most important was C. lycimnia, as speciments from the survey have been recently identified by Rosen as such. In the more recent survey Rosen (1964) also found this parasite dominant in crowded colonies of C. hesperidum, and it seems the ants do not frighten it away.

Notes on Scutellista cyanea Motsch.

This external parasite was always common in the two Ceroplastes species and in the two Saissetia species. It ranks second among the parasites and is feeding on the eggs of the host. As a rule some eggs are left after the parasite has completed its development, so that its value in regulating its host populations is thereby reduced.

APHIDIDAE

Before discussing the aspects of biological control and natural balance of Aphids in Israel, a summarizing description should be given of the ecology of this group and the trend of its population fluctuations.

It was pointed out (Bodenheimer 1940, Harpaz 1953, Swirski 1951) that this group is active in Israel mainly during the late winter and early spring, and not in the summer as is the case in more northern countries.

While in colder regions sexual forms appear at the end of the summer, the eggs of which hibernate and carry the species over the cold winter, in Israel as in other subtropical countries, parthenogenetic reproduction may take place in many species throughout the year.

As a rule, a sharp decline in the population of Aphids takes place at the end of the spring. This sharp decline was attributed to the direct effects of temperature and humidity (Bodenheimer 1940). However, a thorough analysis of the situation was made by Harpaz (1953), who while not minimizing the direct influence of the climate, attributed importance to the food factor which in turn is influenced by the climate. His analysis is as follows: He recalled the findings of previous writers, that the feeding of Aphids is a chain of processes involving osmosis of the cell sap into the intercellular spaces where the stylets of the Aphid are located. This osmosis is made possible due to differences in osmotic pressure between cell sap and the salivar secretion of the insect. But Harpaz points out that the osmotic pressure of the cell content may change. Quoting plant physiologists who point out that high temperature and low humidity cause the loss of water and thereby increase the osmotic pressure of the plant sap, he thinks that it may exceed that of the insect secretion and thereby prevent osmosis to the intercellular spaces. In other words, the sap although plentiful, becomes unavailable for the insect. The above mentioned factors also explain why insects often prefer young leaves, the osmotic pressure of the sap in such leaf sap being lower than that in older leaves. In hot dry weather the microclimate in which the Aphid is found changes too. The closing of the stomata cause less transpiration and reduce thus the humidity of the environment which is unfavourable for the Aphid. In high summer, some Aphids are located in closely hidden sites such as whirls of corn or sorghum, where the humidity is higher, because that air space is less influenced by the wind.

As will be enumerated below, there are many predators and parasites associated with Aphids. Unlike with their hosts, the fluctuations in their populations are directly influenced by the climatic factors. This may account for the reason that there is little correlation between their peak and that of the Aphids, their hosts. The peak of the parasites occurs when the host population had been on the decline for some time. Time and again entomologists stress the fact that the reduction of the Aphids preceeds that of their parasites and was not caused by them.

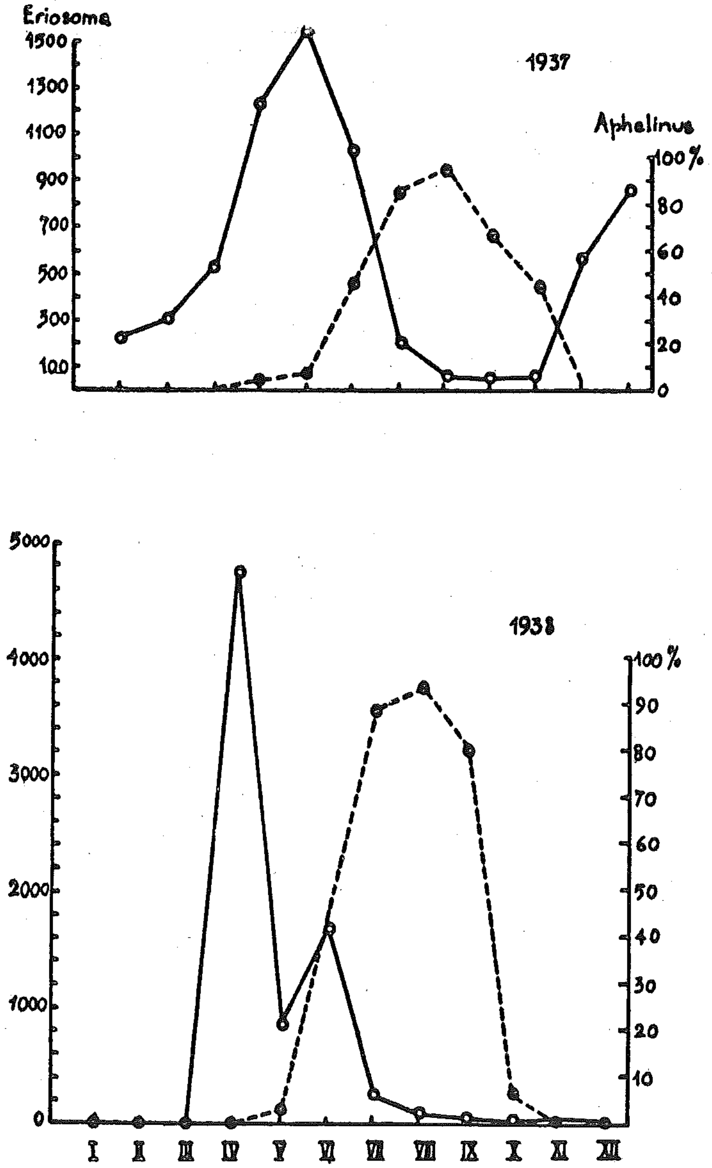
Eriosoma lanigerum Hsm.

After the successful establishment of Aphelinus mali against the Wooly Aphis Eriosoma lanigerum Housm., in various apple growing countries, - New Zealand, Australia, England, etc., it was introduced into Israel by Ballard, Government entomologist, in 1934, and was reared and liberated by Gruenberg; no records are available of these releases (Gruenberg: verbal communication). Later Bodenheimer (1947) decided to study its potentialities in Israel, where its host had become established and was doing damage especially in the hilly region.

Specimens were obtained through the courtesy of the Ministry of Agriculture of Egypt in 1935, and after breeding it in the laboratory, specimens were released at Kiryat Anavim early in 1937 (Bodenheimer 1947). Counts on three trees at Kiryat Anavim showed that the peak in the population of the host occurred in 1937, in May, that of the parasite (based on the percentage of host individuals with exit holes of the parasite) occurred in August. In 1938, the host peak occurred in April, and that of the parasite in July-August. In other words, there was a lagging of from 3-4 months between the peak of the parasite and that of the host. The first appearance of the parasitized individuals in both years occurred when the host population was at its climax.

Bodenheimer concluded, therefore, that A. mali was not able to prevent a spring outbreak of E. lanigerum; climatic factors prevented such outbreaks. The parasite caused a reduction in the number of its host entering hibernation, but was not responsible for the sharp decline in the population of the host in the early summer. As a further support to this conclusion the population trends of E. lanigerum and its parasite at Ataroth in 1938 are mentioned. In this case the parasite population (having been introduced late in May, began to rise when the host population had come down in August-September.

Fig. 13 - Fluctuations of Eriosoma populations and the seasonal trend of the percentage of parasitization by Aphelinus mali (broken line) at Kiryat Anavim.



Coccinellidae

Harpaz (1953) compiled a list of the species of Coccinellidae associated with Aphids.

LIST 8 - Coccinellidae associated with Aphids - after Harpaz (1953)

Bulaea lichatschovi Humm.	Platynaspis luteorubra Goeze
Chilocorus bipustulatus L.	Scymnus apetzi Muls. var. quadriguttatus Muell.
Coccinella conglobata L.	Scymnus frontalis F.
Coccinella septempunctata L	Scymnus levaillanti Muls. f. vaulogeri Sic.
Coccinella undecimpunctata L.	Scymnus (Exochomus) quadrimaculatus Hbst.
Exochomus flavipes Thunbg.	Scymnus (Pullus) subvillosus Goeze
Exochomus quadripustulatus L.	Scymnus syriacus Mars.
Nephus bipunctatus Kugel	Vibidia bisoctonotata Woll.

Biology of Coccinella 7-punctata L.

The biology and ecology of C. 7-punctata in the Near East was studied by Bodenheimer & Klein (1937) and Bodenheimer (1943). The following were the findings;

The threshold of development was 12.8°C, and the thermal constant from the egg to the first egg laid, 197 days degrees C. The length of the total development at 25°C was 24 days, at 24°C 41 at 15°C 135 days. 16-20°C, and 60-85% R. H. seemed to be the most favourable conditions for the insect.

The total mortality from egg to adult was 70% at 15-17°C (70-75% R. H.) and 90% at 17-24°C (70-80% R. H.).

The lowest mortality of the eggs, 30-50%, occurred in the autumn at 19-22°C, while in the winter and early spring it was 76-87%, the temperature being 13-19°C. The highest mortality of the eggs, 97%, occurred in the summer when the average temperature was 25°C.

The lowest mortality of larvae, 33-40%, occurred in the spring at 17-19°C, and the highest in the cold wet winter at 13-16°C. The lowest mortality of the pupae, 13%, occurred in the spring, and the highest, 60%, occurred in the summer at 25°C.

Dry desert winds, when high temperatures and low relative humidities prevail, have a devastating effect on all stages of the beetle, similarly detrimental are the temperatures below 13°C.

The preoviposition period is shortest, 15 days, at 16-24°C and longest, 80 days, at 12-14°C.

The preoviposition period is shortest, 15 days, at 16-24°C and longest, 80 days, at 12-14°C.

The average number of eggs laid was 352, (60-650). At a temperature below 14°C the activity of the beetle was greatly reduced, and in the field it was active only on sunny days.

Coccinella 7-punctata is distributed in many countries of diverse climates, and its diapause is regulated accordingly (Hagen 1962). In accord with the temperatures prevailing in each country, the insect may be univoltine, bivoltine or multivoltine. In Northern Europe it is univoltine. Adults are active in the spring and summer, while immature stages occur during the summer only. The new generation bettles do not reproduce that summer, but hibernate. In India, the climate being favourable, the beetle develops uninterruptedly throughout the year. In Turkey there is also one generation, the insect spending a long aestivohibernating diapause there. In the Ukraine two generations develop, the offspring of the second enter a hibernating diapause. In Israel also, there are two generations, but with an aestivating diapause; it was described by Bodenheimer (1943) as follows: adults appear in March, and reproduce during March and April. Their offspring, the second generation, mature in May. Most of these do not reproduce immediately, but go through a period of diapause of the reproductive organs, and oviposit about 4 months later in September. The offspring of these do not reproduce because of the low winter temperature; they begin to reproduce towards March.

In both generations a small percentage of the beetles continue to reproduce without going through a rest period. Their offspring, however, die off before reproducing, in the summer because of the high, and in the winter because of the low temperatures. Thus there are two sterile side lines which have no bearing upon the existence of the species.

Biology of Coccinella undecimpunctata L.

The bionomics of Coccinella undecimpunctata were studied by I. Harpaz (1958). Although the beetle can be seen in Israel throughout the year, its reproduction is limited to the late spring, May-June, and autumn, September - November. The first observed spring egg laying was on 26. IV, the last on 29. VI. The first observed autumn egg laying was on 29. VIII, the last on 17. XI. The average temperature in both these periods is about 22-23°C, at which temperature the development took about 23 days (see Table 11).

Table 11 - Development of C. 11-punctata at 23°C (after Harpaz, 1958),

	Incubation period	Larval period	Pupal period	Total development
Average	3.4	14.5	5.3	23.5
min. /max.	(2/6)	(11/18)	4/7	17/28

Due to summer and winter gaps in reproduction, the beetle raises only about 2-3 generations. The bridging over the sixty-day summer gap - between the last of the spring eggs and the first autumn oviposition is made possible by the length of the development period and longevity of adult. The overbridging of the winter gap is made possible by retarded development. During the development, the larva consumes 200 medium size second stage aphids, while the adults devours 800 aphids.

In view of its characteristics Harpaz comes to the following conclusions:

The small number of generations (three at the most), as compared with 20 or more generations in most aphid species in the area, the limited predatory capacity, as compared with, for instance, C. septempunctata L. of which every individual can destroy 4600 aphids, and the extremely cannibalistic habits of the larvae, all lead to the conclusion that this predator is of no significant value in restraining the build-up of aphid populations to damaging levels. Moreover, reproduction in the spring begins at a time when the large aphid populations are already breaking down due to other primary factors, and after most of the economic damage has already been done (Harpaz 1953).

Notes on Exochomus flavipes Thunb.

According to Bodenheimer & Neumark (1955), this beetle did not develop in the hills of Samaria during the winter. Adults survived the cold season, but oviposition was interrupted from December to the middle of March. Thus only six generations developed annually. The first, starting at the end of March, developed within 44 days; the last generation which started in November, developed in 55 days. The summer generations of July-August developed in 26 days. As a rule, the preoviposition period was 6-10 days, and on the average a female laid about 100 eggs.

The main food of E. flavipes on Pinus is Cinara palestinensis HRL. One larva consumed 5000-6000 aphids in the course of its development.

Ex. flavipes was attacked by Homalotylus quaylei Timb; by July 80-90% of its larvae were parasitized by this Encyrtid. The peak of parasitization occurs between the two peaks in the Ex. flavipes population which occur in May-June and October-November (Bodenheimer & Neumark 1955).

Notes on Adalia decempunctata L.

The development of A. 10-punctata at 25°C was 24 days, at 20°C,-36 and at 15°C 24 days. The threshold of development was set at 9.1 and the thermal constant from egg to the first egg was 390 days degrees C. The insect thus raised eleven generations in the hills of Samaria.

The winter generation developed within 50 days, whereas the summer generations within 16-21 days.

In the winter an adult lived about 120 days and laid about 300 eggs; in the late spring an adult lived over 90 days and laid on the average of 700-800 eggs. The preoviposition period was 14 days in the winter and 6 in the spring.

Egg mortality was high, especially in the autumn when it reached even 91%.

The beetles reaches the peak of the population density twice, in April-May and in November-December (Bodenheimer & Neumark 1955).

Notes on Synharmonia conglobata L.

At Ein Hashophet the development from egg to egg was complete at 25^{o}C within 24 days, at 20^{o}C in 42 days and at 15^{o}C within 124 days. The threshold of development was set at 12.4^{o}C and the thermal constant at 323 day degrees C. The beetle thus raised 10 generations there. The winter generations developed within 60 days, and the summer generation within 15-20 days each.

This beetle is active throughout the year but in the winter months the activity as well as reproduction are greatly reduced, but not interrupted.

During the summer, adults lived about 100 days, in the autumn, they lived longer, some females even lived nearly 200 days and more.

A female of the spring generation laid on the average of over 600 eggs, during the summer not more than 200-300 eggs were laid on the average by one female.

The main food of S. conglobata is Cinara palestinensis. An adult beetle devoured six adults and several larvae per day. The scale insect Matsucoccus josephi Boden and Harp, may serve as food when offered.

In the summer the mortality was low, about 15%, but in the autumn 45% of the eggs died, and in January about 91% of the eggs failed to hatch.

Biology of Chrysopa carnea St.

The biology of C. carnea was studied by Neumark (1952). From breedings at Ein-Hashophet, in the Samaria Hills, the duration of the development from egg to egg was 25^{o}C - 33 days, at 20^{o}C - 48 days and at 15^{o}C - 89 days. The threshold of development was set at 9.2^{o}C and the thermal constant for the period from egg to egg was 518 day degrees.

The spring generation, beginning in March lasted 50 days, the summer generations 22-26 days each, and the winter generations 72-89 days.

Adults lived over 100 days in the summer and over 250 days during the autumn-winter.

Copulation, which took place at night, had to be repeated frequently, otherwise oviposition ceased. Sugar or honey-fed individuals lived longer than others but laid on the average of not more than 70 eggs per female.

When crushed aphids or yeast hydrolyzate were added to the diet, about 600 eggs were produced. In the general breedings the average number of eggs was 210 eggs (88-330).

The temperature above 27°C proved to be detrimental to this Chrysopa. 10% of the egg, 8% of the larvae and 33% of the pupae died at these temperatures. The temperature above 28°C caused the prolongation of the preoviposition period and the reduction in the number of eggs. The threshold of reproduction seems to be at 9°C,

One of the drawbacks of this predator are its parasites. Six primary parasites were reared, and the total parasitization reached 30% in May and 70% in August. The most active of these parasites is Gelis. aff. areator Pzr. which may parasitize 38% of the Chrysopa population. Perilampus sp. follows with 19.5%; other important parasites were Helorus sp. and Tetrastichus sp.

LIST 9. Parasites of Chrysopa

Gelis aff. areator Pzr. This Ichneumonid is a parasite of Chrysopa feeding on Matsucoccus. Its development at 25°C lasted 120 days. From cocoons collected during the winter, parasites emerged in May-June. Thus two generations probably exist annually. Adults lived over a month.

Helorus sp. This species is a parasite on the first stage larva of Ch. carnea. In the summer it developed within 26 days, and adults lived about 20 days.

Perilampus sp. This insect is a predator on the pupa of Chrysopa living within the cocoon of the host. In the summer it completed development within 18-20 days and the adult lived 50 days.

Eupelmus sp. Apparently this Eupelmus is a hyperparasite on the hymenoptera parasitizing Chrysopa. The adult lived 4-10 days.

Tetrastichus aff. claviger. This Eulophid parasitized all stages of Chrysopa larvae. Several individuals emerged from one cocoon. Adults lived as long as 60 days, and nine generations were bred in succession in a year.

Syrphidae

A survey of Syrphidae was made by Harpaz (1953). He lists about 21 aphid feeding species of Syrphidae which he reared from aphid colonies or collected from flowers in the field.

The highest number of species and as well specimens was found during the period February-March, the lowest in October-December.

Six species were most common: Epistrophe balteata de G., abundant from January to April; Melanostoma mellinum L., occurring from February to May; Sphaerophoria scripta L., occuring from February to July; Syrphus corollae F., from January to May with the peak in March-April. The two other species were less limited and may be found throughout the year.

Ischidon aegyptius Wied. was found mostly in June and September, but contrary to others not in February-March. Paragus tibialis Fall was found mainly in May and November.

At 16°C P. tibialis may develop within 83 days (egg-10, larva 37, and pupa 36) at 26°C within 18 days (egg-3, larva 8 and pupa 7).

Some species of Syrphidae are attacked by Diplazon laetatorium F. Parasitization may be as high as 20%. The species attacked are E. balteata and P. tibialis during the winter and spring, and I. aegyptium in the summer. Other parasites of Syrphidae found by Harpaz were: Zootrephus aff. bizonarius (Grav.), very rare, and Catlaspidia aff. provancheri Ashm., both from I. aegyptium and Lonchidia sp. - also very rare.

As to the importance of Syrphidae in affecting the population of aphids, Harpaz comes to the conclusion that their importance is negligible.

Notes on Leucopis puncticornis Meig.

The predator occurs in Israel throughout the year, but two peaks in the population are distinct, one in May and the other in October-November. These peaks are in coordination with the trend of the populations of many aphids. As a rule, the peaks of the predator lag somewhat, in particular in the spring, when it occurs after the aphid population has been on the decline for some time.

The low level of the population of the predator in winter is due to retardation in its development and reproduction, that of the summer population is due to diapause. It was observed that a great proportion of the pupae during the latter part of May aestivate and adults emerge in October, only a small part of the pupae of that period emerge at the end of May (Harpaz 1953).

Of common occurrence in aphid colonies of various kinds is the gall midge Phaenobremia aphidimyza Rond. (Swirski 1951, Plaut 1949, Harpaz 1953).

In the trend of its population in the coastal plain of Israel, two peaks are recognizable, one in May, the other in October-November. No midges are to be found in the summer (Harpaz 1953).

The species is attacked by a Eulophid- Aprostocetus cirsii Kurdj.

Hymenoptera

The following is a list of aphid parasites and their respective hosts reared in Israel by various writers. The references are indicated as follows: (B & N) = Bodenheimer and Neumark 1955; (H) = Harpaz 1953; (P) = Plaut 1949; (R) = Rosen 1964; (S) = Swirski 1951.

LIST 10. Parasites of Aphids.

Parasite	Host
Braconidae	
Diaeretus rapae Curt	Schizaphis graminum Rond (H)
Diaeretus ervi Hal.	Acyrthosiphon pisum Harris (H)
Aphidius sonchi Marsh	Hyalopterus pruni Geoff (H)
Aphidius varius Nees	Cinara palestinensis H.R.L. (B & N)
Aphidius matricariae Haliday	Myzuz persicae Sulzer (R)
Trioxys angelicae mediterraneus Mack	Toxoptera aurantii Boyer (R)
Ephedrus pulchellus Stel.	Brachycaudus amygdalinus Schout. (P)
Ephedrus nitidus Gahan	Toxoptera aurantii Boyer (R)
Ephedrus spp.	various aphids (H)
Praon volucre Haliday	Myzus persicae Sulzer (R)
Praon spp.	various aphids (H)
Lysiphlebus ambiguus Halid	Toxoptera aurantii Boyer (R)
Lysiphlebus fabarum Marsh	Toxoptera aurantii Boyer (R)
Lysiphlebus plantensis Brethes	Toxoptera aurantii Boyer (R)
Lysiphlebus sp.	Rhopalosiphum padi L. (H)
Chalcidoidea - Eulophidae	
Aphelinus mali Haliday	Eriosoma lanigerum Hsm. (Bod. 47)
	Toxoptera aurantii Boyer (R)
Aphelinus maidis	Rhopalosiphum maidis Fitch (H)
Aphelinus flavipes Forst	Toxoptera aurantii Boyer (R)
Tetrastichus spp.	Rhopalosiphym padi L. (H).

Parasite	Host
Encyrtidae	
Aphidencyrtus aphidivorus (Mayr)	Brachycaudus amygdalinus Schout (P)
	Toxoptera aurantii Boyer (R)
	Macrosiphum fragariae (Walk) (H)
	Macrosiphum avenae F (H)
	Rhopalosipum padi L. (H)
Pachyneuron siphonophorae Ashm.	Primary and secondary parasite.
	On Diaeretus rapae Curt (H)
	In Macrosiphum fragariae (Walk)
	Brachycaudus amygdalinus Schout. (P)
	Hyalopterus pruni Geoff. (H)
	Macrosiphum fragariae (Walk) (H)
	Toxoptera aurantii Boyer (R)
Pachyneuron minutissimum (Foerst.)	Toxoptera aurantii Boyer (R)
Pachyneuron aphidis Brachy	Brachycaudus amygdalinus Schout. (P)
Pachyneuron sp.	on various aphids
Asaphes vulgaris Wlk.	Brachycaudus amygdalinus Schout. (P)
	Toxoptera aurantii Boyer (R)
	On Aphidius varius Nees, in Cinara
	palestinensis HRL (B & H)
Cynipidae-Charipinae	Rhopalosiphum padi L (H) on Aphydius sp.
Alloxysta campyla Kieffer	Macrosiphum fragariae Walk
Alloxysta sp.	Toxoptera aurantii Boyer (R)
Charips spp.	On Aphelinus maidis Timb.
	in Macrosiphum sp. (H)
	Sitobium avenae F (H)
Proctotrupoidea Ceraphronidae	
Lygocerus sp.	On Praon sp. in Schizaphis graminum Rond
	Rhopalosiphum padi L. and
	Macrosiphum fragariae Wlk (H)

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