development of Sc. includens

Temperature	Development in Days			
	Egg	Larva	Pupa	Total
29°C	4-5			20
27	6-7	10-12	6-8	28
25	8-9			

Notes on Scymnus quadrimaculatus Hbst.

This Scymnus feeds exclusively on mealy bugs, and in the coastal plain raised 5 generations. In July the development of larva and pupa each lasted 5-6 days whereas in September-October 8-15 days (Bodenheimer 1951). In the laboratory, under controlled temperatures, the insect completed its entire development (excluding preoviposition period) in 35 days at 25°C, and in 28 days at 29°C (Rivnay et al. 1943).

Notes on Hyperaspis polita Weise

This beetle was found on trees heavily infested with P. citri. Its activity is limited to the summer only, no oviposition having taken place during the winter. It thus raised five generations annually. In June the generation developed within 45 days, in August in 35 and in September-October in 70 days. During the summer the average number of eggs was 400 per female (Bodenheimer 1951).

Notes on Oxynychus marmottani Fairm
(Syn. Hyperaspis pumila Mulsant)

This beetle may be found together with P. citri (Bodenheimer 1951) or P. aff. citriculus (Rivnay et al. 1943). In the field it was active in the summer only June-October, and the winter is passed as an inactive adult (Bodenheimer 1951). At a regulated temperature of 27-28°C eggs developed within 6-9 days, larvae and pupae within 9-14 days each (Rivnay et al. 1943).

Notes on Leptomastidea abnormis Girault

Oviposition takes place freely upon P. citri and P. aff. citriculus with no discrimination between the two. Marked preference was shown to younger stages. Oviposition may occur immediately after emerging from the pupal case, and being arrhenotokous, only males emerged when the female was not fertilized. Its development at 24-26°C was 17-18 days at 20°C-24.5 days whereas at 15°C - 45 days (Rivnay et al. 1943); from these values the threshold of development was set at 9°C and the thermal constant at 270 days degrees C.

Eight generations were reared during the year. The summer generation lasted 20-28 days, and the winter generation 110-120 days (Gruenberg 1950).

When reared in cages with an abundant supply of host individuals 183 offspring per female were obtained (Gruenberg 1950).

Biology of Leptomastix dactylopii Howard

Samples of this parasite were obtained by Cohen from Canada for liberation against P. citri. A few individuals were given to E. Rivnay at Rehovot for breeding in the laboratory and subsequent liberation in the field.

Outdoors breedings in jars containing citrus fruit infested with P. citri showed that this wasp completed its development within 14 days, the average temperature at the site of the breedings was 28°C. Indoors, towards the end of September and early October, the average temperature being 27°C, the wasp developed within 16-17 days.

The species is arrhenotokous, and unfertilized females laid 12-15 eggs from which males hatched, but fertilized females produced more. The maximum number of offspring obtained was 44, the average of 9 females was 26. The ratio between males and females was about equal. At the cold temperature of 14°C, such as prevails in the coastal plain during the winter, individual adults survived over 70 days, the food being honey dew of the mealy bug and sugar solutions.

Biology of Leptomastix flavus Mercet

Of the three local parasites this species was the most active, and most common in the colonies of P. citriculus. It may also attack Ps. citri (Rivnay et. al. 1943) and P. filamentosus (Gruenberg 1950). Parasitization of P. citriculus in the field in its active period was over 35%.

The development of an individual lasted 16-18 days at 23-25°C (Rivnay et al. 1943) and 27 days at 22°C. The threshold of development was set at 12.7°C (Gruenberg 1950).

Gruenberg raised about 10 generations annually. The duration of the development for the summer generations was 19-13 days, for the autumn and spring generations 38-47 days, while the winter generations lasted 97-105 days (Gruenberg 1950). One female lived 37 days in the summer.

Leptomastix flavus is active mainly in the early summer, the peak of the density of its population is in June and it was absent, or very rare, during the winter (Rivnay et al. 1943).

Biology of Anagyrus pseudococci (Girault)
Syn: A. Kivuensis Comp.

The biology of Anagyrus pseudococci was studied by Rivnay et al. 1943, Gruenberg 1950, and Roessler 1964.

The development of the species in the laboratory lasted over 60 days at 17°C (Rivnay et al. 1943), 29 at 20°C, 17 at 24°C and 13 days at 28°C (Roessler 1964). The threshold of development is 14°C (Gruenberg 1950), while the thermal constant was 202 day degrees C (Roessler 1964). Outdoor the development was slower, the threshold 12°C and the thermal constant was 285 days degrees C.

Roessler also studied the length of the various stages. At 28°C the incubation period was 1-2 days, that of the larvae 4-5, prepupal and the pupal stage 4-6 days. The adults lived longest when fed on honey - namely 21 days at a temp. of 28°C; sugar-fed females lived 10 and honey-dew fed lived only 4 days at that temperature. With other food they lived less than three days. Honey-fed females lived on the average 47 days at 15°C, 21 at 28°C and 10 days at 32°C (Roessler 1964).

The threshold of reproduction was considered to be at 14-15.5°C. Females laid 0.4 eggs during their life time at 11-13°C (Roessler 1964) and reproduction increased as the temperature rose. Roessler found that in P. citri the female of Anagyrus pseudococci may oviposit in all stage except the first and second. Furthermore the females oviposit more readily in older or gravid females (Table 9).

The percentage of females in the offspring depended upon the size of the host individuals in which the eggs were laid, confirming thereby previous findings with other parasitic hymenoptera.

Table 9 - Anagyrus pseudococci: Number of laying females and number of eggs laid by one female during the first 24 hours of her life in host of various ages. (After Roessler 1964.)

Total Number of females	Number of laying females	Age of host	Size of hosts in mm.	Number of off-spring	Percentage of females in offspring	Number of offspring per female in 24 hours
20	0	1st & 2nd stage larvae		0	0	0
20	10	3rd stage larvae	1.1 2	x	16	2.5
20	12	young females	1.8 2.9	44	57	3.7
20	15	laying females	2-3.2	89	76	5.9

When parasitized host individuals were placed in a refrigerator at a temperature of 0-2°C for 24 hours a great percentage of the parasites died. In comparison with the control only 8.33% of the larvae emerged and 27.6% of the pupae. These being apparently more resistant than the larvae. 41 eggs were obtained by a female, five eggs having been laid per day (Rivnay et al. 1943). At a controlled temperature 33 eggs were laid on the average by 8 females. Non-fertile females, the wasp being arrhenotokous, laid 15 eggs under the same conditions(Roessler 1964).

Biology of Clausenia purpurea Ishii

The biology of Clausenia purpurea was studied by E. Rivnay (1942) in 1940-41 and by Gruenberg (1950) in 1946-47. This review is based mainly on the first study. After giving a description of the various stages, the biology is described. As a rule the female being thelytokous develops parthenogenetically, but there is a small percentage of males, about 3% which may increase in number towards the end of the summer, but not over 10% of the number of females.

Oviposition takes place in large larvae or in young adults, but not in gravid females. One host individual may be subject to a few ovipositions, but only one parasite develops. The highest number of offspring obtained by a female was 123 at 25°C. At lower or higher temperatures reproduction decreases. at 30°C only 6 offspring were produced by one female, and about the same number at 17°C. No reproduction took place at a temperature below 15°C or above 32°C.

At a temperature of 25°C the development of the generation was 25-30 days; at 18°C - 60 days; while at 12°C 120 days. The threshold of development was set at 9°C or 9.6°C.

In the course of the biological control studies, the question of cold storage was raised. The effects of low temperatures upon the pupae was studied by E. Rivnay and Gruenberg.

When adults were kept at 6-7°C, they all died after 5-6 days. Keeping the pupae at a temperature of 4-7°C showed that the effects of such low temperatures became more accentuated with the extension of exposure. The effects were manifested upon the pupae and upon the fecundity of the surviving females, as seen from the Table 10.

Table 10 - **Effects of storage in low temperatures upon mortality and fertility of C. purpurea (after Rivnay 1942).**

Period of exposure of pupae to 4-7°C (in days)	Number of pupae	Number of Dead pupae	Number of surviving females bred further	Average number of offspring
Control	10	1	7	73
6	10	1	2	63
12-18	20	6	5	56
25-30	20	7	4	37
30-40	20	7	4	29
45	10	5	2	15

Dicrodiplosis sp.

Oviposition by this midge takes place on the mature host female, as a rule 1-3 eggs in each case. The eggs hatch a very short period afterwards. The larvae crawl to the ovisac and feed on the eggs of the mealy bug. About one-hundred eggs are devoured before the larva pupates. The development of the larvae is complete in about 5-6 days, in the summer. The entire development of the species lasts about 10 days at 27.3°C and 40 days at 15.9°C. From these data the threshold of development was calculated and was set at 12.1°C, and the thermal constant at 152 days degrees °C. Adults lived about 12 days on an average.

The midge is very sensitive to climatic conditions in the summer and in the winter. Actual increase of the population takes place only in the spring and to a small degree in the autumn (Bodenheimer 1951).

Breeding Technique of Dicrodiplosis

The breeding of the midge was made in test tubes where 4-5 adult midges were put together with 4-8 mealy bugs ready to oviposit.

On a larger scale, cages with potato sprouts infested with mealy bugs were populated with some gall midges. The cage soon became infested with the midge. In such heavily infested cages corrugated paper was placed between the potato sprouts, and laying females settled there and the paper became infested with eggs and larvae of the midge. The corrugated paper was then taken to the infested groves.

Karnyothrips flavipes Jones

K. flavipes is a common predator and probably feeds on mealy bugs too, as Rivnay (1933) found it in large numbers between sepals and orange fruit where P. citri abounds. A more recent survey in the neighbourhood of Rehovot showed that eggs and larvae of these thrips were also found under sepals.

MARGARODIDAE

The Cottony-Cushion Scale Icerya purchasi Maskell

Icerya purchasi was introduced into Israel (then Palestine) towards the end of the first decade of this century. Its serious damage to citrus trees, such as described during its early days in California was first felt in the groves of Petach Tikvah and Jaffa. Twenty years later M. Apfelbaum (1931) described the grave situation of the citrus groves in the following words:

"There was a period when we were discouraged beyond measure, namely in 1910-11, when we had a serious attack of the parasite known as "Icerya purchasi"; this parasite attacked the orange groves in a most extraordinary virulence, the groves being entirely stripped of their fruit and leaves, the trees were in places white, where they were covered by this insect, and had the appearance, from a distance, of tufts of cotton (cottony scale). In other parts, the trees were black, covered with smut. All methods adopted to combat this parasite proved unsuccessful."

As mentioned in an earlier paragraph, there were no entomologists who could offer advice, and help was solicited from the Turkish Governor of Jaffa who summoned a meeting of notables. Details of the meeting were also recalled:

"All those interested were deeply concerned at the seriousness of the plague which raged particularly in the neighbourhood of Jaffa. A joint meeting held with the Governor of Jaffa and the principal orange growers, at which ways and means of combating the disease were discussed. It was then that the writer of this article recommended the introduction of the 'Coccinella' (Lady Bird) known as 'Novius cardinalis'. My recommendation was adopted and the insect brought into the country. Wonders were worked: What human power had not been able to do for years, this tiny creature accomplished in a very short space of time. This is how we were able to save the orange plantations" (Apfelbaum 1931).

It may be surmised that the job of handling this matter, writing and asking for the predators and taking care of them upon their arrival was placed upon the person who proposed it. Mr. Apfelbaum wrote to Italy where Rodolia (Novius) Cardinalis had been introduced and established since 1895. Details of events as they happened later were received now verbally from the octogenarian Mrs. Apfelbaum, the wife of the late agronomist: "Two shipments were received, each consisted of a match box containing about a dozen bettles. In the first they were all dead, the second had some beetles still living, and they were liberated in the groves. Wonders were accomplished by them and the trees were cleaned after a short period".