Notes on Aphelinus mali Hold.

The following details on the biology of A. mali were obtained by Bodenheimer (1947) at Kiryat Anavim:

The threshold of development of the parasite is at 8.6°C, and the thermal constant from egg laying to the emergence of the first adult is 227 day degree C. The total development at 25°C, the average summer temperature, is about 14 days, while at 15°C, the average winter temperature, it is 35 days.

Normal activity of the wasp takes place at 16-30°C. 27°C being its optimum temperature; cold torpor is at 7.6°C, while heat paralysis begins at 43 and instantaneous death at 47°C.

Fourteen generations of A. mali may develop in the hilly region of Israel while the host may raise nineteen.

Notes on Aphidius varius Nees

This braconid is a parasite of the first stage larvae of Cinara palestinensis HRL. Its development was complete in 35 days when started in March, and in 15 days during the summer months of June-August. A third of this period was spent in the pupal stage.

Copulation took place immediately after emergence and oviposition started one day after this. In the summer an adult lived about 11 days.

Aleyrodidae

Acaudaleyrodes citri Priesner & Hosni is endemic to Egypt and Israel. It is widespread in Egypt, especially in its upper part, where severe attacks were recorded on citrus, but is rather rare in Israel.

Rosen (1966) in his survey obtained two parasites from samples of this species - Eretmocerus diversiciliatus Silvestri, and Prospaltella lutea Masi.

An Eretmocerus sp. of insignificant importance was recorded by Priesner et al. from Egypt. In Israel, however, both above mentioned species "are rather abundant, and were obtained relatively in large numbers even from extremely sparse populations of their host, a fact attesting to their high efficiency. It seems most probable that the general scarcity and insignificance of A. citri in Israel is attributable to the efficient action of E. diversiciliatus and P. lutea" (Rosen 1966).

ACARINA

Generally speaking Acarina assumed agricultural economic importance in Israel only towards the middle of the era under discussion. Some important injurious Eriophyidae became noticeable only as late as 1949.

The most injurious Tetranychidae are: Tetranychus cinnabarinus which attacks field crops and fruit trees as well. Devastating injury is often felt particularly in melon, bean and beet fields. Eutetranychus orientalis Klein attacks citrus and other trees, especially in the innder valleys and the Negev.

The following injurious Eriophydae are known: Phyllocoptruta oleivora Ashmead, the most notorious of all, is injurious to citrus of all varieties. It was reported for the first time in Israel in 1944. The growth of injured fruit is stunted, its taste deteriorates and the marking on the fruit, rusty on oranges and silvery on lemons and grapefruit, render it unmarketable. In untreated citrus groves, damage was as high as 70-100% of the crop.

Vasates lycopersicae Massee first discovered here in 1949. It injures tomatoes.

Aceria oleae Nalepa causes the curling and stunted growth of young olive leaves.

Aceria sheldoni Ewing causes the deformities in the lemons and oranges, and dwarfed knots as well.

Eriophyes pyri Pgst. - the pear blister mite is injurious to pears, whereas Eriophyes vitis Pgst. which attacks grapevines causes the abnormal leaf growth and dwarfed knots.

All these pests have been studied, and control has been applied whereever appropriate measures were available. The treatment of citrus with sulfur against P. oleivora was temporarily satisfactory as far as the farmer was concerned. But it did not take long before the situation deteriorated as sulfur exterminated also predator mites and parasites. When the conventional acaricides became less effective against red mites in field crops, high dosages of parathion were used. In the end red mites became resistant to parathion too. Mites were not the only pests attacking some of the plants. In peanuts and beets several applications of synthetic insecticides were aimed at Spodoptera littoralis. These substances killed off many of the Hemiptera, Coccinellidae, Neuroptera, Phytoseiid mites and others that destroyed Acarina. It became evident that in addition to the acaricidal applications, these predators played an important role in maintaining the mite population below an economic level.

Entomologists in Israel made attempts to alter this situation. The activities were in two directions:

(1) An endeavour to maintain the local biological balance included a survey of local acarophagous mites and the use of selective acaricides and reduced applications of insecticides.

(2) An attempt to change the ecosystem by introducing new predaceous mites, their mass breeding and liberation in the groves.

a) The reduction in the number of applications.

A campain was launched against the lavish use of insecticides. In the citrus groves it was suggested that only infested spots should be treated against the rust mite and not the entire grove as was the practice before.

In the report dealing with Spodoptera littoralis in peanuts, Teich (1965) gives a detailed account as to how the number of treatments against that pest was greatly reduced by a careful scrutinization into the situation and by always questioning whether the presence of the pest really brought about the alleged injury.

Similar studies were carried out in connection with pests of other crops. It should be remembered that this tendency of avoiding insecticides may be exaggerated, and a fundamental knowledge of the pest, its biology and role must govern this practice.

b) Selective insecticides.

Gradually, due to the pressure of entomologists, insecticides with a wide spectrum of potency were eliminated or restricted to certain occasions only. The use of parathion and DDT became far less common than it was a few years ago. In addition, selective insecticides are recommended whenever feasible. As examples, the control of some citrus pest should be mentioned. Early in the period of synthetic insecticides the incorporation of some synthetic insecticides with the oils against the scale insects was advised, but it soon became evident on many occasions that this practice with some insecticides brought more harm than benefit. A study should be made for the proper insecticides that should be applied in this form and under what circumstances.

Cover sprays with contact synthetic insecticides against the Mediterranean fruit fly were replaced by poisoned baits.

These were based on reports from Hawaii, and consisted of yeast hydrolizate. The formula of Steiner of the U. S. D. A. in which Staley's brew S. W. 7 was employed as bait, and malathion as the insecticides, was adopted for the general treatments of the citrus groves.

These are applied from the ground and to spots only, or they are sprayed from the air. The routine preventive applications were substituted by indicative bait traps which mark the presence and abundance of the fly in a certain locality.

(a) A survey of local insect predators.

\- Stethorus punctillum vs. Tetranychus cinnabarinus Boisd.

Entomologists and agronomists who are familiar with field crops in Israel know that infestations by the red spider mite are usually accompanied by the presence of the minute lady-beetle Stethorus punctillum which feeds upon it. An evaluation of its economic importance and observations on its phenology were made only recently.

Counting specimens in various parts of the country, Plaut (1965) found that the beetle may occur anywhere as from April to November as long as the host is present and no pesticides were applied. The density of the population may vary in August from 11 larvae per watermelon fruit to 0.4 - 0.8 individuals per apple leaf.

Further observations and counts showed that dense populations of the mite on beet leaves in April were overcome by the beetles in May. On another occasion, in a fodder beet field, 96% of the leaves were densely populated with the mite; the mites were totally overcome by an average beetle population of 6 individuals per leaf (including all stages) within two weeks. An adjacent plot similarly infested was sprayed 10 days after the beginning of these observations, and five days before the last count. Here 36% of the leaves remained densely populated with the mite.

Plaut claims that no other factors such as heat, drought, or lack of proper food could have been responsible for the collapse of these mite populations.

(b) A Survey of local predaceous mites.

Swirski and Amitai (1961 and 1965) carried out a survey of predaceous mites in Israel while Porath and Swirski (1965) made a parallel survey in the citrus groves only. The species found by all are listed below. The list includes five species new to science.

The most common in the citrus groves and probably important from an economic point of view are as follows: Amblyseius swirskii Athias which feeds on various mites including the rust mite, and which is dominant in the coastal plain, and Thyphlodromus athiasae P & S, common in the inner valleys and Galilee. Iphiseius degenerans Berlese which is common all over the country is abundant also in the citrus groves. Its presence in large numbers on Ricinus where to Tetranychidae may be present is an indication that it feeds on these mites.

LIST 11. Phytoseiidae found in Israel
in surveys on behalf of the Citrus Marketing Board.

The references are : S & A = Swirski and Amitai ; S & Sh = Swirski and Shechter; P & S = Porath and Swirski.

1 Typhlodromus athiasae P & S
every where - P & S 1965

2 Typhlodromus rhenanus Oudemans
coastal plain and hills, S & A 1961, P & S 1965

3 Typhlodromus negevi S & A
Yotvata on Phoenix, S & A 1961

4 Typhlodromus talbii Atheas
coastal plain & inner valley P & S 1965

5 Amblyseius rubini S & A 1961, P & S 1965
every where

6 Amblyseius judaicus S & A
Judean hills on Salvia

7 Amblyseius eitanae S & A
Ein Gedi on Salvatora and Calotropis S & A 1965

8 Amblyseius aberrans Oudemans
Jerusalem - S & A 1965

9 Amblyseius barkeri Hughes
Coastal plain and inner valleys S & A 1965

10 Amblyseius chergui Athias
Jerusalem S & A 1965

11 Amblyseius messor Wainstein
Coastal plain

12 Amblyseius setosus Muma.
Coastal plain and inner valley P & S 1965

13 Amblyseus swirskii Athias
Coastal plain P & S 1965, S & A 1965

14 Iphiseius degenerans Berlese
all over the country on various plants.
S & A 1961, P & S 1965

15 Phytoseius finitimus Ribaga

(c) In search for, and importation of predatory mites.

Cohen and Nadel of the Citrus Marketing Board, while in Hong Kong in 1958, collected mites there and made arrangements with Cheng for further shipments of predatory mites to Israel. Here the mites were handled by Swirski who sent the material for identification to Chant. The species were:

Amblyseius largoensis (Muma), A. newsami Evans, A. ovalis Evans, A. asiaticus Evans, A. floridanus (Muma), Typhlodromus contiguus Chant, and Iphiseius degenerans (Berlese). (Swirski and Shechter 1961).

At the initiative of I. Cohen, and on behalf of the citrus marketing Board Swirski made in 1960 a special trip to Hong Kong for further collections of Phytoseiidae. He stayed there during August-September. In addition to the predaceous mites obtained from Hong Kong earlier, Swirski collected eight species, seven of which were new to science. The species are enumerated in List 12.

LIST 12. Predaceous Mites from Hong Kong

Typhlodromus vulgaris Ehara

Phytoseius crinitus S & Sh

Phytoseius hong-kongensis S & Sh

Phytoseius (Dubininellus) maeropilis coheni S & Sh

Phytoseius (Dubininellus) brevicrinis S & Sh

Phytoseius (Dubininellus) rachelae S & Sh

Phytoseius (Dubininellus) bambusae S & Sh

Phytoseius taiyushani S & Sh

The biological Control laboratory of the Citrus Marketing Board together with Swirski introduced in addition to Amblyseius largoensis Muma from Hong-Kong, also the following:

Amblyseius limonicus Garmar & McGregor from the U.S.A.

Amblyseius hibisci Chant from the U.S.A.

Amblyseius chilensis Doss, from Chile through U.S.A.

Phytoseiulus persimilis Athias from Chile through Germany

Typhlodromus rickeri chant, from India through U.S.A.

Typhlodromus occidentalis Nesbitt from U.S.A.

(Swirski- verbal comunication)

(d) Liberation of Predaceous mites:

Amblyseius largoensis was liberated by Swirski on the ground of the Institute at Beit Dagan (S & A 1961) as early as 1960. It was recovered in March 1961 about one mile from the point of release.

In 1964 about 200,000 specimens were liberated by Stephan Kamburov of the Citrus Marketing Board all over the country. Recovery was made during August-September 1964 in the coastal plain, the inner valleys and the Negev.

At the time of writing this the following species and their respective numbers were liberated by E. Swirski in collaboration with S. Kamburov: (Swirski 1965)

Typhlodromus rickeri	5,000
Amblyseius hibisci	30,000
Amblyseius limonicus	160,000
Phytoseiulus persimilis Ath.	200,000

The situation in 1966-67

The elimination of lavish treatments with insecticides in field crops reduced the red mite problem. Early in the summer cotton fields, especially those adjacent to beet fields, usually become infested with T. cinnabarinus. No treatment is made against it; experience has shown that in the middle of the summer the mite problem is below economic level. In the autumn the mite population may rise again in the cotton fields, but an experiment by Plaut (unpublished report) has demonstrated that the cost of its control is far more than the loss of crop it may incur.

In the citrus groves this mite is abundant on the weed Solanum nigrum. When the weeds in the grove are destroyed, the mites crawl on the trees. Most affected become the cederate trees (Ethrog), as due to the continuous applications with insecticides against other pests the predaceous arthropodes were exterminated.

Occasionally outbreaks of Eutetranychus orientalis (Klein) occur in the arid warm valleys. On such occasions tedion or diccofol are applied. Sulfur against the rust mite has been substituted by zineb and chlorobenzilate.

The diminishing of sulfur dusting in the citrus groves had double favourable effects. Instead of 3-4 applications with sulfur dust, only one or mostly two applications are made with zineb. The reduction in the number of applications and replacing dusting with spraying affected favourably the balance between predacious and injurious mites. The rust mite had become far less injurious than it had been in the fifties.

Notes on Amblysius spp.

Effects of food on the development and reproduction of two Amblyseius spp.

Swirski et. al. (1967) made a study on the effects of various kinds of food on two predaceous mites, Amblyseius rubini S. A. and Amblyseius swirskii Ath. They found that the kind of food influences development and fertility of the predators. Even more, the host of the prey also affects the predator. Thus, when A. rubini fed on Tetranychus cinnabarinus feeding on lemon, the mortality of the predator nymphs was larger and the egg-laying of adults less than when the prey fed on castor oil plants. The same predator mite suffered a larger percentage of mortality when the red scale crawlers upon which it fed originated from breedings on squash, more so than when they originated from the citrus grove. Similarly when A. swirskii fed on rust mites there was more mortality when the prey originated from young lemon seedlings grown in sterile soil, than when the rust mites originated in the grove.

Of the two species, A. swirskii was more impartial to various foods. It fed equally and developed well on T. cinnabarinus, E. orientalis and Brevipalpus phoenicis Geij. on whichever host plant they fed. Their life span was long and their reproduction fair. On the other hand, A. rubini did poorly on Brevipalpus, E. orientalis, on T. cinnabarinus when fed on lemon, and on Phylocoptruta.

Both predators fed on the eggs of Lepidoptera, but the mortality in the nymphs of both was high. The eggs of the pyralids Prays citri and Ectomyelois ceratoniae had better effects on both than did the eggs of Spodoptera littoralis. Both species fed eagerly on the eggs and larvae of Bemisia tabaci. The mortality of the nymphs was low and the reproduction fair and regular.

A. rubini fed on Retithrips syriacus only when no other food was available. Its reproduction was low. A. swirskii suffered a high mortality when fed on this thrips, but the survivors laid many eggs, regularly until their death. A diet on red scale crawlers resulted in heavy mortality of A. swirskii; only 32% developed to maturity and egg-laying was fair.

Honey dew from Pseudococcus citriculus alone was not a favourable diet for both predators.

A diet of pollen from various flowers was favourable for both predators. On pollen of Mesembryanthemum, avocado and maize A. rubini developed well with a low percentage of mortality. On the other hand, this latter diet caused a high mortality among A. swirskii, but the survivors laid many eggs.

Rearing methods of predaceous mites

The following description of the rearing methods of predaceous mites was based on Kamburov (1966), Swirski and Amitai (1966), verbal communication with both and visits in the respective laboratories of both.

The basic principle rearing predaceous mites is the enclosing of a space of optimal rearing conditions with a barrier which should prevent the mites from escape.

At the beginning, Kamburov reared the mites on castor oil plants infested with Tetranychus spp. However, in addition to the cumbersomeness in handling, the isolation was not complete as the cobwebs of the phytophagous mite created bridges of escape.

Swirski and Amitai made barriers around small plates through which wires were heated by electric currents. The heat prevented the mites from escape. This method too was cumbersome.

The best method to prevent the mites' escape proved to be a ring of oil around the space. Kamburov used machine oil to which he added grease or vaseline (2 volume oil:1 weight grease). The addition of the grease or vaseline was to make the oil more viscous.

To rear and study individual mites, Kamburov used the cavities in colour boxes, in which the colours are mixed, or the like, a small plastic ring 2 cm in diameter was placed in the cavity, oil was placed around the ring and the mite reared within. For this purpose also two plastic rings one within the other were employed. The oil was placed in the space between the rings.

To raise predacious mites in small numbers, small plastic plates such as covers of small jars or bottles, 5-8 cm in diameter, provided with a groove along the circumference, were employed. The groove was filled with the oil compound to prevent escape. Water was supplied by cotton wicks which passed through the walls of the plate, which were, in turn, placed in larger plastic trays as described below. Pollen was offered as food.

Swirski and Amitai carved flat concavities in plastic boards around which a groove, 3 mm wide was carved. The oil was placed in the circular groove and the mites reared in the flat cavity. In accordance with the requirements, those cavities were of different dimensions, 2, 5 and 10 cm in diameter. Moisture was supplied through a cotton wick which passed through a hole in the center. In order to rear the mites on a fruit or leaf infested with Tetranychidae, a circular hole, instead of the concavity, was cut out and was placed over the fruit or leaf. The leaf was placed over a sheet of plastic sponge, 5 mm thick, with a filter paper between them. The three layers were then sandwiched between two plastic boards 10x10 cm, the upper one being with the hole and circular groove as described above. All layers were fastened tight with screws, provision was made for the leaf petiole to be in water, and all superfluous holes or spaces were smeared with liquid plastic which dried immediately. On the fruit, the board with the hole was fastened with rubber bands which passed through specially made holes.

For mass breedings, predacious mites were reared by Kamburov in plastic trays 22x28x16, Here, too, the border of the tray was provided with a trough 2-3 mm deep and 6 mm wide, and it was filled with the viscuous oil compound as described above. The viscosity of the oil enabled the tilting of the tray for manipulations and microscopic examinations. Over the bottom of the tray a sponge carpet was spread which in turn was covered with a filter paper. This "floor" was moistened periodically to maintain the desired humidity. To supply water, 6-8 wicks were provided leading from containers beneath the tray through holes in its walls or floor. Humidity in the tray could be regulated by a clip which could alter the opening as desired. As food, pollen was offered. Also "live food" could be provided in these trays by placing in it citrus fruit or leaves of citrus, beans or castor oil plant infested with Tetranychus cinnabarinus.

For distribution, the mites were sucked with the aid of a vacuum-cleaner into plastic tubes in which they were transferred to the groves.

According to Kamburov, this method was much simpler than that described by McMurtry and Scriven (1962). The possibility to regulate the humidity in the trays eliminated the necessity to keep the entire room humid, and when the room humidity was reduced to 45%, saprophytic mites did not develop. One tray could last 6-7 months, requiring the change of water and the addition of food only.

D I P T E R A

The Mediterranean Fruit Fly Ceratitis Capitata Wied

The Mediterranean fruit fly invaded Israel early this century; perhaps even at the end of the last.

George Compere (1912) reports having found Mediterranean fruit fly maggots in fruit in the markets of Port Said in 1904. No doubt it was also found in Jaffa. It took the fly over a decade before it became a country-wide pest of prominence.

The first attack by this pest witnessed by the writer was at Zichron Yakov, in the spring of 1915 when the entire crop of an orange grove dropped due to the attack of the fly. Because of World War I, oranges were not marketed and the abundance of ripe fruit on the trees probably caused an overwhelming increase of the fly population. In the northern part of Israel the fly assumed the role of a severe pest in the early thirties.

Two reasons account for the successful and quick establishment of the fly in Israel:

1) The climate. With the exception of the three winter months, when the fly passes a period of quiescence, it is active throughout the year. Some adverse conditions may happen during the period of activity when the mortality of adults is high due to high temperature and low relative humidity, or when no reproduction and slow development takes place due to low temperature - but as a rule the climate in the coastal plain enables the fly to raise 8-9 generations there.

2) The continuity of host plants. In Israel fruits suitable to the fruit fly attacks are available all year round. Guava, clementine, tangerines and grapefruits in the autumn, are followed by Jaffa oranges in the winter and Valencia oranges in the spring; finally come the many summer fruits, apricots, peaches, figs, cactus, etc., etc. Thus there is an adequate bridging over for the fly from season to season.

The damage of this fly is manifested in many ways:

1) Wormy fruit: The situation has come to a stage that when no measures are taken one cannot be certain whether the fruit picked from the tree or purchased in the market is worm infested or not. In particular figs, apricots and peaches were often marketed with the worms, as signs of attack were not visible from the outside.

2) Fruit drop: Attacked fruit in advanced stage drops before it matured or was picked. Loss of fruit in this way is high, especially in the case of peaches, Jaffa oranges and Valencia oranges. In the latter, over 50% of the fruit may drop prematurely.

3) Cull fruit: Jaffa oranges are attacked by the fly before being ripe. In such cases the reaction of the peel hinders larval development. Thus the fruit may remain with no worms, but the oviposition punctures mar the appearance of the fruit and it is unmarketable.

4) Decayed fruit: In mature fruit the oviposition holes facilitate the entry of fungus spores and increase decay of fruit.

5) Cryptic infestation: In mature Valencia oranges the oviposition puncture is not visible and not detectable. Thus in a year of a mild winter, when the fly has become active earlier than usual, infested fruit may be packed as wholesome and shipped to the foreign markets. The maggots, which in the meantime had developed in transit, are easily detected by the inspectors at the port of destination.

This cryptic infestation causes a loss to the exporters in a few ways:

a) Direct loss of infested fruit;
b) Extra weight in shipping unmarketable fruit;
c) Cost of repacking of the fruit;
d) Restrictions of import in various countries;
e) Exclusion of fruit from import into various countries;
f) Compulsory treatment of fruit even when not infested;
g) Effects on the prices on the markets.

No attempt is made here to evaluate in terms of money the loss due to the fly in the various ways. The above discussion should help the reader to understand the reason for the efforts involved to overcome this pest.

1. **The endeavour to initiate biological control in Israel by Bodenheimer (1951)**

A short time after having established the entomological division at the research station, Bodenheimer as early as 1925 began to study the possibilities of biological control of the fruit fly in Israel (then Palestine). His survey of local parasites revealed that a few species attack the Mediterranean fruit fly, but to a negligible extent. These parasites were Trichopria sp., Pachyneuron vindemniae Rond. and Opius concolor. Szepl. He thought that these parasites should be studied further.

However, the establishment in Hawaii of imported parasites induced Bodenheimer to try to import them into Israel, too. Upon request, Willard of Honolulu was kind enough to send a shipment of parasites to Israel. As mentioned earlier, it took six weeks before this parcel reached its destination during which time the parasites died in transit. No further shipments were made then.

Bodenheimer's approach to introducing parasites into a new country was that before their release a study should be made of the climatic effects upon the insects in their new environments. Other factors which bear upon the successful establishment of the insect should be studied too, as an example the following should be quoted:

Of the four parasites which had become established in Hawaii, he studied the merits and demerits of the two most successful, namely those of Opius humulis Silv. and Diachasma tryoni Cam. and their suitability to Israel.

Using the biological data obtained by the Hawaian entomologists, he calculated their threshold of development and the number of generations each could raise and he found that from this point of view they would be both equally suitable to Israel. However, these two insects are antagonistic to each other. D. tryoni larvae exterminate those of O. humilis whenever encountered. If a choice was to be made between the two, D. tryoni would be more suitable for Israel because of the longer ovipositor it possesses, as in Israel large fruit is attacked by the fly. This choice is made regardless of the fact that O. humilis develops faster, is more prolific and the adults live longer.

In the meantime, the attention of Bodenheimer was diverted to other subjects of study and this project was abandoned.

2. The endeavours by Cohen. (Based upon the correspondence files to the Agr. Tech. Division of the Citrus Marketing Board.

Thirty years passed before the efforts to import Mediterranean fly parasites were renewed. Two factors lay behind this renewal: 1) During the three decades transportation facilities improved. A stage was reached when a parcel from Hawaii to Israel travelled by air in only three days, and not six weeks by boat, as in 1925). 2) During this period the oriental fruit fly Dacus dorsalis Hendel invaded Hawaii. This incident stimulated U.S. entomologists to renew with increased force the search for fruit fly parasites against the oriental fruit fly and other fruit fly parasites as well; as a result many parasites were introduced into Hawaii from various countries (Clausen et al 1965).

Upon request, in June 1956, Christensen of Hawai was kind enough to send eight species of parasites, all belonging to the genus Opius. They were received by the Agro technical division of the Citrus Marketing Board and were delivered to Mrs. R. Gavrielith-Span for breeding.

List 13 gives the original number of each species in the shipment, the number that were alive upon arrival in Israel.

LIST 13 Opius species introduced into Israel (1st shipment)

	males		females	
	Num. sent	alive upon arrival in Israel	Num. sent	alive upon arrival in Israel
Opius compensans (Silv)	100	84	100	64
" formosanus (Full)	100	85	100	73
" incisi Silv.	75		75	34
" longicaudatus novocaledonicus Full.	100	67	100	34
" longicaudatus taiensis Full.	100	85	100	69
" oophilus Full.	-		65	42
" tryoni Cam.	50	46	50	40
" vandenboschi Full.	100	88	100	87

It seems that the laboratory was not sufficiently prepared to cope with all the eight parasites, since, as stated in a letter of Mr. Cohen to Christensen, only T. oophilus was expected.

A few parasites however were reared as follows: Opius incisi, O. longicaudatus novocaledonicus and O. l. taiensis.

A second shipment was sent about a month later, most of them arrived alive. The species received and the respective numbers are given in List 14..

LIST 14 Med.-fruitfly Parasites introduced into Israel (2nd shipment)

Trybliographa daci Weld	600
Dirhinus giffardii Silvi.	1009
Opius compensans (Silv.)	150
Opius trynni Cam.	100
Opius fletcheri (Silv.)	35
Opius incisi (Silv.)	50
Opius vandenboschi Full.	350

Of these, three species were liberated at Mikveh Israel and Kiryat Anavim on avocado trees, and clementine tangerines, known to be infested with the fruit fly.

The parasites liberated were those of which large numbers were recevied, namely Dirhinus giffardi, Trybliographa daci and Opius vandenboschi. No recovery of these parasites was made then.

In the laboratory, however, Mrs. Gavrielith-Span succeeded in breeding eight of the eleven imported species on peaches, guavas and clementines infested with the fruit fly. On January 15, 1957, Mrs. Gavrielith-span was able to report the following:

Opius compensans develops quickly and may raise five generations during the year.

Trybliographa daci and Dirhinus giffardii may raise only three generations each, Opius formosanus two, O. longicaudatus taiensis and novo caledonicus, O. incisi and O. vandenboschi one generation each.

The other parasites died before leaving any offspring.

The breeding of the Mediterranean fruit fly parasites was interrupted for nearly two years, until October 1958, when Thistle of Hawaii, having met Cohen in Hawaii, informed him that another parasite, Syntomosphyrus indicum may be more promising against C. capitata than the parasites sent earlier. Upon request a shipment was sent by Thistle in November 1958, which included Syntomosphyrus indicum, O. oophilus, and Dirhinus giffardi. Of the three, the last one only was recovered in small numbers. This parasite is being bred in the laboratory of the Citrus Marketing Board at Rehovot together with S. indicum which was imported again.

Other methods within the frame of biological control were tried by the members of the Citrus Marketing Board - namely sterile male technique and male annihilation.

Sterile male technique:

In 1963 over three million irradiated individuals tagged with either Calco blue or P^{32} or both were released in the groves. The release was first in the pupal stage and then as adults. The release of pupae was soon abandoned as ants devoured them before they hatched.

In 1965, 90-100 million of irradiated flies were released in experimental groves;

Male annihilation:

In 1964, 1400 trap-jars containing the male fly attractant "trimedlure" were hung in the town area of Rehovot. Every yard or house garden containing fruit trees was supplied with one or more trap-jars. During the summer 100,000 male flies were caught, and the citrus fruit in the town area remained uninfested during the 1964-1965 season. Furthermore, the citrus fruit in the groves around the town of Rehovot received one bait application less than other groves around which no male annihilation was made.

Male trapping was resumed also during the summer of 1965, 50,000 trap jars were hung in various areas. In this case the infestation of summer fruit at Rehovot was investigated. It became evident that with summer fruits this method was not successful, for the summer fruits became totally infested. However, the success with the citrus fruit stimulated the extension of this method to other areas on a larger scale.

If the further experiments will sbustantiate those described above, the difficulties of spraying over inhabited areas will be overcome, and a reduction of the number of bait applications may be attained. (Cohen et al. 1965).

Rearing Mediterranean Fruit Flies in Israel

The method described herewith is taken from Nadel (1965) with slight changes as per verbal communication with him.

Oviposition. A system of mass rearing of the Mediterranean fruit fly was copied from the fruit fly laboratories in Hawaii. Small changes were made whereby one laboratory technician can produce one million pupae per week with a weekly work load of 6 to 8 hours when laboratory conditions are kept at a temperature of 25°C and a relative humidity of 60%.

The oviposition cage is a rectangular plastic box (35x19x20 cm), closed by a removable nylon-screened frame. One face of the box is cut out and a fine-mesh silk cloth is heat-sealed into the opening. The cage is placed in the silk screen facing a light source and the female flies oviposit through it, most of the eggs falling to a receptacle containing water. Each cage is set up with about 3000 pupae, a water source and about 90 g of food consisting of 3 parts sucrose to 1 part of Fleischmann's Type M yeast mixed together. After loading, the cage is closed by clamping the nylon-screened frame in place. The cage remains closed through the entire oviposition period. For convenience, units of five cages on a single wooden frame are optimal. All the eggs produced by the unit are collected in a single receptacle. The position of the cages on the frame is staggered so that the top cage extends forward on the frame and each succeeding cage is slightly inset so that all the eggs have a free line of fall to the receptacle. Each unit is used for a period of two weeks at which time the survivors are discarded. It is convenient and economical to work on a surplus egg system allowing at least two eggs for each pupa finally required. In a continuous production schedule of one million pupae per week, the output of six producing units (thirty cages) of ovipositing flies is required. On the average, each unit produces approximately 50, 000 eggs per day. Collection and volumetric estimation of the number of eggs of all the producing units require about ten minutes per day for the 300, 000 eggs.

More recently improvements upon this method were developed, whereby several million of pupae can be produced per week with the same amount of labour and the same conditions. Instead of units of five small cages, one large cage which can be set up with 25, 000 pupae is employed. The cage is 50 cm high, 22 cm wide and 210 cm long. One wall is of silk as described above through which the flies oviposit. Three such cages are set one over the other and several receptacles containing water receive the eggs which drop from the three cages. Eggs are collected from each cage.

Larval medium. The chief improvement in rearing is, however, the development of a larval medium in which inexpensive and readily available wheat bran replaces the carrot powder allowing the production of one million pupae at a cost in larval food of less than $5.

Larval medium is prepared weekly. The medium is held in a cold room at 5°C until required. The expected return per 2326 g portion is 30, 000 or more pupae from approximately 50, 000 eggs. The medium formula is given below.

Constituent	Quantity (g)
(1) Water	1200
(2) Nipagin (the control of contaminating microorganisms is affected)(Merck)	3. 0
(3) Nipasol (Merck)	3. 0
(4) Sucrose	300. 0
(5) Brewer's yeast, dry	200. 0
(6) HCl, 1N 23%	20. 0
(7) Wheat bran, small grains	600. 0
Total:	2326. 0

The best results are obtained by heating the water to boiling point, then adding the preservatives Nipagin (methyl p-hydroxybenzoate) and Nipasol (propyl p-hydroxybenzoate) and heating until these ingredients are completely dissolved. This solution is transferred to a large capacity mixer and the sugar and dry brewer's yeast added. Next, approximately 20 ml of 1 N HCl is added and finally the wheat bran. After mixing, the pH of the medium should range between 4.3 and 4.5, but sometimes further adjustment with HCl may be necessary. According to the particle size of the bran, an adjustment in the amount of water may prove advisable. The diet mixture, loose but not flowing, is then transferred to plastic refrigerator boxes (30x25x7.5 cm) to a depth of about 2.5 cm. The boxes are immediately covered with a glass plate.

Egg collection. Eggs are collected daily and their numbers estimated volumetrically: 20, 000 = 1 ml. Approximately 250, 000 eggs are segregared and placed in a common table salt shaker with a small amount of water to act as a carrier. The appropriate number of larval food portions are placed side by side on a work bench and the eggs are shaken evenly over the entire surface area of the portions, resulting in a distribution of approximately 50, 000 eggs per portion. The boxes are again covered with glass plates to ensure maintenance of maximum humidity and then placed on open-bottom holding racks where they remain until one day before pupation. Control of the humidity and temperature of the medium by adjustment of the glass plate is essential. For the first three days the plate covers the box entirely, resulting in a high humidity bath for the eggs and newly-hatched larvae. From the fourth to the seventh day, it is necessary to progressively open the box so that only a few if any larvae are visible on the surface of the medium. If a box inadvertently remains closed, the temperature rises and the medium becomes unsuitable. Proper adjustment of this simple temperature-humidity control devise is the key to successful production. On the seventh day the glass plates are removed and a thick crust is allowed to form on the surface of the medium. On the eighth day the crusts are removed and the moist, larva-filled media are transferred to a plastic strainer on an emergence stand. The stand, of sheet metal or wood, is simply a series of chutes set at an angle, each chute capable of holding a number of strainers loosely covered to insure against drying and unwanted pupation in the medium. The emerging larvae fall from the plastic strainers to the chute and make their way to a collection box set at the bottom. The portions are held in the chutes for a maximum of four days after which they are discarded. Maximum larval emergence takes place on the tenth day. The pupal collection boxes containing fine sand to discourage larval movement and permit quicker pupation are changed twice daily. Following complete pupation of one day's collection, the sand is sifted off and the pupae are measured - 50, 000 pupae per litre. The pupae are then transferred to screen-bottomed holding boxes.

Laboratories initiating or conducting rearing research should be particularly aware that humidity plays a significant role in successful larval rearing. Also mould formation can be elimiated by replacing sodium benzoate with Nipagin or Nipaso; moreover, additional benefits can be derived. It was noted that upon change of these materials, Drosophila larvae could not compete successfully in the two litres of medium containing approximately 30, 000 Ceratitis larvae.

Insecticide contamination of the wheat bran can also be a serious problem, but if one purchases a bran that is slightly infested with grain beetles, this hazard is elimiated.

The situation in 1966-67

As far as citrus is concerned, the Mediterranean fruit fly is well under control by the aerial and some ground applications with yeast hydrolizate bait.

Early in the fifties, tests with various brands of yeast hydrolizate were carried out by Rivnay against the Mediterranean fruit fly in the citrus groves. Although the method proved to be effective, complete control of the fly was not attained in the experimental plots because of the constant influx of flies from the surrounding, untreated groves. The conclusion arrived at was that unless all the groves were treated periodically and simultaneously, no complete control of the pest would be achieved.

This could not have been accomplished or would not have been effective had it been left to each individual grove owner to do it for himself. It was imperative that this enterprise should be centralized and executed for the farmers by an authoritative body. It was thus convenient and feasible that the agrotechnical division of the Citrus Marketing Board, under the management of L. Cohen, took this task upon themselves.

Again,, as per the practice suggested by Steiner of Hawaii, (Steiner 1952, 1955), initial blanket applications were carried out in the groves, while follow-up applications were decided upon by the indication of infested fruit. Naturally the groves were under constant inspection. Later on, a net of traps was laid in the citrus groves. The most effective male attractant "trimedlure" was used. Thus application was made only where concentrations of flies were indicated by the traps. The trap recommended by Steiner (1957) was employed, and later some improvements were incorporated in it.

In such an enterprise, naturally errors and mistakes were unavoidable. At the beginning, intervals between applications were about three weeks. It soon became evident that these should be shortened if a better control of the fly is desired.

There was also much groping as to which hydrolizate should be employed and which insecticide should be added. After many tests in the citrus groves of Israel Nasiman 73* was adopted as the protein hydrolizate bait against the fruit fly in Israel.

For ground, the following mixture is used:

* Produce of Tamogan Ltd. - Tel-Aviv.

220 grams Nasiman 73
200 grams Malathion 25% w. p.
Water to make 5-10 litres of spray.

Aerial material consists of:

220 grams Nasiman 73.
100 grams Malathion 50% e. c.
665 grams of water.

Other errors and mistakes were corrected and many difficulties were overcome.

The result of this large scale enterprise may be summed up as follows:

Such seasonal treatments bring the population of flies in the citrus groves to a low level and no other treatments against the fly are necessary. In fact no cover sprays in the citrus groves are carried out; also the specific treatment in the packing house, fumigation or dipping with bromide compounds, became superfluous. The fruit comes from the groves free from maggots, no wormy fruit is shipped to the foreign markets, no repacking is necessary and no fruit is barred because of infestation with the pest.

Although the population of the fly at the end of the citrus season is much reduced, the warm summer and the continuity of host fruit enable it to build up the population anew. It was felt that unless drastic measures were taken, the citrus treatments will remain always unjustifiably high. The citrus groves are populated with the flies throughout the summer Rivnay (1953). In view of this, summer applications were initiated in the citrus groves in 1963. As a result the average number of applications dropped from an average of over four to an average of less than three per dunam.

However, rosy as it looks, the fruit fly problem in Israel is not entirely solved.

The cultivated summer fruit orchards are not treated against the fly as are the citrus groves. Each owner carries out his own control measures - as a rule by cover sprays. This fact, and the climatic conditions which are more favourable for the fly than in the winter, make it possible for the fly to build up its population. There are also many fruit bearing trees in the country which are not treated. There are small home gardens which may contain one peach, or apricot or one guava tree not always taken care of. In addition, there are a number of the so-called wild trees; fig trees and cactus hedges are still a part of the Israeli landscape and flies develop in such fruits; and finally, the farmers in the neighbouring countries do not treat their fruit trees, and in many places their orchards are in the neighbourhood of Israeli fruit trees, thus there is surely an influx of flies from beyond the frontiers of the country.

The result of this is that small as the fly population at the end of the winter may be, under these combined favourable factors the population is built up anew.

The Olive Fly - Dacus oleae Gmel.

The olive fly is a monophagous pest of primary importance attacking only olives of various species and varieties.

The injury consists of ovipositing in the olive fruit in which the larva develops and then pupates. It is quite unpleasant for the consumer to bite into a pickled olive and discover in it a maggot, or find the contents had been emptied before the pickling.

In the oviposition holes and cavities fungi develop which affect the quality of the oil pressed from the infected fruit.

In Israël the European varieties are attacked to a greater extent (about 60% in the autumn) than the local varieties, (about 30% only). When olives are allowed to mature and darken, the percentage of infested fruit increases, and a lot of fruit drop before harvest.

Various attempts have been made to control the fly, and some studies are still pursued in some Mediterranean countries. Among others, efforts are being made to develop biological control and sterile male technique. For this purpose efforts have been exerted simultaneously in Greece and Israel to develop a method for artificial cultures of the maggots. The method developed in Israel (Moore 1962) is given below.

A survey of parasites showed that in Israel two parasites attack the maggots in the fruit. These are Opius concolor Szepl. and Dinarmus virescens Masi, which are active mainly during the summer.

Technique for artificial breeding of the Olive fly

Materials and Methods

Wild flies were used for producing the eggs needed to raise the first artificially-bred generation. These flies, and those bred on the media, were kept at room temperature and relative humidity in one-pint, muslin-covered jars containing a single glass slab (12.0 x 2.5 cm) onto which the food mixture was atomized; tap water absorbed on cotton wool in small plastic containers was also included. The wild flies were kept in small groups and those artificially bred, in pairs. The adult diet was a mixture of one part yeast hydrolysate a), one part Brewer's yeast a), four parts sucrose and five parts water. The oviposition substrate was a paraffin hemisphere sealed directly into the food slab.

The composition of the medium for artificial culturing is given below:

Composition of medium

"Vitamin free" casein (a)	3. 8 g
Brewer's yeast (a)	5. 6 g
Powdered cellulose	5. 0 g
Agar agar	3. 0 g
Salt mixture, W (a)	2. 8 g
Sucrose	4. 0 g

Beta sitosterol (b) emulsion. 20. 0 ml (0. 18 g sitosterol + 0. 16 ml Tween 40).
Choline chloride solution 0. 25 ml (0. 084 g choline chloride)
Distilled water q. s. 120 ml. 99. 75 ml.

The sitosterol stock emulsion was prepared by dissolving the sterol in boiling ethanol (95%), transferring this to the Tween 40/water solution, evaporating the alcohol in an autoclave with the valve kept open and adding water up to the appropriate volume.

Collective breeding was carried out in Erlenmeyer flasks (100 ml) with batches of eggs; individual culturing was conducted in test tubes (15. 0 x 1. 5 cm) with single neonate larvae. In the former case, the medium was sterilized directly by autoclaving at 15 p. s. i. for 20 minutes; in the latter, the pressure was first allowed to reach 5 p. s. i to dissolve the agar, the medium dispenses at about 5 ml per tube and the tubes sterilized as above.

Eggs collected daily from the oviposition substrates were surface-sterilized with mercuric chloride (1/1000) and transferred with a pipette connected to a syringe (6). However, for individual culturing, the eggs were first injected aseptically into sterile Petri dishes containing filter paper, and incubated at $27^{o} \pm 1$ for 24-48 hr. The neonate larvae were then aseptically transferred with a small platinum loop, one to each test tube of medium (2).

Inoculated media were kept in an incubator at $27^{o} \pm 1$ and about 90% R. H. ; they were examined daily and contaminated material was discarded.

The situation in 1966-67

The efforts toward biological control of the fly described above are long-term plans. In the meantime, in order to prevent damage as described, measures must be taken. Actually the control practices were cover spray treatments with organophosphorous insecticides. This method did not yield always satisfactory results. The use of these insecticides are curtailed by health considerations since they are applied when fruit matures and when the fly is most active. Furthermore, this method disturbed the natural balance as has been evidenced by outbreaks of scale insects in treated groves.

(a) Nutrional Biochemicals Co., 21010 Miles Avenue, Cleveland 28, Ohio, U. S. A.

(b) L. Light and Co. Ltd., Colinbrook, Bucks, England.

In view of this, D. Nadel et al (1966), carried out control tests wherein a protein hydrolyzate was employed as an attractant and malathion as the insecticide. The hydrolyzate was Zitan 85 and was used at the rate of 220 ml per dunam with 55 ml of a. i. of malathion. This latter was used as a 25% wettable powder in 3 liters of water for ground spot treatments, and as a 50% emulsifiable concentrate in one liter of water for areal applications.

Four applications were made at weekly intervals during June early July, and four in August-September, at 7-12 days intervals.

Satisfactory control of the fly was thereby obtained.

LEPIDOPTERA

Spodoptera littoralis Boisd.

Spodoptera littoralis spread into Israel late in the last or early in this century. It was first mentioned in Egypt in 1880 (Bishara et al. 1940). Judging from the rate of its spread along the Eastern Mediterranian shores, one may surmise that it took about two decades before it became well established in Israel. During the first three decades of the century, the pest was of no great importance. It assumed a prominent role when new crops were introduced, thereby establishing a continuous large-scale supply of food throughout the period when caterpillars may be active. Today severe attacks of this pest may entirely destroy the cotton bolls. In addition, this pest may reduce tomato yields by boring into the fruit and destroy other vegetables. In recent years it became a serious pest to apple orchards as well as vineyards.

The situation of the pest becomes more grave when mild, comparatively arid winters precede the summer, as happened during 1959-1963, when the densities of the Spodoptera populations were very serious. The gravity of the pest became accentuated when the insect became hard to kill. Although young larvae could be killed with many insecticides, older larvae were not killed except with high dosages of parathion. The insect is now considered as the arch-enemy of summer field crops in Israel and no wonder the entomologists concerned began to look for other means to control the pest.

Integrated control against Spodoptera littoralis

a. In cotton fields.

Farmers and agricultural officers noticed that larvae of Spodoptera littoralis were often devoured by predators. Other larvae bore dipterous eggs, probably Eutachina larvarum L. Fields in which insecticidal applications were not made were claimed to be less infested by S. littoralis than those treated with chemicals. This was attributed to the adverse effects of insecticides on beneficial insects.

A preliminary survey of beneficial insects in cotton fields was conducted by Vermes in 1961. About ten predators, excluding spiders, were recorded, and