

Israel Journal of Entomology Vol. IV, 1969.

THE PARASITES OF COCCIDS, APHIDS AND ALEYRODIDS ON CITRUS IN ISRAEL:
SOME ZOOGEOGRAPHICAL CONSIDERATIONS

by

David Rosen¹

The Hebrew University, Faculty of Agriculture
Rehovot, Israel

ABSTRACT

Although citrus has been present in Israel since ancient times, and is now the most important crop of Israel, the fauna of citrus in this country is composed almost exclusively of foreign species. Of 16 species of stemorrhynchous Homoptera infesting citrus, only 2 species are apparently indigenous to Israel. Likewise, of 42 species of parasitic Hymenoptera associated with this group of citrus pests, only 8 are of local origin. In both groups, the indigenous species are relatively rare. The changes which have taken place in the parasite fauna of citrus groves in Israel during the past 3 decades indicate that competitive displacement of indigenous species by better adapted invaders may have accounted for the present composition of the citrus fauna in Israel.

The genus Citrus, native to the Far East, has been present in Israel since ancient times. The citron, Citrus medica L., was introduced into this country at least 2,000 years ago, if not considerably earlier (see Tolkowsky, 1938; Isaac, 1959). Other species and varieties of citrus followed, until in the present century citrus has become the most important crop and main export of Israel, total grove area, having increased from 7,000 acres in 1922 to about 100,000 acres at the present (Burke, 1967). However, the local fauna has not adapted itself to this well-established, abundant host, and the fauna of citrus pests in Israel is composed almost exclusively of foreign or widely distributed species (see Bodenheimer, 1951). It is the purpose of the present paper to show that the same is true also for the parasite fauna associated with one of the major groups of citrus pests in Israel, and to suggest a possible explanation.

During the last decade, the parasites of citrus-infesting coccids, aphids, and aleyrodids were studied in a series of extensive surveys, covering the main citrus areas of Israel (Rosen, 1962, 1965b, 1966a, 1966b, 1967a, 1967b, 1967c; Gerson, 1964). Altogether, the populations of 16 species of stemorrhynchous Homoptera were regularly sampled on citrus in these surveys:

COCCOIDEA:

DIASPIDIDAE:

Aonidiella aurantii (Maskell)

Chrysomphalus aonidum (L.)

Lepidosaphes beckii (Newman)

Parlatoria cinerea Hadden Parlatoria

pergandii Comstock

	COCCIDAE:	<u>Ceroplastes floridensis</u> Comstock
		<u>Ceroplastes rusci</u> (L.)
		<u>Coccus hesperidum</u> L.
		<u>Saissetia oleae</u> (Bernard)
	PSEUDOCOCCIDAE:	<u>Planococcus citri</u> (Risso)
		<u>Pseudococcus citriculus</u> Green
	MARGARODIDAE:	<u>Icerya purchasi</u> Maskell
APHIDOIDEA:	APHIDIDAE:	<u>Aphis gossypii</u> Glover
		<u>Myzus persicae</u> (Sulzer)
		<u>Toxoptera aurantii</u> (Fonscolombe)
ALEYRODOIDEA:	ALEYRODIDAE:	<u>Acaudaleyrodes citri</u> (Priesner & Hosni)

Only two of these species are apparently indigenous to Israel or to the eastern Mediterranean Basin: the fig wax scale, Ceroplastes rusci, and the citrus black aleyroidid, Acaudaleyrodes citri. Both are rare on citrus, and are rather commonly associated with various indigenous plants: The fig wax scale is a pest of fig and sycamore, and the citrus black aleyroidid has been recorded from pomegranate and Zizyphus. All the other species are now very widely distributed. The 5 armored scale insects are of Oriental origin. Of the unarmored scale insects, the Florida wax scale, Ceroplastes floridensis, and the brown soft scale, Coccus hesperidum, are also of Oriental origin; the black scale, Saissetia oleae, originated in the Ethiopian region and the cottony cushion scale, Icerya purchasi, is of Australian origin. The mealybugs and aphids infesting citrus in Israel are virtually cosmopolitan and their origin cannot be ascertained.

Most of these species are polyphagous in Israel. Only four are restricted to citrus: the purple scale, Lepidosaphes beckii, the chaff scale, Parlatoria pergandii, the tropical grey chaff scale, Parlatoria cinerea, and the citriculus mealybug, Pseudococcus citriculus. Of these, the first three are known to attack additional hosts elsewhere.

The following species of Hymenoptera were recorded in the surveys as parasites or hyperparasites of sternorrhynchous Homoptera on citrus (hosts are listed in the order of their importance to each parasite):

<u>PARASITES</u>	<u>HOSTS</u>
CHALCIDOIDEA: APHELINIDAE	
<u>Aphelinus flavipes</u> (Förster) ²	<u>Toxoptera aurantii</u>
<u>Aphelinus mali</u> (Haldeman) ²	<u>Toxoptera aurantii</u>

2) Rare

<u>Aphytis chrysomphali</u> (Mercet)	<u>Aonidiella aurantii</u> , <u>Parlatoria pergandii</u> (?), <u>Chrysomphalus aonidum</u>
<u>Aphytis coheni</u> DeBach	<u>Aonidiella aurantii</u>
<u>Aphytis hispanicus</u> (Mercet)	<u>Parlatoria pergandii</u> , <u>Parlatoria cinerea</u>
<u>Aphytis holoxanthus</u> DeBach	<u>Chrysomphalus aonidum</u>
<u>Aphytis lepidosaphes</u> Compere	<u>Lepidosaphes beckii</u>
<u>Aphytis lingnanensis</u> Compere	<u>Aonidiella aurantii</u>
<u>Aphytis melinus</u> DeBach	<u>Aonidiella aurantii</u>
<u>Aphytis</u> spp. ²	<u>Aonidiella aurantii</u> , <u>Chrysomphalus aonidum</u> , <u>Parlatoria pergandii</u>
<u>Coccophagus bivittatus</u> Compere ²	<u>Coccus hesperidum</u>
<u>Coccophagus lycimnia</u> (Walker)	<u>Coccus hesperidum</u> , <u>Ceroplastes floridensis</u>
<u>Coccophagus scutellaris</u> (Dalman)	<u>Coccus hesperidum</u>
<u>Eretmocerus diversiciliatus</u> Silvestri	<u>Acaudaleyrodes citri</u>
<u>Marietta exitiosa</u> Compere ³	<u>Coccus hesperidum</u> , <u>Ceroplastes floridensis</u> , <u>Chrysomphalus aonidum</u> , <u>Aonidiella aurantii</u>
<u>Prospaltella inquirenda</u> Silvestri	<u>Parlatoria pergandii</u> , <u>Parlatoria cinerea</u>
<u>Prospaltella lutea</u> Masi	<u>Acaudaleyrodes citri</u>
<u>Prospaltella</u> sp. (♂♂) ³	<u>Coccus hesperidum</u> , <u>Chrysomphalus aonidum</u>
<u>Pteroptrix</u> (=Casca) <u>smithi</u> (Compere)	<u>Chrysomphalus aonidum</u>
CHALCIDOIDEA: ENCYRTIDAE	
<u>Achrysopephagus aegyptiacus</u> Mercet ³	<u>Planococcus citri</u>
<u>Anagyrus pseudococci</u> (Girault)	<u>Planococcus citri</u> , <u>Pseudococcus citriculus</u>
<u>Aphidencyrtus aphidivorus</u> (Mayr) ³	<u>Toxoptera aurantii</u>
<u>Bothriophryne fuscicornis</u> Compere	<u>Ceroplastes floridensis</u>
<u>Cheiloneurus claviger</u> Thomson ^{2,3}	<u>Coccus hesperidum</u>
<u>Cheiloneurus paralia</u> (Walker) ³	<u>Coccus hesperidum</u> , <u>Ceroplastes floridensis</u>
<u>Clausenia purpurea</u> Ishii	<u>Pseudococcus citriculus</u>
<u>Diversinervus elegans</u> Silvestri	<u>Saissetia oleae</u> , <u>Ceroplastes floridensis</u> , <u>Coccus hesperidum</u>
<u>Encyrtus lecaniorum</u> (Mayr)	<u>Coccus hesperidum</u>

2) Rare

3) Hyperparasitic

<u>Habrolepis fanari</u> Delucchi	<u>Chrysomphalus aonidum</u>
<u>Leptomastidea abnormis</u> (Girault)	<u>Planococcus citri</u> , <u>Pseudococcus citriculus</u>
<u>Metaphycus flavus</u> (Howard)	<u>Coccus hesperidum</u> , <u>Saissetia oleae</u>
<u>Metaphycus zebratus</u> (Mercet)	<u>Ceroplastes floridensis</u>
<u>Microterys flavus</u> (Howard)	<u>Coccus hesperidum</u> , <u>Ceroplastes floridensis</u>
<u>Microterys tricoloricornis</u> (De Stefani) ²	<u>Coccus hesperidum</u>

CHALCIDOIDEA: EULOPHIDAE

<u>Tetrastichus ceroplastae</u> (Girault)	<u>Ceroplastes floridensis</u> , <u>Ceroplastes rusci</u> , <u>Coccus hesperidum</u>
<u>Tetrastichus ceroplastophilus</u> Domenichini ^{3, 4}	<u>Ceroplastes floridensis</u> , <u>Coccus hesperidum</u>
<u>Tetrastichus sicarius</u> Silvestri	<u>Ceroplastes floridensis</u>

CHALCIDOIDEA: PTEROMALIDAE

<u>Asaphes vulgaris</u> Walker ^{2, 3}	<u>Toxoptera aurantii</u>
<u>Enargopelte nigra</u> (Mercet)	<u>Ceroplastes floridensis</u>
<u>Pachyneuron minutissimum</u> (Förster) ³	<u>Toxoptera aurantii</u>
<u>Pachyneuron siculum</u> Delucchi ³	<u>Coccus hesperidum</u> , <u>Ceroplastes floridensis</u> , <u>Planococcus citri</u> , <u>Pseudococcus citriculus</u>
<u>Scutellista cyanea</u> Motschulsky	<u>Ceroplastes floridensis</u> , <u>Saissetia oleae</u> , <u>Ceroplastes rusci</u>

CYNIPOIDEA: CYNIPIDAE

<u>Alloxysta</u> sp. ³	<u>Toxoptera aurantii</u> , <u>Myzus persicae</u>
<u>Charips</u> spp. ³	<u>Toxoptera aurantii</u>

ICHNEUMONOIDEA: APHIDIDAE

<u>Aphidius matricariae</u> Haliday	<u>Myzus persicae</u>
<u>Ephedrus persicae</u> Froggatt	<u>Toxoptera aurantii</u>
<u>Lysaphidus ? platensis</u> (Brèthes) ²	<u>Toxoptera aurantii</u>
<u>Lysiphlebus ambiguus</u> (Haliday)	<u>Toxoptera aurantii</u>

2) Rare

3) Hyperparasitic

4) Recorded as "Tetrastichus sp." by Rosen (1966b, 1967a).

<u>Lysiphlebus fabarum</u> (Marshall)	<u>Toxoptera aurantii</u>
<u>Praon volucre</u> (Haliday)	<u>Myzus persicae</u>
<u>Trioxys angelicae</u> (Haliday) ²	<u>Aphis gossypii</u> , <u>Toxoptera aurantii</u>

PROCTOTRUPOIDEA: PLATYGASTERIDAE

<u>Allotropa ? mecrida</u> (Walker) ²	<u>Planococcus citri</u>
--	--------------------------

Several species in the above list have not been identified beyond the generic level. These are excluded from the following discussion, since there is no way to determine their distribution or origin.

It is usually very difficult to determine the origin of parasitic Hymenoptera associated with sternorrhynchous Homoptera. Before the importance of strict quarantine procedures became generally recognized, many species of homopterous pests had been widely distributed over the world by commerce. Being sedentary and often rather cryptic, many sternorrhynchous Homoptera may still gain entrance to new countries on imported host plants. Many species of parasites have undoubtedly been distributed in the same manner with their hosts, and their present distribution may not yield any clue to their origin. Moreover, the parasite fauna of vast areas is still rather poorly known, and our information on the distribution of many parasite species is therefore very incomplete. Thus, certain species currently present a very spotty pattern of distribution: Coccophagus bivittatus, for instance, has hitherto been recorded from South Africa, Argentina, India, Italy, and Israel; such a discontinuous pattern may be due both to recent distribution by commerce and to our lack of knowledge of the presence of this species in other countries. The inadequate state of the taxonomy of many parasite groups is a further complication, since in the absence of reliable identifications, even the available data on the distribution of certain species are often doubtful.

Of the parasitic Hymenoptera associated with the sternorrhynchous Homoptera on citrus in Israel, 6 species have been intentionally introduced into the country for biological control. Five of these are of Oriental origin:

Four from northeastern Asia (China, Japan):

<u>Aphytis holoxanthus</u>	<u>Clausenia purpurea</u>
<u>Aphytis lingnanensis</u>	<u>Pteroptrix smithi</u>

2) Rare

and one from southeastern Asia (India, Pakistan):

Aphytis melinus

One species was introduced from the Nearctic region:

Aphelinus mali

(This species was introduced against the woolly apple aphid, Eriosoma lanigerum (Hausmann), on deciduous fruit trees, and is very rare on citrus.).

There are some reasons to believe that two additional species, Aphytis coheni and Aphytis lepidosaphes, were unknowingly introduced into Israel from Hong Kong together with A. holoxanthus (see Rosen, 1967c; Rivnay, 1968). However, this assumption cannot be proven, and it is just as well possible that these species have gained access into Israel on their own accord.

Several additional species were introduced into Israel and released in citrus groves during the last decade, but have failed to become established (Rosen, 1967c).

Of the species that were not intentionally introduced into Israel, 8 are very widely distributed and their origin is unknown:

Anagyrus pseudococci

Coccophagus lycimnia

Aphidencyrтус aphidivorus

Coccophagus scutellaris

Asaphes vulgaris

Metaphycus flavus

Coccophagus bivittatus

Microterys flavus

Two species are now widely distributed, but are apparently of Mediterranean origin:

Aphytis chrysomphali

Leptomastidea abnormis

One widely distributed species apparently originated in the Middle East or Central Asia:

Ephedrus persicae

Two widely distributed species are apparently of Oriental origin:

Aphytis hispanicus

Scutellista cyanea

Two widely distributed species are of Palearctic origin:

Aphidius matricariae

Encyrtus lecaniorum

Eleven species belong to the fauna of the Palearctic region (including Central Asia):

<u>Allotropia mecrida</u>	<u>Lysiphlebus fabarum</u>
<u>Aphelinus flavipes</u>	<u>Pachyneuron minutissimum</u>
<u>Cheiloneurus claviger</u>	<u>Pachyneuron siculum</u>
<u>Cheiloneurus paralia</u>	<u>Praon volucre</u>
<u>Lysiphlebus ambiguus</u>	<u>Prospaltella lutea</u>

Trioxys angelicae

Seven species are Ethiopian:

<u>Achrysoophagus aegyptiacus</u>	<u>Eretmocerus diversiciliatus</u>
<u>Bothriophryne fuscicornis</u>	<u>Marietta exitiosa</u>
<u>Diversinervus elegans</u>	<u>Tetrastichus ceroplastae</u>

Tetrastichus sicarius

Three species are apparently of Oriental origin:

<u>Aphytis coheni</u>	<u>Aphytis lepidosaphes</u>
<u>Prospaltella inquirenda</u>	

One species apparently belongs to the fauna of the Neotropic and Australian regions:

Lysaphidus platensis

Only 5 species may at present be considered as representing the local Mediterranean fauna:

<u>Enargopelte nigra</u>	<u>Metaphycus zebratus</u>
<u>Habrolepis fanari</u>	<u>Microterys tricoloricornis</u>
<u>Tetrastichus ceroplastophilus</u>	

Thus, of the 42 species that were not intentionally introduced into Israel, only 8 species (= 19.0%) represent the local Mediterranean or Middle Eastern fauna, or have originated in this region. Significantly, they are all relatively rare on citrus. All the other species are widely distributed, or have originated in other zoogeographical regions.

The relatively small role played by indigenous species of sternorrhynchous Homoptera and parasitic Hymenoptera in the fauna of citrus in Israel does not necessarily indicate an inherent lack of adaptability of the local fauna to the citrus ecosystem. Competitive displacement of indigenous species by more efficient, better adapted invaders may have accounted for the present composition of the citrus fauna in Israel.

The considerable changes which have taken place in the parasite fauna of citrus groves in Israel during the past 3 decades may serve as examples for such processes of competitive displacement. Some of the more striking cases are summarized below.

After Pseudococcus citriculus invaded the citrus groves of Israel in the late nineteen-thirties, it came under attack by several local species of parasitic Hymenoptera. However, when Clausenia purpurea was introduced from Japan in 1940, it soon reduced the pest's populations far below the threshold of economic injury. Being a much more efficient parasite, C. purpurea has effectively displaced the local parasites from the populations of the citriculus mealybug in Israel (see Rivnay, 1946; Bodenheimer, 1951; Rosen, 1965a).

More recently Aphytis holoxanthus, introduced in 1956 from Hong Kong, has similarly reduced the populations of the Florida red scale, Chrysomphalus aonidum, to extremely low levels within a short period of 2-3 years. During that period, A. holoxanthus has apparently managed to entirely displace Aphytis chrysomphali, a local parasite of the Florida red scale. Another recent arrival, Aphytis coheni, has in the meanwhile displaced A. chrysomphali from the populations of the California red scale, Aonidiella aurantii, in certain citrus areas (Rosen, 1965b, 1967c).

Twenty-five years ago, Metaphycus flavus was recorded as an insignificant parasite of the brown soft scale in Israel. Tetrastichus ceroplastae was not even recorded among the parasites of the Florida wax scale. Recent surveys have shown these species to be the most abundant parasites of their respective hosts. On the other hand, Encyrtus lecaniorum, previously recorded as the most important parasite of the brown soft scale in Israel, has become very rare in recent years (Rosen, 1967a, 1967c).

One may assume that similar changes have occurred also in the citrus pest fauna in Israel.

In conclusion, it seems quite possible that competitive displacement by exotic species has prevented the local fauna of Israel from becoming better adapted to citrus.

LITERATURE CITED

- Bodenheimer, F.S. 1951. Citrus Entomology in the Middle East. Junk, The Hague, 663 p.
- Burke, J.H. 1967. The commercial citrus regions of the world. Chapter 2 (p. 40-189) IN: The Citrus Industry, W. Reuther, H.J. Webber and L.D. Batchelor, Editors, Vol. I, Rev. Ed., Univ. Calif. Div. Agr. Sci., 611 p.
- Gerson, U. 1964. Parlatoria cinerea, a pest of citrus in Israel. FAO Plant Protect. Bull., 12: 82-85.
- Isaac, E. 1959. Influence of religion on the spread of citrus. Science, 129:179-185.
- Rivnay, E. 1946. The status of Clausenia purpurea Ishii and its competition with other parasites of Pseudococcus comstocki Kuw. in Palestine. Boll. Soc. Fouad 1er Entomol., 30: 11-19.
- _____. 1968. Biological control of pests in Israel (a review 1905-1965). Israel J. Entomol., 3(1): 1-156.
- Rosen, D. 1962. An annotated list of hymenopterous parasites of citrus soft scales in Israel. Entomophaga, 7: 349-357.
- _____. 1965a. A new species of Clausenia Ishii (Hymenoptera: Encyrtidae) from Israel. Proc. R. Entomol. Soc. Lond. (B), 34: 61-64, 3 pl.
- _____. 1965b. The hymenopterous parasites of citrus armored scales in Israel (Hymenoptera: Chalcidoidea). Ann. Entomol. Soc. Amer., 58: 388-396.
- _____. 1966a. Notes on the parasites of Acaudaleyrodes citri (Priesner & Hosni) (Hem.: Aleyrodidae) in Israel. Entomol. Ber., 26: 55-59.
- _____. 1966b. Keys for the identification of the hymenopterous parasites of scale insects, aphids and aleyrodids on citrus in Israel. Scripta Hierosolym., 18: 43-79, 267 figs.
- _____. 1967a. The hymenopterous parasites of soft scales on citrus in Israel. Beitr. Entomol., 17: 251-279.
- _____. 1967b. The hymenopterous parasites and hyperparasites of aphids on citrus in Israel. Ann. Entomol. Soc. Amer., 60: 394-399.
- _____. 1967c. Biological and integrated control of citrus pests in Israel. J. Econ. Entomol., 60: 1422-1427.
- Tolkowsky, S. 1938. Hesperides. A History of the Culture and Use of Citrus Fruits. John Bales, Sons and Curnow, London, 371 p.