Israel Journal of Entomology Vol. IV, 1969.

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

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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, C itrus medic a 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:

COCCOIDEAi	DIASPIDIDAE:	Aonidiella aurantii (Maskell)
		Chrysomphalus aonidum (L.)
		Lepidosaphes beckii (Newman)
		Parlatoria cinerea Hadden Parlatoria pergandii Comstock

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

PARASITES	HOSTS
CHALCIDOIDEA: APHELINIDAE	
Aphelinus flavipes (Förster)[2]	Toxoptera aurantii
Aphelinus mali (Haldeman)[2]	Toxoptera aurantii

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2) Rare

Aphytis chrysomphali (Mercet)	Aonidiella aurantii, Parlatoria pergandii (?), Chrysomphalus aonidum
Aphytis coheni DeBach	Aonidiella aurantii
Aphytis hispanicus (Mercet)	Parlatoria pergandii, Parlatoria cinerea
Aphytis holoxanthus DeBach	Chrysomphalus aonidum
Aphytis lepidosaphes Compere	Lepidosaphes beckii
Aphytis lingnanensis Compere	Aonidiella aurantii
Aphytis melinus DeBach	Aonidiella aurantii
Aphytis spp. [2]	Aonidiella aurantii, Chrysomphalus aonidum, Parlatoria pergandii
Coccophagus bivittatus Compere[2]	Coccus hesperidum
Coccophagus lycimnia (Walker)	Coccus hesperidum, Ceroplastes floridensis
Coccophagus scutellaris (Dalman)	Coccus hesperidum
Eretmocerus diversiciliatus Silvestri	Acaudaleyrodes citri
Marietta exitiosa Compere[3]	Coccus hesperidum, Ceroplastes floridensis, Chrysomphalus aonidum, Aonidiella aurantii
Prospaltella inquirenda Silvestri	Parlatoria pergandii, Parlatoria cinerea
Prospaltella lutea Masi	Acaudaleyrodes citri
Prospaltella sp. (♂♂)[3]	Coccus hesperidum, Chrysomphalus aonidum
Pteroptrix (=Casca) smithi(Compere)	Chrysomphalus aonidum

CHALCIDOIDEA: ENCYRTIDAE

Achrysopophagus aegyptiacus Mercet[3]	Planococcus citri
Anagyrus pseudococci (Girault)	Planococcus citri, Pseudococcus citriculus
Aphidencyrtus aphidivorus (Mayr)[3]	Toxoptera aurantii
Bothriophryne fuscicornis Compere	Ceroplastes floridensis
Cheiloneurus claviger Thomson[2,3]	Coccus hesperidum
Cheiloneurus paralia (Walker)[3]	Coccus hesperidum, Ceroplastes floridensis
Clausenia purpurea Ishii	Pseudococcus citriculus
Diversinervus elegans Silvestri	Saissetia oleae, Ceroplastes floridensis, Coccus hesperidum
Encyrtus lecaniorum (Mayr)	Coccus hesperidum

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2) Rare

3) Hyperparasitic

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

CHALCIDOIDEA: EULOPHIDAE

Tetrastichus ceroplastae(Girault)	Ceroplastes floridensis, Ceroplastes rusci, Coccus hesperidum
Tetrastichus ceroplastophilus Domenichini[3, 4]	Ceroplastes floridensis, Coccus hesperidum
Tetrastichus sicarius Silvestri	Ceroplastes floridensis

CHALCIDOIDEA: PTEROMALIDAE

Asaphes vulgaris Walker[2, 3]	Toxoptera aurantii
Enargopelte nigra (Mercet)	Ceroplastes floridensis
Pachyneuron minutissimum(Förster)[3]	Toxoptera aurantii
Pachyneuron siculum Delucchi[3]	Coccus hesperidum, Ceroplastes floridensis, Planococcus citri, Pseudococcus citriculus
Scutellista cyanea Motschulsky	Ceroplastes floridensis, Saissetia oleae, Ceroplastes rusci

CYNIPOIDEA: CYNIPIDAE

Alloxysta sp.[3]	Toxoptera aurantii, Myzus persicae
Charips spp.[3]	Toxoptera aurantii

ICHNEUMONOIDEA: APHIDIDAE

Aphidius matricariae Haliday	Myzus persicae
Ephedrus persicae Froggatt	Toxoptera aurantii
Lysaphidus ? platensis (Brèthes)[2]	Toxoptera aurantii
Lysiphlebus ambiguus (Haliday)	Toxoptera aurantii

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

Lysiphlebus fabarum (Marshall)	Toxoptera aurantii
Praon volucre (Haliday)	Myzus persicae
Trioxys angelicae (Haliday)[2]	Aphis gossypii, Toxoptera aurantii

PROCTOTRUPOIDEA: PLATYGASTERIDAE

Allotropa ? mecrida (Walker)[2]	Planococcus citri

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):

Aphytis holoxanthus	Clausenia purpurea
Aphytis lingnanensis	Pteroptrix smithi

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[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
Aphidencyrtus 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):

Allotropa mecrida	Lysiphlebus fabarum
Aphelinus flavipes	Pachyneuron minutissimum
Cheiloneurus claviger	Pachyneuron siculum
Cheiloneurus paralia	Praon volucre
Lysiphlebus ambiguus	Prospaltella lutea

Trioxys angelicae

Seven species are Ethiopian:

Achrysopophagus aegyptiacus	Eretmocerus diversiciliatus
Bothriophryne fuscicornis	Marietta exitiosa
Diversinervus elegans	Tetrastichus ceroplastae

Tetrastichus sicarius

Three species are apparently of Oriental origin:

Aphytis coheni	Aphytis lepidosaphes

Prospaltella inquirenda

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:

Enargopelte nigra	Metaphycus zebratus
Habrolepis fanari	Microterys tricoloricornis

Tetrastichus ceroplastophilus

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.

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