

האוניברסיטה העברית בירושלים

The Hebrew University of Jerusalem
Faculty of Agriculture
Rehovot (Israel)

DAVID ROSEN

The hymenopterous parasites of soft scales on citrus in Israel¹

With 15 textfigures

Introduction

Four species of soft scales (Hemiptera: Coccidae) infest citrus in Israel. These are: the Florida wax scale, *Ceroplastes floridensis* COMSTOCK; the fig wax scale, *Ceroplastes rusci* (LINNAEUS); the black scale, *Saissetia oleae* (BERNARD); and the soft brown scale, *Coccus hesperidum* LINNAEUS. All four species attack citrus leaves and twigs, causing damage both by direct feeding and by the formation of sooty mold on the copiously excreted honeydew.

Although these pests have been studied in Israel over an extended period (see BODKIN, 1927; KLEIN, 1940; BODENHEIMER, 1951; HARPAZ, 1961), their natural enemies have remained relatively little known. Some information concerning parasites of citrus soft scales has still been accumulated, mainly by RIVNAY (1944). However, BODENHEIMER (1951, p. 390), summing up the then-available data, concluded that parasites "are sometimes quite numerous, but are of no decisive importance in the general epidemiology of the soft-scales".

Changes in citricultural practices — such as the introduction of sprinkler irrigation, the thinning of groves, and the adoption of a country-wide system of compulsory aerial sprays against the Mediterranean fruit fly, *Ceratitis capitata* (WIEDEMANN) — have considerably altered the ecological conditions in citrus groves in Israel. In view of these changes, as well as of the recent rise of interest in biological and integrated pest control, a reappraisal of the role of parasitic Hymenoptera in the epidemiology of soft scales on citrus seemed desirable.

Extensive monthly and bi-monthly surveys were therefore initiated in 1960, covering the main citrus-growing regions of Israel. Samples of the above-mentioned scale-insect pests were brought into the laboratory, where parasites were reared therefrom. Altogether, 23 species of parasitic Hymenoptera were obtained, 14 of which are primary parasites. The rates of parasitism in the populations of the Florida wax scale and the soft brown scale were determined in many citrus groves.

¹ This research has been financed in part by Grant No. FG-Is-227, made by the United States Department of Agriculture under P.L. 480.

The results of these studies are presented hereunder, including many additions and some corrections to the preliminary notes of ROSEN (1962) and of AVIDOV, ROSEN & GERSON (1963).

The Florida Wax Scale

The Florida wax scale is a polyphagous species, apparently of Central American origin, now widespread in tropical and subtropical regions all over the world (BORKHSENIUS, 1957). Although the insect is supposed to have entered the Mediterranean Basin only relatively recently (HARPAZ, 1961), it has become by far the most abundant and injurious coccid pest of citrus in Israel. In the present survey this species was found to infest citrus all the year round, throughout the coastal plain as well as in the Jezreel Valley. It was scarce in the Eastern Jezreel Valley, and was absent from citrus groves in the Jordan Valley, where it was found occasionally infesting ornamentals.

Very little information was available regarding the parasites of this important pest in Israel. BODENHEIMER (1951) mentioned only *Scutellista cyanea* MOTSCHULSKY, *Microterys frontatus* (MERCET), *Coccophagus scutellaris* (DALMAN) and *Diversinervus elegans* SILVESTRI.

Over 4500 specimens of parasitic Hymenoptera, including 9 species of primary and 4 species of secondary parasites, were reared from numerous samples of females and second-stage larvae of the Florida wax scale in the present study (First-stage larvae did not yield any parasites; males are unknown in Israel). These parasites are listed below according to their relative abundance.

- Primary parasites: *Tetrastichus ceroplastae* (GIRAULT)
Scutellista cyanea MOTSCHULSKY
Microterys flavus (HOWARD)
Diversinervus elegans SILVESTRI
Bothriophryne fuscicornis COMPERE
Tetrastichus sicarius SILVESTRI
Enargopelte nigra (MERCET)
Metaphycus zebratus (MERCET)
Coccophagus lycimnia (WALKER)
- Hyperparasites: *Tetrastichus* spec.
Cheiloneurus paralia (WALKER)
Pachyneuron siculum DELUCCHI
Marietta exitiosa COMPERE

Two additional species — *Anastatus bifasciatus* (FONSCOLOMBE) and *Aphanogmus* spec. near *remotus* SZELÉNYI — were occasionally obtained from samples of the Florida wax scale, but their host relations are as yet obscure.

Populations of the Florida wax scale were systematically sampled in many localities in order to determine the rates of parasitism by the various parasite species. Only scales which did not contain exit-holes of parasites were included in these samples. The number of scales in each sample, and the number of parasites emerging from them, were recorded. Except for rare occasions, only one

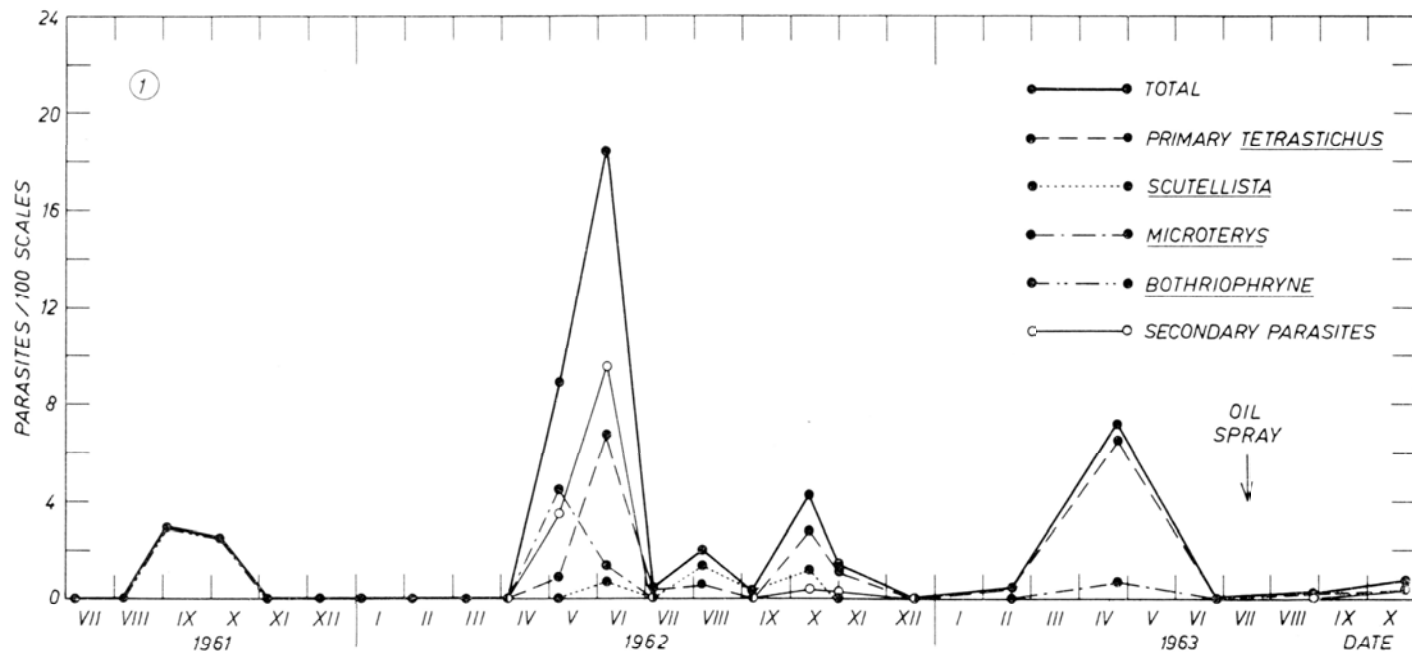


Fig. 1. Florida wax scale: Rates of parasitism by major parasite species (Shamouti orange, Ashqelon)

parasite emerged from each parasitized host. Hence, the data on the number of parasites reared from the samples represent quite accurately the rates of parasitism in the wax scale's populations.

Figures 1—11 represent the data obtained in these studies. All the citrus plots concerned were treated in the autumn with poison baits against the Mediterranean fruit fly (see AVIDOV et al., 1963). Two plots were oil-treated for scale control (Figs. 1, 10). Mites were controlled when necessary, by selective acaricides such as zineb (Zinc ethylene-1,2-bisdithiocarbamate) or chlorobenzilate (Ethyl 4,4'-dichlorobenzilate). No other pesticidal treatments were applied to these plots throughout the period of this study.

Rates of parasitism were generally rather low, being in many plots well under 20%. Only on one occasion were there nearly 50% of the scales in a sample

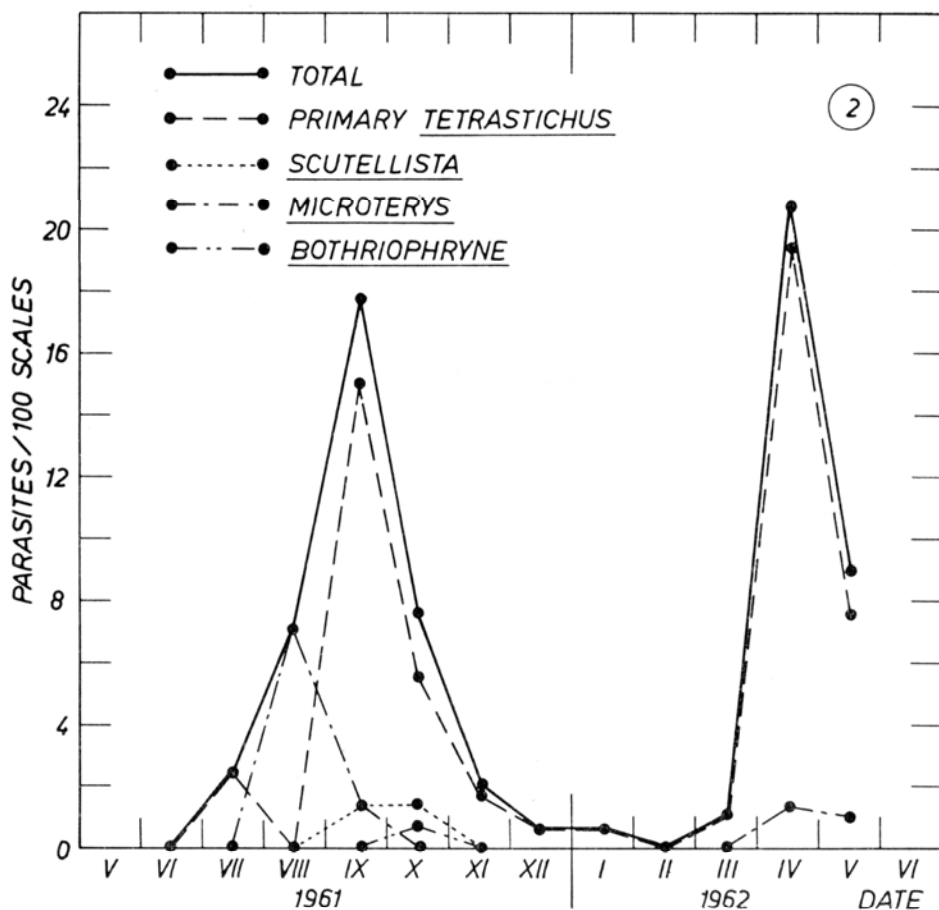
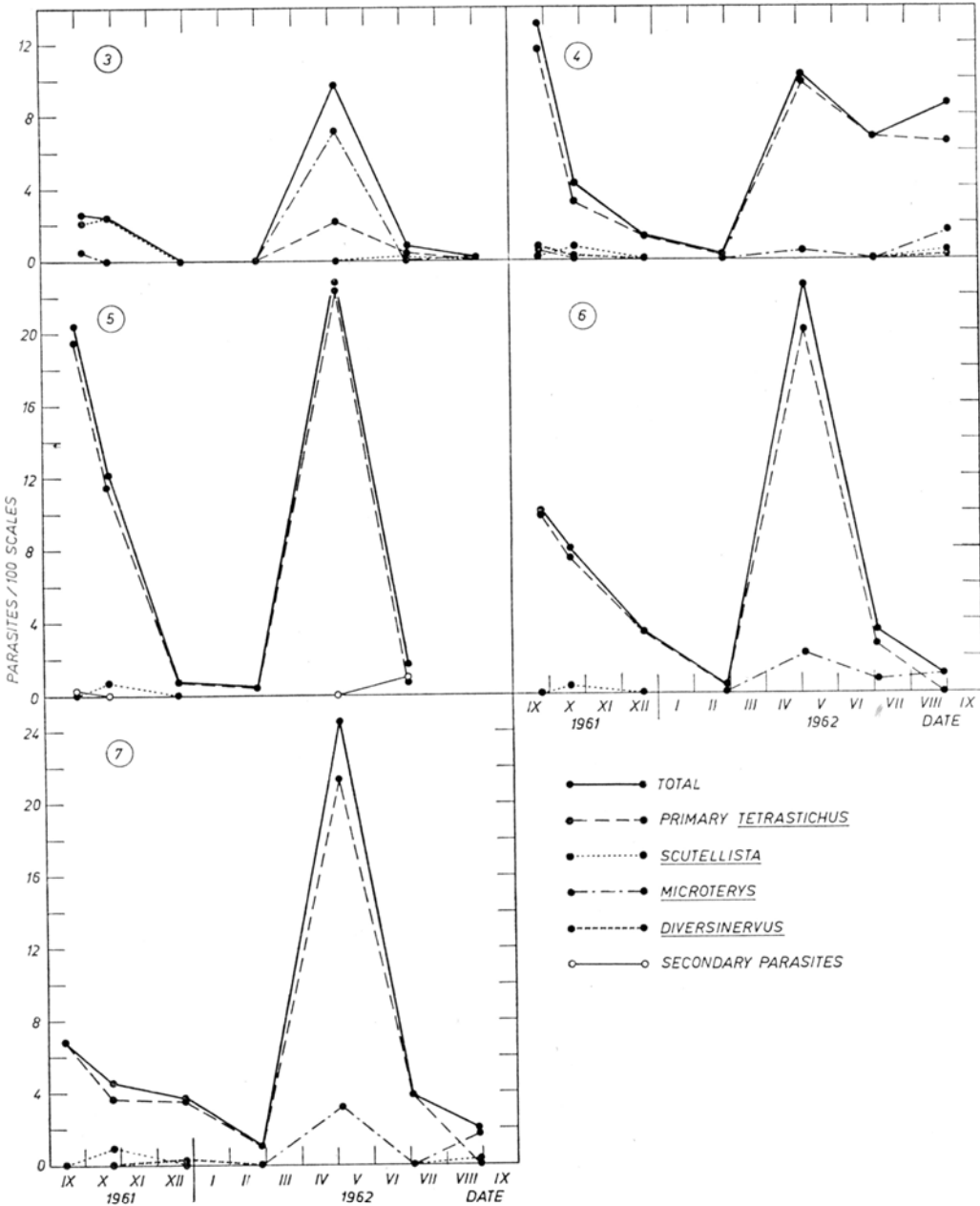
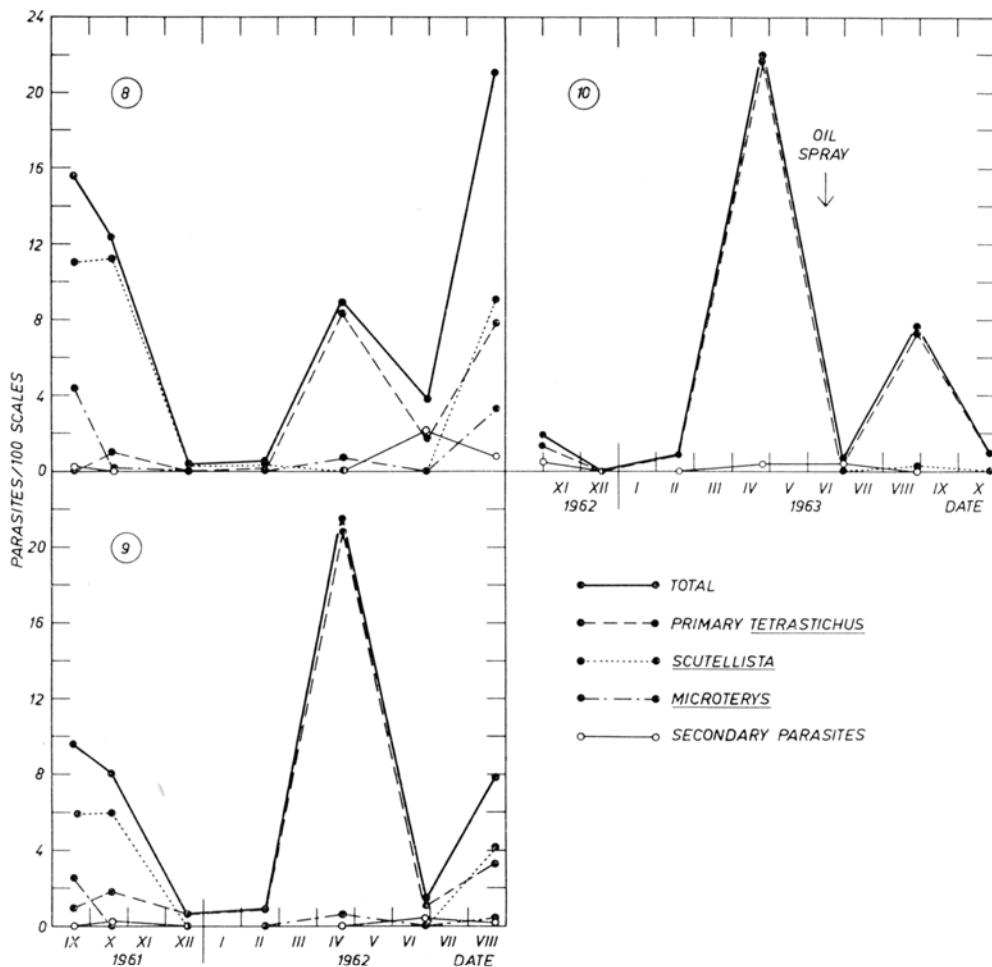


Fig. 2. Florida wax scale: Rates of parasitism by major parasite species (mixed citrus plot, Rosh Haniqrah)



Figs. 3—7. Florida wax scale: Rates of parasitization by major parasite species (Shamouti orange; Fig. 3. Meretz. — Figs. 4—5. Bnay Zion. — Fig. 6. Tel Mond. — Fig. 7. Gan Ephraim)



Figs. 8–10. Florida wax scale: Rates of parasitism by major parasite species (Shamouti orange; Fig. 8. Tirah. — Fig. 9. Kfar Hess. — Fig. 10. Ashqelon)

parasitized (Fig. 11). Two peaks of parasitism were clearly observed in all plots — in spring (April–June) and autumn (September–October). The spring peak was usually the highest (Figs. 1, 3, 6, 7, 9, 11). In several plots, however, the autumn peak was also relatively high, sometimes even higher than the spring peak (Figs. 2, 4, 5, 8). Parasitism was very low during winter and usually declined sharply after the spring peak. The peaks of parasitism roughly coincided with the peaks in the abundance of susceptible host stages.

Tetrastichus ceroplastae was the dominant parasite, comprising about two-thirds of all parasite specimens obtained from the Florida wax scale. *Scutellista cyanea* was also rather common, especially in the autumn. *Microterys flavus* was much less abundant; other primary parasites were relatively rare.

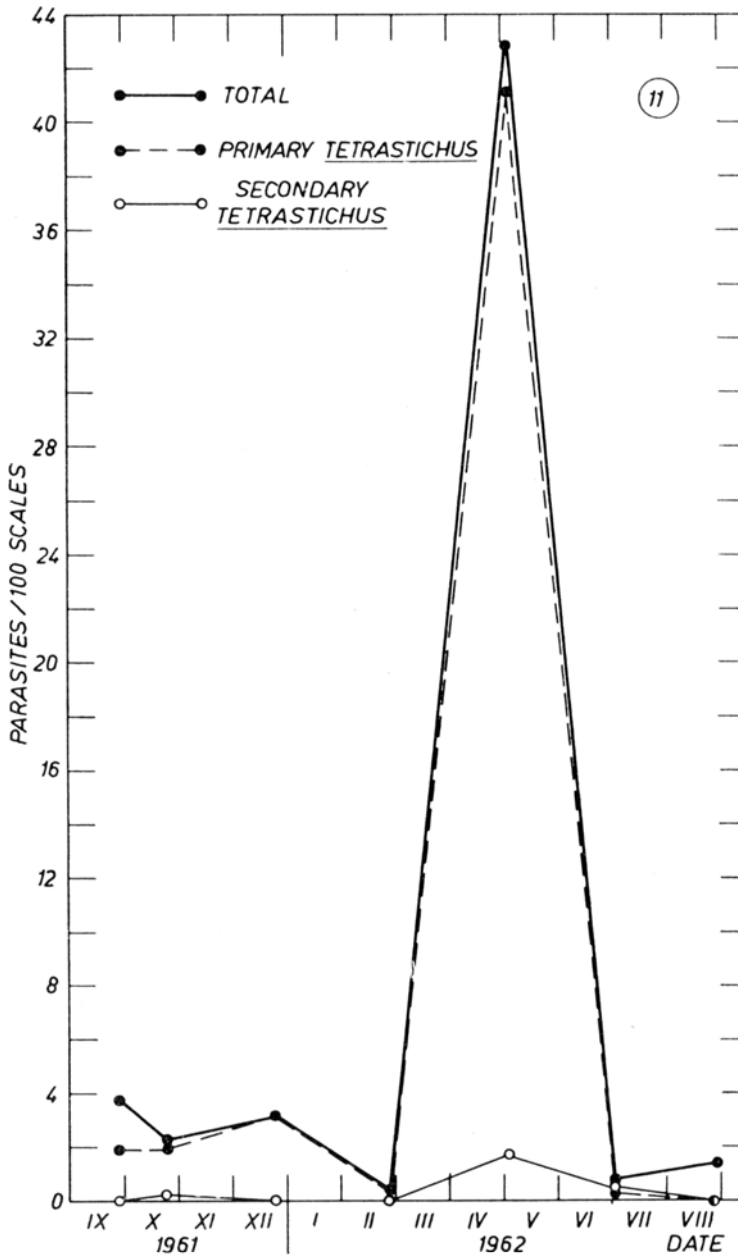


Fig. 11. Florida wax scale: Rates of parasitization by major parasite species (Shamouti orange, Petakh Tiqvah)

Hyperparasites were altogether absent from many plots (Figs. 2—4, 6, 7). In most other plots they were rare and apparently insignificant. Only rarely were they relatively abundant during the spring peak of parasitism (Fig. 1), sometimes lagging after that peak (Fig. 8).

The outbreaks of the Florida wax scale in Israel are usually prolonged and cover wide areas, thus indicating insufficient natural control (see RUBTSOV, 1958); chemical control is often required. Parasites and predators, however, may play a significant role in the prevention of severe outbreaks. This was recently confirmed by BEN-DOV (1963), who reported that after several monthly or fortnightly treatments, the population-level of the Florida wax scale on DDT-sprayed citrus trees was 3.6 to 7 times higher than on adjacent untreated trees.

The Fig Wax Scale

The fig wax scale, apparently of eastern Mediterranean origin (HARPAZ, 1961), is a minor pest of fig and sycamore in Israel, occurring mainly in the hill regions. It is rather rare in the coastal plain and in the interior valleys, and only occasionally infests citrus. BODENHEIMER (1930, 1951) recorded only *Scutellista cyanea* MOTSCHULSKY as a parasite of this scale insect in Israel.

Only very light infestations of the fig wax scale were encountered on citrus during the present study, mainly in the Western Galilee (northern coastal plain) and in the Jezreel Valley. Only *Tetrastichus ceroplastae* (GIRAULT) and *S. cyanea* were reared from the few, small samples taken on citrus. Several additional species, including *Tetrastichus* spec., *Marietta exitiosa* Compere and *Metaphycus* ? *zebratus* (MERCET), were obtained from samples taken on fig and sycamore.

The Black Scale

This polyphagous, cosmopolitan species, apparently of Aethiopian origin, is a serious pest of citrus and olive in many subtropical regions. Wild olive is supposed to be its original host (BODENHEIMER, 1951). In Israel, where the black scale has long been established, it infests citrus (preferably old, dense groves), olive and various ornamentals throughout the coastal plain and in the Jezreel Valley. On citrus it is univoltine, even-hatched, with young larvae developing very slowly during summer. Two overlapping generations may develop annually in irrigated olive groves, and the scale's colonies in that habitat usually consist of a variety of developmental stages (see also PELEG, 1965).

BODENHEIMER (1951) recorded only *Scutellista cyanea* MOTSCHULSKY as a parasite of the black scale in Israel. In the present study another species, *Diversinervus elegans* SILVESTRI, was found to be even more abundant than *S. cyanea*. Both were reared from mature scales only, from May through July. Rates of parasitism by these species were usually low. Samples of citrus-infesting scale larvae yielded no parasites, except for a single specimen of *Metaphycus flavus* (HOWARD). Hyperparasites were not obtained from samples of the black scale taken on citrus.

Also in irrigated olive groves, *D. elegans* and *S. cyanea* were the only parasites reared from mature females of the black scale, and *Metaphycus flavus* was very rarely obtained from larvae. In addition, the hyperparasites *Pachyneuron siculum* DELUCCHI and *Marietta exitiosa* COMPERE were occasionally reared from olive-infesting black scale.

The poor parasite fauna associated with the black scale in Israel stands in marked contrast to the rich fauna found in Africa (see SMITH & COMPERE, 1928; COMPERE, 1931b, 1940; VAN DEN BOSCH et al., 1955). This difference may be partly explained by lack of synchronization due to the long absence of susceptible stages of the scale from citrus groves in Israel. Indeed, all the parasites of the black scale in Israel have alternative hosts on citrus, to which they take in the absence of susceptible stages of the black scale. This explanation, however, is obviously not applicable to irrigated olive groves, where all stages of the scale are present almost all the year round. These differences between the Israeli and African faunas of black-scale parasites may be attributable to the existence of distinct, taxonomically indistinguishable, geographical races of the black scale, differing in their susceptibility to various parasitic Hymenoptera (see BARTLETT, 1960).

The Soft Brown Scale

The soft brown scale is a polyphagous, cosmopolitan species, apparently of Oriental origin (BORECHSENIUS, 1957). In Israel it is a very common pest of citrus — preferring young, well-spaced trees — and various ornamentals. In the present surveys it was frequently found infesting citrus throughout the coastal plain and in the interior valleys. In the Jordan valley it was rare on citrus, but was occasionally found infesting ornamentals.

Many parasites of the soft brown scale were listed in Israel by RIVNAY (1944) and BODENHEIMER (1951). *Encyrtus lecaniorum* (MAYR) was considered as the most important parasite of this pest.

Over 4750 specimens of parasitic Hymenoptera were obtained from samples of the soft brown scale taken in the present study, including 9 species of primary parasites and 6 species of hyperparasites. These are listed below according to their relative abundance.

- Primary parasites: *Metaphycus flavus* (HOWARD)
Microterys flavus (HOWARD)
Coccophagus lycimnia (WALKER)
Coccophagus scutellaris (DALMAN)
Encyrtus lecaniorum (MAYR)
Coccophagus bivittatus COMPERE
Diversinervus elegans SILVESTRI
Tetrastichus ceroplastae (GIRAULT)
Microterys tricoloricornis (DE STEFANI)
- Hyperparasites: *Pachyneuron siculum* DELUCCHI
Cheiloneurus paralia (WALKER)
Prospaltella spec.

Marietta exitiosa COMPERE
Cheiloneurus claviger THOMSON
Tetrastichus spec.

An additional species — *Eupteromalus* spec. — was once obtained from a sample of the soft brown scale, but its host-relations are still unknown.

The number of parasites reared from a sample of the soft brown scale does not necessarily reflect the actual percentage of parasitization, as both *Metaphycus flavus* and *Microterys flavus* may develop gregariously. The trends of the numbers of parasites obtained from successive samples may, however, indicate the changes in the relative abundance of parasites in the scale's populations. Some representative trends are shown in Figures 12—15.

Parasites play a decisive role in the control of soft brown scale populations on citrus in Israel, appearing very abundantly whenever the scale becomes numerous. Soft brown scale colonies appear on citrus at the end of winter, attaining their peak usually by April or May. Parasites become very numerous at that period, virtually exterminating the pest's colonies, and the soft scale becomes extremely rare throughout summer and autumn (Figs. 12—14²). Sometimes very localized, dense, heavily ant-attended colonies persist through July (Fig. 15), only to be eventually destroyed by heavy parasitization. Outbreaks of the soft brown scale in Israel are always localized and short-lived, thus indicating efficient natural control.

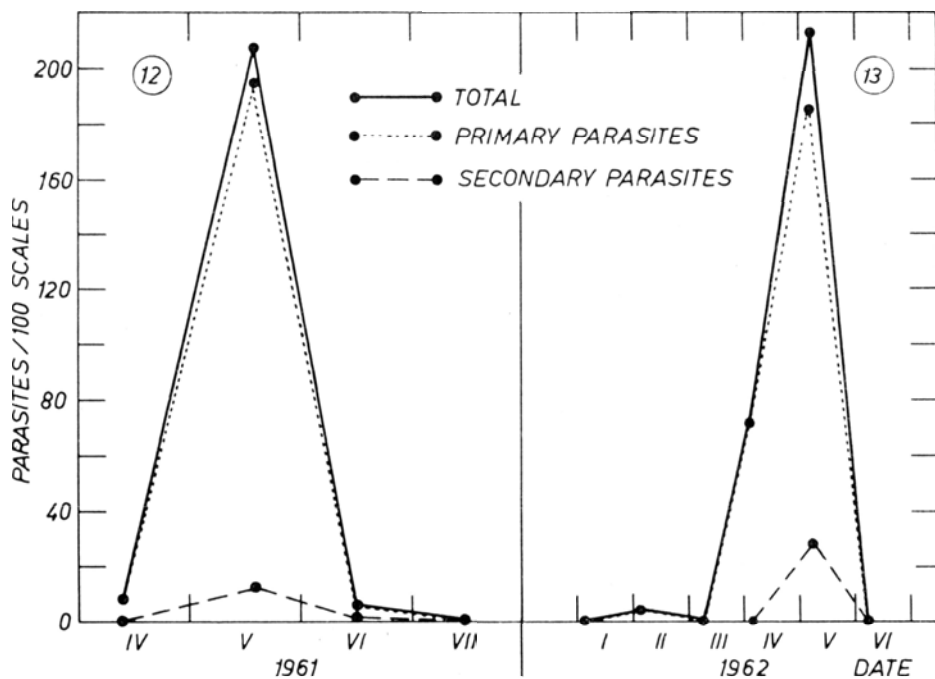
Of the major primary parasites, *Metaphycus flavus* and *Microterys flavus* were by far the most abundant and important, both being common even in very sparse populations of the scale. *Coccophagus* spp., on the other hand, were usually restricted to dense host colonies, where they usually dominated (see also ROSEN, 1967). Hyperparasites were relatively unimportant, unable to check the rapid extermination of the scale's colonies. They usually appeared at the peak of abundance of primary parasites (Figs. 12, 13), sometimes lagging after that peak (Figs. 14, 15).

The parasite fauna associated with the soft brown scale in Israel must have undergone considerable changes since the studies reported by RIVNAY (1944) and BODENHEIMER (1951). *Metaphycus flavus* and *Microterys flavus*, apparently of minor importance some 20 years ago, have recently risen to a dominant position, while *Encyrtus lecaniorum*, then reported as the most important parasite, is now rare and of no economic value.

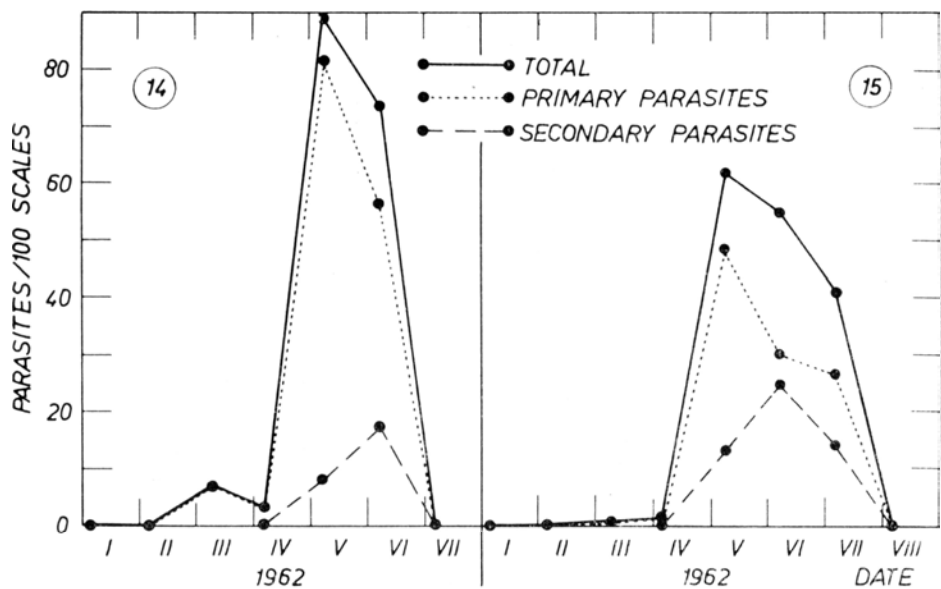
Discussion of Individual Parasite Species

All the Hymenopterous parasites mentioned in the previous paragraphs will be discussed below in alphabetical order. All the dates pertain to the collection of host samples.

² The drop of these curves down to zero is due to the total absence of live scales in the observation plots during summer.



Figs. 12–13. Soft brown scale: Rates of parasitism (Shamouti orange; Fig. 12. Rosh Haniqrah. — Fig. 13. Kfar Bilu)



Figs. 14–15. Soft brown scale: Rates of parasitism (Fig. 14. Shamouti orange, Ashqelon. — Fig. 15. Grapefruit, Gan Yavneh)

Anastatus bifasciatus (FONSCOLOMBE) (Eupelmidae)

This species, here for the first time recorded from Israel, has been known as a parasite of Lepidopterous and Heteropterous eggs (NIKOL'SKAJA, 1952). Four males were reared in the present study from eggs of *Stenozygum coloratum* KLUG (Heteroptera: Pentatomidae) collected on citrus. Two additional males were obtained from samples of the Florida wax scale, and several female and male specimens were reared by YNON (1964) from field-collected, mummified larvae of *Chilocorus bipustulatus* (LINNAEUS) (Coleoptera: Coccinellidae), a predator of citrus scale insects.

Our samples of the Florida wax scale were occasionally contaminated with the predatory larvae of *Lestodiplosis* sp.³ (Diptera: Cecidomyiidae). The latter were also present in Mr. YNON's samples of mummified *Chilocorus* larvae. *Anastatus* spp. have been recorded as parasites of Cecidomyiid puparia (CLAUSEN, 1940), and it seems possible that in this case *A. bifasciatus* was actually parasitic in *Lestodiplosis*. A wide range of host preferences is a rather common occurrence among the Eupelmidae (CLAUSEN, 1940).

Aphanogmus spec., near *remotus* SZELÉNYI (Ceraphronidae)

Several female specimens of this presumably undescribed species were obtained from samples of scale insects, most frequently from the Florida wax scale. A few additional females were obtained by YNON (1964) from mummified larvae of *Chilocorus bipustulatus*. As in the case of *Anastatus bifasciatus*, it seems very probable that larvae of *Lestodiplosis* spec. (Diptera: Cecidomyiidae), contaminating the samples, actually served as hosts of this species, rather than the scales themselves. In fact, species of *Aphanogmus* have been recorded as parasites of *Lestodiplosis* before (NEISWANDER, 1962; PARNELL, 1963).

Bothriophryne fuscicornis COMPERE (Encyrtidae)

This species was first described by COMPERE (1939) as a parasite of *Ceroplastes* sp. in South Africa. ANNECKE (1962) listed several species of *Ceroplastes* serving as its hosts in that country.

B. fuscicornis is a rare parasite of the Florida wax scale in Israel. It was reared from samples of this pest collected on citrus throughout the coastal plain during September and October, 1961 (ROSEN, 1962). Percentage of parasitism was always very low (Figs. 1, 2). Altogether, 18 ♀♀ and 12 ♂♂ were obtained in the present study. The species is arrhenotokous; courtship and mating were described in detail by ANNECKE (1962).

B. fuscicornis seems to have been long established in Israel. Several specimens exist in the collection of the Volcani Institute of Agricultural Research, Beit Dagan, but have not been hitherto identified. These were reared by Dr. E. RIVNAY from *Ceroplastes* in Rehovot more than 20 years ago (1 ♂ on *Myrtus*, 8. XII. 1941; 1 ♂ on mango, 5. XI. 1942; 1 ♀ on citrus, 29. XI. 1942).

³ Kindly identified by Dr. W. NIJVELDT, Wageningen, Netherlands.

***Cheiloneurus claviger* THOMSON (Encyrtidae)**

Until recently this species was misidentified, and data concerning its distribution and life history are very scarce (see CLARIDGE, 1958). It was recently recorded as a hyperparasite of various soft scales in the U.S.S.R., and appears to be distributed throughout Europe (SUGONJAEV, 1962).

Ch. claviger is a very rare hyperparasite of the soft brown scale in Israel. A single female specimen was obtained in the present study from a sample of this host, collected on citrus in the northern coastal plain (Gesher Haziv, 18. V. 1961). Two male specimens, obtained from the soft brown scale in the southern coastal plain (Kfar Bilu, 5. VI. 1961), are provisionally assigned to this species.

This is the first record of *Ch. claviger* from Israel. Incidentally, it seems to constitute also a new host-record for this species.

***Cheiloneurus paralia* (WALKER) (Encyrtidae)**

Like the preceding species, *Ch. paralia* appears to be a widely distributed, Palaearctic hyperparasite of soft scales that was misidentified until recently (see CLARIDGE, 1958; SUGONJAEV, 1962). It is rather non-discriminating in its host preferences, hyperparasitizing somewhat remotely related scale-insect species such as the soft brown scale and the Florida wax scale.

Ch. paralia is a rather common hyperparasite of the soft brown scale in Israel. It was reared from samples of this host collected on citrus mainly during May and June, i.e. during the peak of abundance of primary parasites, and even then it was usually obtained in small numbers only. Occasional specimens were reared from the soft brown scale also during July and October.

This species is also a very rare hyperparasite of the Florida wax scale. Altogether, only 17 specimens were obtained from samples of this host in the present study, most of them during September–October and a few during May–June. The Florida wax scale seems to serve as an alternate host when the preferred soft brown scale is scarce on citrus.

Ch. paralia is an arrhenotokous species, males comprising about one-third of its populations. Altogether, 137 ♀♀ and 64 ♂♂ were obtained in the present study from the soft brown scale, 12 ♀♀ and 5 ♂♂ from the Florida wax scale. The parasite was found throughout the coastal plain of Israel.

5 ♀♀ of *Ch. paralia* exist in the collection of the Volcani Institute of Agricultural Research, Beit-Dagan. These were reared by Dr. E. RIVNAY from the soft brown scale on mango (Rehovot, 2. VI. 1943) but have not been hitherto identified.

Males of *Ch. paralia* were erroneously recorded by the author as "*Microterys* sp." (ROSEN, 1962).

***Coccophagus bivittatus* COMPERE (Aphelinidae)**

C. bivittatus was first described by COMPERE (1931 c) as a parasite of soft scales in South Africa; it was later redescribed by DE SANTIS (1948) from Argentina and by ZINNA (1961) from Italy, and was recorded also from India (SANKARAN, 1955)

and Israel (ROSEN, 1962). Such a scattered distribution evidently indicates recent transfer by man.

This species is a very rare parasite of the soft brown scale in Israel. Only 8 ♀♀ and 7 ♂♂ were obtained in the present study from samples of this host collected on citrus in the northern coastal plain, and several additional specimens from samples collected on sycamore and mulberry in the southern coastal plain. This material agrees best with ZINNA's (1961) redescription of the species, differing in minor details of coloration from the specimens described by COMPERE (1931c) and by DE SANTIS (1948). Second-stage larvae of the scale are preferred by this parasite; the dorsum of parasitized hosts remains transparent throughout the parasite's development.

C. bivittatus is a "ditrophic primary arrhenoparasite", females developing as primary endoparasites and males as primary ectoparasites of the soft brown scale (ZINNA, 1961).

Coccophagus lycimnia (WALKER) (Aphelinidae)

This cosmopolitan species is a polyphagous parasite of soft scales (see DE SANTIS, 1948; NIKOL'SKAJA, 1952; PECK, 1963). Females develop as primary endoparasites, whereas males are obligatory direct hyperparasites, developing ectoparasitically on the immature stages of primary endoparasites of soft scales (FLANDERS, 1937, 1959).

Females of *C. lycimnia* were first reported from Israel as *C. cowperi* GIRAULT (ROSEN, 1962); males of this species were then recorded as "males of a *Coccophagus* species belonging to the *lecanii* group". Female specimens of *C. lycimnia* may be distinguished from those of *C. cowperi* by the coloration of the hind tibiae, being blackish basally in the former and entirely yellow in the latter species. This character proved to be very variable in the female specimens studied in the present investigation, hind tibiae ranging from almost entirely yellow to shining black on the basal two-thirds or more. The male specimens, however, agree best with COMPERE's (1931c) characterization of *C. lecanii* (FITCH) (= *C. lycimnia*). The Israel material is, therefore, for the time being referred to *C. lycimnia*, although more than a single species may be involved.

C. lycimnia is the most abundant species of *Coccophagus* in citrus groves throughout the coastal plain and in the interior valleys of Israel. It is an important parasite of the soft brown scale, preferring dense host colonies. It was obtained mainly from April through June, when dense, ant-attended colonies of the soft brown scale were common. Numerous specimens were reared also from small host colonies, collected all the year round, except during September and October, when the soft brown scale was extremely rare on citrus.

Males of *C. lycimnia* usually outnumbered the females; batches of males only were often obtained from samples of the soft brown scale. Altogether, 541 ♀♀ and 692 ♂♂ were reared from this host. On several occasions, a few male specimens emerged from isolated, mature scales, in which specimens of *Metaphycus flavus* (HOWARD) had previously developed. Some of the latter had even complet-

ed their development up to maturity. The primary parasites had thus apparently served as hosts of the *C. lycimnia* males.

As a primary parasite, *C. lycimnia* develops solitarily in immature, medium-sized scales. The dorsum of the host turns black during the parasite's development.

Specimens of *C. lycimnia* were very rarely reared also from the Florida wax scale. Altogether, only 6 ♀♀ and 2 ♂♂ were obtained from samples of this host, collected in citrus groves in the coastal plain from May through September. *C. lycimnia* is, of course, an insignificant parasite of this scale in Israel. The Florida wax scale may, however, serve as an alternate host during periods of extreme scarcity of the soft brown scale.

C. lycimnia is, apparently, the species recorded by RIVNAY (1944) from Palestine as "*Coccophagus* sp." Several specimens exist in the collection of the Volcani Institute of Agricultural Research at Beit Dagan. These were reared by Dr. E. RIVNAY from citrus-infesting soft brown scale during May, 1940.

***Coccophagus scutellaris* (DALMAN) (Aphelinidae)**

C. scutellaris is a cosmopolitan, well-known parasite of various soft scales. Recorded hosts include the soft brown scale, the black scale, and the fig wax scale (NIKOL'SKAJA, 1952). Extensive bibliographies and a detailed synonymy of this species were given by COMPERE (1931c) and PECK (1963).

RIVNAY (1944) related that "this species was obtained on several occasions by BODENHEIMER during the years 1927—1929", adding that he (RIVNAY) never succeeded in rearing the parasite from the soft brown scale. BODENHEIMER (1951), on the other hand, recorded *C. scutellaris* as "a common parasite of *Coccus hesperidum* and *Ceroplastes floridensis* in Palestine".

In the present study, *C. scutellaris* was repeatedly obtained from dense, ant-attended colonies of the soft brown scale, but never from sparse populations of this host, nor from any other species of soft scale. It was reared from samples of the soft brown scale collected on citrus throughout the coastal plain (from January through June) and in the Jezreel Valley (from April through June) as well as on ornamentals in the Jordan Valley (ROSEN, 1962).

The peculiar biology of *C. scutellaris* was studied in detail by CENDAÑA (1937) and by FLANDERS (1937, see also 1959). The female develops as a primary endoparasite of the soft scale, preferring non-gravid scales. The pale larva and blackish pupa of the parasite may be easily recognized through the transparent dorsum of the host, the latter staying alive until the mature parasite emerges. The male develops as a direct, secondary endoparasite, preferably in the female larva of its own species. There is a great preponderance of females over males; only 31 males were obtained in the present study, as compared to 240 female specimens.

***Diversinervus elegans* SILVESTRI (Encyrtidae)**

This beautiful species was recorded as a primary parasite of various soft scales in Africa and Australia (SILVESTRI, 1914; COMPERE, 1931a). It was recently introduced into California (VAN DEN BOSCH et al., 1955).

In Israel, *D. elegans* is the most abundant parasite of the black scale, *Saissetia oleae*. It prefers mature scales, in which it develops gregariously, and was reared from samples of such scales taken on citrus from May through August. The latter date is of special interest, as by August all citrus-infesting mature black scales are long dead and dry. The emergence of specimens of *D. elegans* from such hosts may be explained by the observation of VAN DEN BOSCH et al. (1955) that pupae of the parasite may sometimes remain in the host for long periods before adult emergence, an adaptation that "is expected to be advantageous in carrying *D. elegans* over periods of host scarcity such as occur in single-brooded areas".

In irrigated olive groves, the parasite was reared also from samples of the black scale collected from November through January.

D. elegans is a rare and insignificant parasite of the Florida wax scale in Israel. It was obtained in small numbers from samples of this pest collected on citrus from August through December. The Florida wax scale serves as an alternate host, enabling the parasite to exist in citrus groves almost all the year round.

BODENHEIMER (1951) recorded *D. elegans* as a parasite of the soft brown scale. During the present study, only 2 ♀♀ of the parasite were obtained from this host.

A single specimen of *D. elegans* was reared from the hemispherical scale, *Saissetia hemisphaerica* (TARGIONI) on *Cycas* (1 ♀, Rehovot, 27. IX. 1962). This seems to be a new host-record for this parasite.

D. elegans is an arrhenotokous species, males being rather abundant, although far less so than females. Altogether, 292 ♀♀ and 163 ♂♂ were obtained in the present study from the black scale, 40 ♀♀ and 28 ♂♂ from the Florida wax scale.

***Enargopelte nigra* (MERCET) (Pteromalidae)**

E. nigra, first described as a variety of *Scutellista cyanea* MOTSCHULSKY, was reported as a parasite of *Lecaniodiaspis sardoa* TARGIONI (Hem.: Asterolecaniidae) in Spain and North Africa (see MASI, 1931). It was recently recorded from Cyprus as an egg-predator of the fig wax scale (GEORGHIOU, 1957; WOOD, 1963). This is the first record of this species from Israel.

E. nigra is a rare egg-predator of the Florida wax scale on citrus in Israel. It was reared on several occasions from samples of this pest taken in the southern coastal plain (1 ♀, Gan Yavneh, 6. VII. 1961; 25 ♀♀, 31 ♂♂, Ashqelon, 6. X. 1961; 6 ♀♀, 2 ♂♂, Ashqelon, 6. VI. 1962), and is, apparently, of no economic importance.

A part of this material was erroneously referred by the author to *Scutellista cyanea* var. *obscurata* SILVESTRI (ROSEN, 1962).

***Encyrtus lecaniorum* (MAYR) (Encyrtidae)**

First discovered in a greenhouse near Vienna, this Palearctic species is found in the open throughout southern Europe, and in greenhouses as far to the north as Finland and the Leningrad region; it was recorded also from Central Asia, North Africa, southern India and Malaya (see NIKOL'SKAJA, 1952; TRJAPITZIN, 1957), and recently also from Argentina (DE SANTIS, 1957) and South

Africa (ANNECKE, 1964). Confirmed host-records include only the soft brown scale and the citricola scale, *Coccus pseudomagnoliarum* (KUWANA) (TRJAPITZIN, 1957).

RIVNAY (1944) and BODENHEIMER (1951) recorded *E. lecaniorum* as the dominant parasite of the soft brown scale in Palestine. In the present study the species was reared most often from small, localized colonies of this host, and proved to be very rare, and apparently of no economic value. It was obtained from samples of the soft brown scale collected on citrus along the coastal plain all the year round, and also in the Jezreel Valley.

E. lecaniorum was reared in the laboratory for several consecutive generations, soft brown scales infesting "Butternut" squash serving as hosts. The parasite proved to be capable of continuous parthenogenetic development, unfertilized females readily ovipositing in soft scales, whence female progeny subsequently emerged. Males are very scarce: A single male was found among 65 specimens reared from field-collected hosts, and 6 males—among over 100 laboratory-reared specimens. Scarcity of males was noted also by RUBTSOV (1954), who recorded a ratio of 50—100 ♀♀ to 1 ♂ in this species.

The parasite develops solitarily in medium-sized and full-grown individuals of the soft brown scale; ovipositing scales are also accepted as hosts. Parasitized hosts may be readily recognized by their humped, swollen appearance and greyish colour. Development of female parasites took an average of 23.3 days at a constant temperature of 24 °C, 18.2 days at 28 °C. The parasite failed to develop at 32 °C. Oviposition commenced on the first day after emergence.

E. lecaniorum is regarded as a highly efficient parasite of the soft brown scale in the USSR (RUBTSOV, 1954). As previous reports from Israel had also regarded it as an important parasite, efforts were made by the U.S. Department of Agriculture to introduce it from Israel into the U.S.A. Several small consignments, containing field-collected parasitized hosts as well as laboratory-reared females of the parasite, were sent by the author during the summer of 1962 to Mr. B. PUTTLER of the USDA Insect Identification and Parasite Introduction Research Branch, upon the latter's request. These parasites were propagated on the soft brown scale at Moorestown, New Jersey, and several thousands of their progeny were released in many infested citrus groves in Texas during 1962 and 1963. The species, however, seems to have failed to establish itself in Texas. The thelytoky of *E. lecaniorum* was further confirmed by the rearings at Moorestown (B. PUTTLER, personal communication, 1962—1965).

***Eupteromalus spec.* (Pteromalidae)**

Species of *Eupteromalus* have been recorded as primary and secondary parasites of various insects, including Lepidoptera, Coleoptera and Diptera (Syrphidae, Cecidomyiidae), but have not been hitherto known to be associated with scale insects (see PECK, 1963; PECK et al. 1964, a.o.). Several specimens of a still undetermined species of *Eupteromalus* were reared in the present study from samples of the soft brown scale, collected on citrus in the southern coastal plain

during the first week of June (2 ♀♀, 2 ♂♂, Ashqelon, 5. VI. 1961; 1 ♀, 1 ♂, Gan Yavneh, 6. VI. 1962). The exact host-relationships of this rare species are as yet unknown.

***Marietta exitiosa* COMPERE (Aphelinidae)**

Like so many hyperparasites, this South African species attacks a characteristically wide range of hosts. COMPERE (1936) and ANNECKE (1964) recorded it from mealybugs, armoured and soft scales, as well as from psyllids and an *Asterolecanium*, in all of which it is undoubtedly hyperparasitic. It is a common species in citrus groves in South Africa.

M. exitiosa is a rather rare hyperparasite of scale insects in Israel. Only once was it reared in considerable numbers — from a sample of the soft brown scale, collected on citrus in the southern coastal plain (19 ♀♀, 20 ♂♂, Nitzanim, 23. I. 1963). A few additional specimens were reared from the Florida wax scale, collected on citrus in the Jezreel valley (ROSEN, 1962) and from citrus-infesting armoured scales in the coastal plain and in the Jordan Valley (ROSEN, 1965). This species was also rarely obtained from olive-infesting black scale (ROSEN, 1962) and from the fig wax scale infesting sycamore in the southern coastal plain (1 ♀, Hafetz Hayim, 10. XII. 1962). Nevertheless, it seems to be economically insignificant in Israel.

COMPERE (1936) described the female of *M. exitiosa* with the club slightly shorter than the penultimate antennal joint. As figured by ANNECKE (1964) this species has the club rather slightly longer than the penultimate joint. Israel specimens agree with ANNECKE's concept of the species in this respect.

***Metaphycus flavus* (HOWARD) (Encyrtidae)**

First described from southern USA (Florida), this species has since been recorded as far to the north as New York, and also from South America (Chile, Peru, Argentina), the West Indies (Trinidad, Puerto Rico), India, Central Europe (Hungary), and around the Mediterranean Basin (Spain, France, Italy, Sicily, Cyprus, Israel, Tunisia, Morocco) (see TIMBERLAKE, 1916; MERCET, 1921; THOMPSON, 1954; COMPERE, 1957; PECK, 1963; WOOD, 1963; ERDÖS, 1964). The species is usually known as an endoparasite of various soft scales. Several records reporting it as an ectoparasite of armoured scales are apparently erroneous (see COMPERE, 1957).

M. flavus was first recorded from Israel by BODENHEIMER (1937). It was reported by RIVNAY (1944) as a very rare parasite of the soft brown scale. BODENHEIMER (1951) listed it, under the synonym *Aphycus hesperidum* MERCET, also as a parasite of citrus armoured scales.

In the present study this species proved to be the most abundant parasite of the soft brown scale on citrus in Israel. It was reared from samples of this host collected throughout the coastal plain, as well as in the interior valleys, all the year round. It was common even in extremely sparse populations of the scale, a fact that attests to its excellent host-searching capacity (ROSEN, 1962).

All stages of the soft brown scale are freely attacked by *M. flavus*, the parasite developing solitarily in younger larvae and gregariously in mature females of the host. Both sexes of the parasite may develop in a single host, whence up to 13 adult parasites have been obtained. The golden larvae and blackish pupae of the parasite, enclosed in distinct, cell-like quarters, may be easily seen through the transparent dorsum of the host.

The species is arrhenotokous. Altogether, 1036 ♀♀ and 621 ♂♂ were reared from the soft brown scale in the present study. The sex ratio, however, varied with the season (see Table 1): Females greatly predominated in the spring and early summer, when the parasite was most abundant and better opportunities for copulation existed; during other seasons, when the parasite, as well as its host, were relatively rare, a higher percentage of males was produced.

Table 1

Emergence of *Metaphycus flavus* from samples of the soft brown scale, collected on citrus in the coastal plain (1961–1963)

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
♀♀	17	10	13	129	451	77	22	1	—	—	22	15
♂♂	14	15	10	84	186	48	27	—	—	—	17	26

M. flavus is an insignificant parasite of the black scale in Israel. Only one female specimen was obtained from this host on citrus in the present study (Kfar Bilu, 5. II. 1962). An additional female specimen was reared from a sample of olive-infesting black scale (Ein Tsurim, 13. XII. 1961). *M. flavus* parasitizes only early-second-stage larvae of this host (VAN DEN BOSCH et al., 1955), and these may be found on citrus in Israel only during autumn, when the parasite is very rare due to the scarcity of the soft brown scale.

Several specimens of *M. flavus* have been obtained from a sample of the hemispherical scale, *Saissetia hemisphaerica* (TARGIONI), collected on ornamentals in the coastal plain (Nes-Ziona, 31. X. 1964).

Metaphycus zebratus (MERCET) (Encyrtidae)

M. zebratus was described from Spain with no reference to its biology. It was recently recorded from Hungary as a parasite of various soft scales (ERDÖS, 1964).

This species is a very rare parasite of *Ceroplastes* spp. in Israel. Altogether, 8 ♀♀ and 4 ♂♂ were reared in the present study from samples of the Florida wax scale, collected on citrus in the Western Galilee and in the Jezreel Valley during September and October, 1961 (ROSEN, 1962). An additional female specimen, apparently belonging to the same species, was obtained from a sample of the fig wax scale, collected on sycamore in the southern coastal plain (Hafetz Hayim, 10. XII. 1962). The species thus seems to be rather widespread in Israel, but is nevertheless extremely rare and economically insignificant. *Ceroplastes* spp. are, incidentally, new hosts of *M. zebratus*.

Microterys flavus (HOWARD) (Encyrtidae)

Microterys flavus is a widely distributed parasite of various soft scales. It has hitherto been recorded from the Far East, North America, North and South Africa, Europe, Australia, New Zealand, and around the Mediterranean Basin (see THOMPSON, 1954; ANNECKE, 1964; and others). If this almost cosmopolitan distribution was assisted by man, this must have taken place relatively long ago, for several geographical strains or races of this species, differing in their host-preferences, are known at present.

The California strain of *M. flavus* prefers the soft brown scale to any other host, and is reported as a specific, efficient parasite of that pest; only rarely does it attack other soft scales, such as *Parthenolecanium corni* (BOUCHÉ) and *Coccus pseudomagnoliarum* (KUWANA). This strain was apparently introduced into California from the Orient (see for instance TIMBERLAKE, 1913; BARTLETT & LAGACE, 1961). A distinct strain was reported from the USSR under the synonym *M. frontatus* (MERCET), preferring *Coccus pseudomagnoliarum*, *Ceroplastes japonicus* GREEN and *Pulvinariella mesembryanthemi* (VALLOT) as hosts; this strain only rarely attacks the soft brown scale and is insignificant as a natural enemy of this pest (RUBTSOV, 1954, 1961). An additional strain, recently discovered in Pakistan, prefers the soft brown scale but parasitizes freely also the black scale, which is not attacked by any of the other strains (BARTLETT & LAGACE, 1961).

The local Israeli strain of *M. flavus*, previously recorded as *M. frontatus*, prefers the soft brown scale to any other host. It may attack also the mango shield scale, *Coccus mangiferae* (GREEN) (AVIDOV & ZAITZOV, 1960) and the Florida wax scale, but not the black scale.

The synonymy of *M. frontatus* (MERCET) with *M. flavus* (HOWARD) was first noted by RUBTSOV (1961). The author had the opportunity to study several specimens of *M. flavus*, from a stock reared on the soft brown scale at the insectary of the Department of Biological Control, University of California, Riverside, and found them to be indistinguishable from local specimens of *M. frontatus*, the identity of which had been confirmed by Dr. CH. FERRIÈRE. Although no type material was examined, it seems safe to conclude that *M. frontatus* should be regarded as a junior synonym of *M. flavus*.

RIVNAY (1944), who first reported this species from Palestine, recorded it as a parasite of the soft brown scale and the Florida wax scale in the southern coastal plain. He noted that the species had been considered rare until 1942, when his own rearings indicated that it might be rather common.

In the present study, *Microterys flavus* proved to be a very abundant parasite of the soft brown scale, second only to *Metaphycus flavus* in this pest's populations. Like *Metaphycus flavus*, it is common mainly at low host-densities, a fact attesting to its high efficacy as a parasite.

M. flavus parasitizes medium-sized larvae and fully-grown females of the soft brown scale, developing solitarily in smaller and gregariously in larger host

individuals. Up to 5 parasites, of both sexes, were observed to concomitantly complete their development within a single mature scale.

M. flavus is a rather common parasite of the Florida wax scale in Israel, developing either solitarily or gregariously. It may, however, be regarded only as a minor natural enemy of this pest, being far less abundant in its populations than are *Tetrastichus ceroplastae* or *Scutellista cyanea*.

The parasite is common in all the citrus-growing regions of Israel, along the coastal plain as well as in the interior valleys. It is present in citrus groves all the year round, having been reared from samples of the soft brown scale collected on citrus from November through August and from samples of the Florida wax scale collected from April through October. In both hosts it was most abundant in the spring (April–May), at which period it was sometimes even the dominant parasite of the Florida wax scale (Fig. 3).

The developmental biology of *M. flavus* was recently discussed in detail by BARTLETT & BALL (1964). The species is arrhenotokous; altogether, 869 ♀♀ and 507 ♂♂ have been obtained in the present study. The sex-ratio varied with the host species: Females comprised 56.6% of 951 specimens reared from the soft brown scale, as compared to 77.9% of 425 specimens reared from the Florida wax scale. These ratios did not change considerably with the seasons of the year.

***Microterys tricoloricornis* (DE STEFANI) (Encyrtidae)**

M. tricoloricornis is a Mediterranean parasite of the soft brown scale (ERDÖS, 1957) that was recently recorded also in the Nearctic region (see PECK, 1963). Its presence in Israel is still uncertain, as only a single male specimen, that, in spite of its poor condition, seems to agree with its description, has been obtained in the present study. It was reared from a sample of the soft brown scale, collected on citrus in the Jordan Valley (Kinnereth, 25. IV. 1961).

Earlier records of this species from Israel should be regarded as doubtful. It was first recorded in Palestine by BODENHEIMER (1937), who listed it, under the synonym *Encyrtus consobrinus* MERCET, as a parasite of soft scales. RIVNAY (1944) stated that he was unable to separate this species from *M. frontatus* (MERCET) [= *M. flavus* (HOWARD)]. It is indeed possible that specimens of *Microterys flavus*, sent by Dr. RIVNAY for determination, were sometimes misidentified as *M. tricoloricornis* (Dr. CH. FERRIÈRE, personal communication, 1962). One of RIVNAY's specimens, still in the collection of the Volcani Institute of Agricultural Research under the name of *M. consobrinus*, was found by the writer to be a female of *M. flavus*.

At any rate, *M. tricoloricornis* is an insignificant parasite of the soft brown scale in Israel.

***Pachyneuron siculum* DELUCCHI (Pteromalidae)**

DELUCCHI (1955) described this species as new in a revision of the European species of *Pachyneuron* WALKER, in which he has shown that the old species

"*P. coccorum* (L.)" is at present unrecognizable and must be treated as a nomen nudum. "*P. coccorum*" had often been recorded as a widely distributed hyperparasite of scale insects, and it may be assumed that many records pertaining to it should now be referred to *P. siculum*.

P. siculum was described from Sicily, where "predators of *Pseudococcus* sp." were suggested as its possible hosts (DELUCCHI, 1955). It was first reported from Israel as a hyperparasite of the soft brown scale (ROSEN, 1962).

Like so many hyperparasites, *P. siculum* proved to be rather non-specific in its host-preferences. Hosts in Israel include the soft brown scale, the Florida wax scale, and the mealybugs *Planococcus citri* (Risso) and *Pseudococcus citriculus* GREEN. In addition, it was recently obtained from mummified larvae of the two-spotted lady beetle, *Chilocorus bipustulatus* (LINNAEUS) (ROSEN and GERSON, 1965). In all these hosts it parasitizes, presumably, the larvae of primary parasitic Encyrtidae, such as *Microterys*, *Anagyrus* and *Homalotylus*.

P. siculum is the most abundant hyperparasite of the soft brown scale in Israel. It was obtained from samples of this scale only when primary parasitization reached its peak, from May through July. Altogether, 282 specimens were reared from this host in the present study, about 38% of them females.

Several specimens of *P. siculum* were reared from samples of the Florida wax scale, collected on citrus in the southern coastal plain of Israel during May and June (Gan Yavneh, Ashqelon, 1961–1962). Altogether, only 6 ♀♀ and 8 ♂♂ were obtained from this host in the present study.

The species occurs in all the citrus-growing regions of Israel. Although more abundant than any other hyperparasite of the soft brown scale, it does not seem to cause any significant damage.

Prospaltella spec. (Aphelinidae)

Only males of this rather rare species have been obtained. They were reared on several occasions from samples of the soft brown scale, collected on citrus along the coastal plain and in the interior valleys (ROSEN, 1962). They were certainly hyperparasitic in this host, being sometimes obtained together with specimens of *Metaphycus flavus* from a single isolated scale. On two occasions, considerable numbers have been reared (11 ♂♂, Kabri, 18. V. 1961; 11 ♂♂, Rosh Haniqra, 18. V. 1961), but on the whole, the species seems to be insignificant on citrus. Altogether, 51 ♂♂ were obtained from the soft brown scale.

Some additional specimens were obtained from the Florida red scale, *Chrysomphalus aonidum* (LINNAEUS), on citrus (ROSEN, 1965).

Scutellista cyanea MOTSCHULSKY (Pteromalidae)

This well-known species has supposedly originated from southeastern Asia (RUBTSOV, 1954). First described from Ceylon, it has become well distributed in subtropical and temperate regions all over the world, into which it was either accidentally or purposely introduced (see SMITH & COMPERE, 1928). The interesting story of its introduction into California was narrated in detail by HOWARD and FISKE (1911, p. 31–33).

S. cyanea has long been established in Israel. GEORGE COMPERE first recorded it from Jaffa at the turn of the present century (SMITH and COMPERE, 1928); BODENHEIMER (1930, 1951) listed it as an important parasite of various soft scales.

In the present study, *S. cyanea* proved to be a common parasite of the Florida wax scale. Present on citrus all the year round, it was most abundant in late summer and autumn, being rather scarce during other seasons. Of a total of 635 specimens reared from the Florida wax scale, 594 were obtained from samples collected from August through October, 303 during October alone. This species was often the dominant parasite of the Florida wax scale in younger observation plots during the autumn peak of parasitization (Figs. 8, 9).

S. cyanea was repeatedly reared also from the black scale, but only when mature, ovipositing females of this pest were present on citrus, i.e. only during June and July. It was less frequent in this host than *Diversinervus elegans*.

Two male specimens of *S. cyanea* were obtained from a sample of the fig wax scale, taken on citrus in the Upper Galilee (Ayelet Hashahar, 24. XII. 1964).

The parasite was found throughout the coastal plain, in the interior valleys, and in the hill regions of Israel.

S. cyanea is an egg-predator and a facultative ectoparasite of soft scales (SMITH & COMPERE, 1928). BODENHEIMER (1930, 1951) listed several species of scales as its hosts in Israel, including the Florida wax scale, the fig wax scale, the black scale and the hemispherical scale, *Saissetia hemisphaerica* (TARGIONI), as well as the soft brown scale. RIVNAY (1944) and the present writer, on the other hand, have never obtained it from the soft brown scale. The eggs of the soft brown scale hatch a few hours after oviposition, and are not accumulated under the body of the female, as is the case with species of *Saissetia* and *Ceroplastes*; this may account for the fact that *S. cyanea* is, at the most, only an occasional parasite of this scale.

The species is apparently arrhenotokous. SMITH & COMPERE (1928) noted that "the proportion of males to females did not vary much, but in general the males were slightly in excess". In the present study, males were found to predominate, females comprising only 10.9% of the specimens of *S. cyanea* obtained from the Florida wax scale. Many samples yielded males only.

The economic importance of *S. cyanea* is greatly reduced by the fact that several offspring of the parasitized scales are usually able to evade the parasite and complete their development unharmed.

Tetrastichus ceroplastae (GIRAULT) (Eulophidae)

GIRAULT (1916) described *T. ceroplastae* as a parasite of *Ceroplastes galeatus* NEWSTEAD from Uganda. Israeli specimens, identified by Dr. B. D. BURKS of the U.S. National Museum by comparison with type material, differed in details of coloration from GIRAULT's short description. GIRAULT (1916) described the species as greenish black, with the antennal scape partly metallic, whereas our specimens are black, with the scape completely yellowish. Recently a species of

Tetrastichus, parasitic in the fig wax scale in southern France, was recorded by BÉNASSY and BILIOTTI (1963) as "*T. gibbus* DOMENICHINI, nomen nudum". This species is identical with the one recorded here as *T. ceroplastae* (G. DOMENICHINI, personal communication, 1964).

T. ceroplastae is by far the most abundant parasite of the Florida wax scale in Israel. It was obtained from samples of this pest collected on citrus all the year round (see Table 2), showing spring and autumn peaks. It was nearly always the dominant parasite of the Florida wax scale at the spring peak of parasitization (Figs. 2, 9), often during all seasons (Figs. 4–7, 10–11), especially in older plots. The species has probably risen to its present dominant position relatively recently, for BODENHEIMER (1951) does not even mention any species of *Tetrastichus* as parasites of wax scales in Israel.

The parasite was found throughout the coastal plain, as well as in the hill regions of Israel. It was rare in the Jezreel Valley, and was absent from the few samples of the Florida wax scale taken on ornamentals in the Jordan Valley.

T. ceroplastae develops as a solitary endoparasite in second-stage larvae and mature females of the Florida wax scale. Parasitized scales are easily recognizable by their brittle, blackish venter. The adult wasps live up to 3 months at room temperatures in summer. The parasite is apparently arrhenotokous; of a total of 3351 specimens, reared in the present study from the Florida wax scale, 2016 were females and 1334 males (the one remaining specimen, a gynandromorph, will be described elsewhere). Females outnumbered the males during all seasons, except for January and August (see Table 2).

Table 2

Emergence of *Tetrastichus ceroplastae* from samples of the Florida wax scale taken on citrus (1961–1963)

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
♀♀	5	43	49	548	405	155	56	112	252	288	27	76
♂♂	11	20	24	273	377	113	28	123	172	121	20	52

T. ceroplastae was the most abundant parasite obtained from the fig wax scale in the present study. Several specimens were reared from small samples of this host, collected on citrus in the northern coastal plain and in Upper Galilee. It was also very frequent in samples of the fig wax scale taken on sycamore in the southern coastal plain.

A single specimen of *T. ceroplastae* was reared from the soft brown scale (1 ♀, Kabri, citrus, 15. VI. 1961).

Tetrastichus sicarius SILVESTRI (Eulophidae)

This species, first described by SILVESTRI (1914) as a parasite of *Chionaspis olivina* (LEONARDI) (Hem.: Diaspididae), is now known as a primary parasite of *Ceroplastes* spp. (B. D. BURKS, personal communication, 1963).

Several specimens of *Tetrastichus*, reared in the present study from the Florida wax scale, were identified by Dr. B. D. BURKS as *T. sicarius*. The writer has found it extremely difficult to separate this species from minute specimens of *T. ceroplastae*, with which it was often reared together. The parasite was obtained in small numbers from second-stage larvae and mature females of the Florida wax scale, collected on citrus throughout the coastal plain of Israel from April through December.

Tetrastichus spec. (Eulophidae)

An apparently undescribed species of *Tetrastichus*, believed to be hyperparasitic, was reared from samples of the Florida wax scale collected on citrus from April through November all over the coastal plain of Israel. Although more abundant than any other hyperparasite of the Florida wax scale, it was usually rather rare. Only during June was this species obtained in considerable numbers, thus following the peak of abundance of the primary *T. ceroplastae*, together with which it was usually reared. A total of 89 ♀♀ and 56 ♂♂ of this species were obtained from the Florida wax scale during the present study, half of them from samples taken in June.

This species was occasionally obtained also from the soft brown scale on citrus (1 ♀, 1 ♂, Ashqelon, 5. VI. 1961), and from samples of the fig wax scale infesting fig and sycamore.

Acknowledgements

This investigation was partly supported by a grant from the Citrus Marketing Board of Israel. The author is grateful to Professor Z. AVIDOV, under whose guidance this study was conducted in partial fulfillment of the requirements for the degree of Doctor of Philosophy of the Hebrew University, and to Dr. I. HARPAZ for critical reading of the manuscript and many helpful suggestions. Thanks are likewise due to Mr. U. GERSON for supplying useful information. Sincerest thanks are especially due to Dr. CH. FERRIÈRE, Genève, to Dr. V. DELUCCHI, Zürich, to Dr. B. D. BURKS, Washington, to Mr. H. COMPÈRE, Riverside, to Dr. G. DOMENICHINI, Milano, to Dr. A. SUNDHOLM, Karlskrona, and to Dr. M. F. CLARIDGE, Cardiff, for their invaluable help in kindly determining Hymenopterous specimens.

Summary

Populations of *Ceroplastes floridensis* COMSTOCK, *Ceroplastes rusci* (LINNAEUS), *Saissetia oleae* (BERNARD), and *Coccus hesperidum* LINNAEUS (Hemiptera: Coccidae), infesting citrus, were regularly sampled in monthly and bimonthly surveys covering the main citrus-growing regions of Israel. Altogether, 23 species of parasitic Hymenoptera were reared from samples of these pests, including 14 species of primary parasites, 6 species of hyperparasites, and 3 species of uncertain status. Trends of parasitism in populations of *C. floridensis* and *C. hesperidum* were followed in detail. The distribution, phenology and economic importance of each parasite species are discussed, together with the available biological data. — Only *C. hesperidum* is kept under satisfactory biological control on citrus in Israel. *C. floridensis* supports a relatively rich parasite fauna, but is nevertheless a serious pest. *S. oleae* is attacked by only a few parasite species. *C. rusci* is an insignificant pest of citrus in Israel.

Zusammenfassung

Populationen von Citrus befallenden Cocciden (*Ceroplastes floridensis* COMSTOCK, *Ceroplastes rusci* (LINNAEUS), *Saissetia oleae* (BERNARD) und *Coccus hesperidum* LINNAEUS

(Hemiptera)) wurden regelmäßig (monatlich oder zweimonatlich) in den hauptsächlich Citrusanbaugebieten Israels untersucht. Insgesamt wurden von diesen Schädlingen 23 Arten parasitischer Hymenopteren gezogen, darunter 14 Arten Primärparasiten, 6 Arten Hyperparasiten und 3 Arten von unbekanntem Status. Der Verlauf des Parasitismus in Populationen von *Ceroplastes floridensis* und *Coccus hesperidum* wurde genau verfolgt. Die Verbreitung, Phänologie und wirtschaftliche Bedeutung jeder Parasitenart wird zusammen mit den bisher bekannten biologischen Daten erörtert. — Nur *Coccus hesperidum* steht unter ausreichender biologischer Kontrolle an Citrus in Israel. *Ceroplastes floridensis* hat eine relativ reiche Parasitenfauna, ist nichtsdestoweniger ein ernstlicher Schädling. *Saissetia oleae* wird nur von wenigen Parasitenarten befallen. *Ceroplastes rusci* ist ein unbedeutender Citrusschädling in Israel.

Резюме

Регулярно monthly или двухмесячно исследовались в Израилии популяции черепашек, которые заражают цитрусы (*Ceroplastes floridensis* COMSTOCK, *Ceroplastes rusci* (LINNAEUS), *Saissetia oleae* (BERNARD) и *Coccus hesperidum* LINNAEUS (Hemiptera)). Выращивались из этих вредителей 23 вида паразитических перепончатокрылых, из этих 14 вида первичные паразиты, 6 видов гиперпаразиты и 3 вида незнакомого положения. Чётко наблюдался ход паразитовки в популяциях *Ceroplastes floridensis* и *Coccus hesperidum*. Распространение, фенология и промышленное значение каждого вида паразитов обсуждались вместе с биологическими данными. — Только *Coccus hesperidum* стоит в Израилии на цитрусах под достаточной биологической контролью. *Ceroplastes floridensis* имеет богатую фауну паразитов, но всё же является серьёзным вредителем. *Saissetia oleae* повреждается только некоторыми вредителями. *Ceroplastes rusci* неважный вредитель цитруса в Израилии.

References

- ANNECKE, D. P., Records and descriptions of African Encyrtidae — 1. (Hymenoptera Chalcidoidea). Journ. Entomol. Soc. S. Africa, **25**, 170—191; 1962.
- , The encyrtid and aphelinid parasites (Hymenoptera: Chalcidoidea) of soft brown scale, *Coccus hesperidum* LINNAEUS (Hemiptera: Coccidae) in South Africa. S. Afric. Dept. Agric. Tech. Serv., Entomol. Mem., **7**, 74 p.; 1964.
- AVIDOV, Z.; ROSEN, D. & GERSON, U., A comparative study on the effects of aerial versus ground spraying of poisoned baits against the Mediterranean fruit fly on the natural enemies of scale insects in citrus groves. Entomophaga, **8**, 205—212; 1963.
- AVIDOV, Z. & ZAITZOV, A., On the biology of the mango shield scale *Coccus mangiferae* (GREEN) in Israel. Ktavim, **10**, 125—137; 1960.
- BARTLETT, B. R., Biological races of the black scale, *Saissetia oleae*, and their specific parasites. Ann. Entomol. Soc. Amer., **53**, 383—385; 1960.
- BARTLETT, B. R. & BALL, J. C., The developmental biologies of two encyrtid parasites of *Coccus hesperidum* and their intrinsic competition. Ann. Entomol. Soc. Amer., **57**, 496—503; 1964.
- BARTLETT, B. R. & LAGACE, C. F., A new biological race of *Microterys flavus* introduced into California for the control of lecaniine coccids, with an analysis of its behavior in host selection. Ann. Entomol. Soc. Amer., **54**, 222—227; 1961.
- BÉNASSY, C. & BILIOTTI, E., *Ceroplastes rusci* L. (Homoptera, Coccoidea, Lecaninae) exemple intéressant pour l'étude de la dynamique des populations. Entomophaga, **8**, 213—217; 1963.
- BEN-DOV, Y., On interrelationships between the California red scale and its natural enemies in citrus groves. M. Sc. thesis, The Hebrew Univ., Faculty of Agric., Rehovot, 47 p. [in Hebrew]; 1963.

- BODENHEIMER, F. S., Die Schädlingfauna Palästinas. Verlag PAUL PAREY, Berlin, 438 p.; 1930.
- , *Prodromus faunae Palaestinae*. Mem. Inst. d'Egypte, **33**, 286 p.; 1937.
- , *Citrus entomology in the Middle East*. W. JUNK Publishers, The Hague, 663 p.; 1951.
- BODKIN, G. E., The fig wax scale (*Ceroplastes rusci* L.) in Palestine. Bull. Entomol. Res., **17**, 259—263; 1927.
- BORKHSENIUS, N. S., Fauna of USSR: Homoptera, IX: Coccoidea: Coccidae. Akad. Nauk SSSR, 493 p.; 1957.
- CENDAÑA, S. M., Studies on the biology of *Coccophagus* (Hymenoptera), a genus parasitic on nondiaspine Coccidae. Univ. Calif. Publ. Entomol., **6**, 337—400; 1937.
- CLARIDGE, M. F., The British and Scandinavian species of the genus *Cheiloneurus* WESTWOOD (Hym., Encyrtidae). Entomol. Mon. Mag., **94**, 156—161; 1958.
- CLAUSEN, C. P., Entomophagous insects. McGRAW-Hill, 688 p.; 1940.
- COMPÈRE, H., A revision of the genus *Diversinervus* Silvestri, encyrtid parasites of coccids (Hymenoptera). Univ. Calif. Publ. Entomol., **5**, 233—245; 1931a.
- , A discussion of the parasites of *Saissetia oleae* (BERN.) collected in Eritrea. Univ. Calif. Publ. Entomol., **5**, 247—255; 1931b.
- , A revision of the species of *Coccophagus*, a genus of hymenopterous coccid-inhabiting parasites. Proc. U. S. Nat. Mus., **78**, 1—132; 1931c.
- , Notes on the classification of the Aphelinidae with descriptions of new species. Univ. Calif. Publ. Entomol., **6**, 277—322; 1936.
- , A second report on some miscellaneous African Encyrtidae in the British Museum. Bull. Entomol. Res., **30**, 1—26; 1939.
- , Parasites of the black scale, *Saissetia oleae*, in Africa. Hilgardia, **13**, 387—425; 1940.
- , Descriptions of species of *Metaphycus* recently introduced into California and some corrections. Boll. Lab. Entomol. Agr. Portici, **15**, 221—230; 1957.
- DELUCCHI, V., Beiträge zur Kenntnis der Pteromaliden (Hym., Chalcidoidea), I. Zeitschr. angew. Entomol., **38**, 121—156; 1955.
- ERDÖS, J., Series encyrtidarum novarum hungaricarum. Acta Zool. Acad. Sci. Hungar., **3**, 5—87; 1957.
- , Fauna Hungariae, XII. Hymenoptera II. 4. Chalcidoidea III. Akadémiai Kiado, Budapest, 372 p.; 1964.
- FLANDERS, S. E., Ovipositional instincts and developmental sex differences in the genus *Coccophagus*. Univ. Calif. Publ. Entomol., **6**, 403—422; 1937.
- , Differential host relations of the sexes in parasitic Hymenoptera. Entomol. exp. appl., **2**, 125—142; 1959.
- GEORGHIOU, G. P., A catalogue of Cyprus insects. Cyprus Dept. Agr. Tech. Bull. TB-7, 65 p. [mimeographed]; 1957.
- GIRAULT, A. A., Description of eleven new species of chalcid flies. Canad. Entomol., **48**, 100—103; 1916.
- HARPAZ, I., Coccoidea, p. 126—165 in: AVIDOV, Z., Pests of the cultivated plants of Israel. MAGNES Press, Jerusalem, 546 p. [in Hebrew]; 1961.
- HOWARD, L. O. & FISKE, W. F., The importation into the United States of the parasites of the gipsy moth and the brown-tail moth. U. S. Dept. Agr. Bur. Ent. Bull., **91**, 312 p.; 1911.
- KLEIN, H. Z., Citrus pests in Palestine. Sifriyat Hassadeh, 216 p. [in Hebrew]; 1940.
- MERCET, R. G., Fauna Iberica, Himenopteros, Fam. Encirtidos. Mus. Nac. Cienc. Nat. Madrid, 732 p.; 1921.
- NEISWANDER, C. R., The phlox midge, *Hyperdiplosis phlox* GREENE, and its insect enemies. Ohio Agr. Exp. Sta. Res. Bull., **915**, 19 p.; 1962.
- NIKOL'SKAJA, M. N., The chalcidoid fauna of the USSR: Opred. Faun. Zool. Inst. Akad. Nauk SSSR, **44**, 575 p. [in Russian]; 1952.

- PARNELL, J. R., Three gall midges (Diptera: Cecidomyiidae) and their parasites found in the pods of broom (*Sarothamnus scoparius* (L.) WIMMER). Trans. Roy. Entomol. Soc. London, **115**, 261—275; 1963.
- PECK, O., A catalogue of the Nearctic Chalcidoidea (Insecta: Hymenoptera). Canad. Entomol. Suppl., **30**, 1092 p.; 1963.
- PELEG, B. A., Observations on the life cycle of the black scale, *Saissetia oleae* BERN., on citrus and olive trees in Israel. Israel J. Agric. Res., **15**, 21—26; 1965.
- RIVNAY, E., The economic status of *Coccus hesperidum* L. and its parasites in Palestine. Journ. Entomol. Soc. S. Africa, **7**, 73—81; 1944.
- ROSEN, D., An annotated list of hymenopterous parasites of citrus soft scales in Israel. Entomophaga, **7**, 349—357; 1962.
- , The hymenopterous parasites of citrus armored scales in Israel (Hymenoptera: Chalcidoidea). Ann. Entomol. Soc. Amer., **58**, 388—396; 1965.
- , On the relationships between ants and parasites of coccids and aphids on citrus. Beitr. Ent., **17**, 285—290; 1967.
- ROSEN, D. & GERSON, U., Field studies of *Chilocorus bipustulatus* (L.) on citrus in Israel. Ann. Épiphyt., **16**, 71—76; 1965.
- RUBTSOV, I. A., Citrus pests and their natural enemies. Akad. Nauk SSSR, 260 p. [in Russian]; 1954.
- , The intraareal translocation of entomophagous insects. Proc. I. Int. Conf. Insect Pathol. & Biol. Control, Prague, p. 389—394 [in Russian]; 1958.
- , Some results and outlooks of entomophage introduction and acclimatization. Zool. Zh., **40**, 637—650 [in Russian]; 1961.
- SANKARAN, T., The natural enemies of *Ceroplastes pseudoceriferus* GREEN (Hemiptera-Coccidae). Journ. Sci. Res. Banaras Hindu Univ., **5**, 100—119; 1955.
- SANTIS, L. DE, Estudio monográfico de los afelinidos de la republica Argentina. Rev. Mus. La Plata (N. S.) Zool., **5**, 23—280; 1948.
- , Anotaciones sobre calcidoideos Argentinos (Hymenoptera). Not. Mus. Univ. Nac. La Plata, **19**, 107—119; 1957.
- SILVESTRI, F., Contributo alla conoscenza degli insetti dell'olivo dell' Eritrea e dell' Africa meridionale. Boll. Lab. Zool. gen. agr. Portici, **9**, 240—334; 1914.
- SMITH, H. S. & COMPERE, H., A preliminary report on the insect parasites of the black scale, *Saissetia oleae* (BERN.). Univ. Calif. Publ. Entomol., **4**, 231—334; 1928.
- SUGONJAEV, E. S., On the fauna and ecology of parasitic chalcid-wasps (Hymenoptera, Chalcidoidea) infesting scale-insects in the Leningrad region. Trud. Zool. Inst. Akad. Nauk SSSR, **31**, 172—196 [in Russian]; 1962.
- THOMPSON, W. R., A catalogue of the parasites and predators of insect pests. Sect. 2: Host-parasite catalogue. Part 3: Hosts of the Hymenoptera (calliceratid to evaniid). Commonwealth. Inst. Biol. Control, Ottawa, p. 191—332; 1954.
- TIMBERLAKE, P. H., Preliminary report on the parasites of *Coccus hesperidum* in California. Journ. Econ. Entomol., **6**, 293—303; 1913.
- , Revision of the parasitic hymenopterous insects of the genus *Aphycus* MAYR, with notice of some related genera. Proc. U. S. Nat. Mus., **50**, 561—640; 1916.
- TRJAPITZIN, V. A., Species of the genus *Encyrtus* LATR. (Hymenoptera, Encyrtidae) in the USSR. Entomol. Obozr., **36**, 699—714 [in Russian]; 1957.
- VAN DEN BOSCH, R., BARTLETT, B. R. & FLANDERS, S. E., A search for natural enemies of lecaniine scale insects in Northern Africa for introduction into California. Journ. Econ. Entomol., **48**, 53—55; 1955.
- WOOD, B. J., Imported and indigenous natural enemies of citrus coccids and aphids in Cyprus, and an assessment of their potential value in integrated control programmes. Entomophaga, **8**, 67—82; 1963.

- YNON, U., Phenology of *Chilocorus bipustulatus* (L.) in various fruit orchards in the coastal plain of Israel. M. Sc. thesis, The Hebrew Univ., Faculty of Agric., Rehovot, 70 p. [in Hebrew]; 1964.
- ZINNA, G., Ricerche sugli insetti entomofagi. II. Specializzazione entomoparassitica negli Aphelinidae: Studio morfologico, etologico e fisiologico del *Coccophagus bivittatus* COMPERE, nuovo parassita del *Coccus hesperidum* L. per l'Italia. Boll. Lab. Entomol. Agr. "FILIPPO SILVESTRI" Portici, **19**, 301—358; 1961.