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AVOCADO PESTS IN ISRAEL

E. Swirski and M. Wysoki
Department of Entomology
A.R.O., The Volcani Center
Bet Dagan 50250, Israel

Y. Izhar
Extension Service
Ministry of Agriculture
Tel Aviv 61700, Israel

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Abstract

A survey of avocado groves throughout Israel was begun in 1969 and continued into 1995. During this period 94 species of avocado pests belonging to 45 families of insects, mites, birds and mammals, were recorded. Outbreaks of the long-tailed mealybug, *Pseudococcus longispinus,* resulting from the drift of aerial sprays from adjacent cotton fields, were controlled by limiting such sprays and by releases of the parasites *Arhopoideus peregrinus and Anagyrus Jusciventris.* The Japanese bayberry *whitefly, Parabemisia myricae,* introduced into Israel in the late 1970s, is successfully controlled by the imported Californian parasite *Eretmocerus debachi.* Since 1980 the pyriform scale, *Protopulvinaria pyriformis,* has been an important pestofavocado; itiscontrolled by the exotic parasite *Metaphycus stanleyi* and by the application of mineral oils. As only young caterpillars of the giant looper, *Boarmia selenaria,* are susceptible to *Bacillus thuringiensis* preparations, a monitoring system was developed using virgin female traps and scouting. *B. thuringiensis* is used as well against the honeydew moth, *Cryptoblabes gnidiella,* and the carnation leafroller, *Cacoecimorpha pronubana.* The parasite *Thripobius semiluteus,* imported from California for biocontrol of the greenhouse thrips, *Heliothrips haemorrhoidalis, has* become established in numerous groves. Sabadilla was found to be effective against the black vine thrips, *Retithrips syriacus.* The appearance of sporadic, minor and potential pests is discussed. An Integrated Pest Management system has been developed in the avocado groves of Israel.

1. Introduction

The first comprehensive list of avocado pests in Israel was published over 40 years ago by Avidov and Ben Haim (1950). In order to prevent the possible sudden and unexpected appearance of a new pest and/or outbreaks of a local one, owing to agrotechnical changes, a survey of pests and their natural enemies was begun in 1969 and continued into 1995. During this period 94 species of potential pests of avocado belonging to 45 families of insects, mites, birds and mammals, were recorded (Swirski et al., 1986, 1991; Wysoki and Izhar, 1978). In the present paper the current status of arthropod pests in the avocado orchards of Israel is reviewed and proposals for further progress in their control are presented.

2. Results

2. 1. Mites(Acarina)

Red spider mites (Tetranychidae) are rarely found in the avocado orchards of Israel, although the avocado brown mite, *Oligonychus punicae,* and the six-spotted mite, *Eotetranychus sexmaculatus,* are pests of avocados in California (McMurtry, 1985). However, in the early 1980s the carmine mite, *Tetranychus cinnabarinus,* and the two-spotted mite, *Tetranychus urticae,* were found in some avocado plots adjacent to cotton fields, which were treated aerially with synthetic pyrethroids. A drift of the pesticides to avocado plots caused outbreaks of the red spider mites. The oriental spider mite, *Anychus orientalis,* was found once in large numbers in the Jordan Valley on the leaves of Pinkerton trees, causing considerable damage.

The broad mite, *Polyphagotarsonemus latus* (Tarsonemidae), sometimes attacks avocado seedlings in glasshouses and greenhouses, causing rolling and browning of the young leaves, severe harm to the foliage of apical buds, development of shoots by lateral buds, as well as dwarfing of the seedlings.

2.2. Thrips (Thysanoptera: Thripidae)

Large populations of the greenhouse thrips, *Heliothrips haemorrhoidalis, usually* start on pest-susceptible trees, such as seedling trees of the Mexican cultivars, or trees of the cvs. 'Benik' and 'Hass'. From these foci the thrips disperse to trees of the commercial cvs. 'Fuerte', 'Nabal' and 'Ettinger'. Recently, heavy damage to cv. 'Ardit' was recorded (Izhar et al., 1990a). The cvs. 'Stuart', 'Nahlat' and 'Horshim' are also susceptible. The rate of damage to Tuerte' fi-uits is probably correlated with the yield: the greater the yield and density of fruits, the higher the rate of infestation. Mortality rate of the thrips is high at relative humidities below 60% and at temperatures above 27ºC (Rivnay, 1935). Thus it seems that outbreaks of the greenhouse thrips at certain sites and years are influenced also, or mainly, by climatic factors. It is found on avocado trees in all seasons of the year and the infestation peak usually occurs in autumn. During the winters, and mainly relatively warm ones, its population may reach considerable numbers.

The following local natural enemies of the greenhouse thrips have been recorded in Israel: predaceous mites *Typhlodromus athiasae and Amblyseius swirskii* (Phytoseiidae); the thrips *Franklinothrips megalops;* and spiders and predaceous bugs of the family Anthocoridae. However the local natural enemies are not sufficiently efficient in curbing the pest populations. Therefore, attempts were made to import exotic natural enemies. The wasp *Thripobius semiluteus* (Eulophidae) was imported to Israel in 1991. It had been introduced into California in 1986 from Australia and in 1988 from Brazil, and became well established there. It is recorded also from India and the western coast of Africa. The female inserts its egg inside the body of first or second stage nymphs. In the laboratory the development of the parasite is completed at 230C within 22-25 days (McMurtry et al., 1991), *Thripobius* was mass-reared at Bet Dagan and released in many avocado plots, became well established, and most probably can be considered an effective natural enemy. Spraying with endosulfan - a partially selective pesticide - is recommended for infested trees only. In our trials the initial kill of the postembryonic stages of the thrips by pyrethrum was very high, but the eggs hidden under the plant cuticle were not affected and a population build up was observed after 15 and 22 days. Oil gave similar results, but was not so effective as pyrethrum. Two treatments of pyrethrurn at an interval of 21 days gave good results. However, due to the high price of pyrethrum, farmers are reluctant to use it (Ben-Yehuda et al., 1994). In trials carried out in avocado orchards in California in 1985 and

1986, pyrethrum. gave inconsistent results against the greenhouse thrips (Goodall et al., 1987). In the past, in the USA, oil was combined with pyrethrum in order to carry the toxicant to the eggs (Ebeling, 1959).

The black vine thrips, *Retithrips syriacus*, has recently caused damage to avocado fruits and leaves, cvs. 'Horshim', TX-531, 4102, 4203, and T-142 being the most heavily infected ones. The thrips can be readily controlled with Sabadilla (Izhar et al., 1992).

2.3. Bugs (Heteroptera)

The variegated caper bug, *Stenozygum coloratum* (Pentatomidae), develops generally on wild caper-bush, *Capparis spinosa*, sometimes migrating to various cultivated plants, including avocado (mainly cv. 'Hass', but also 'Fuerte' and 'Ettinger'). The damage to fruit is accompanied by heavy secretion of persein and by the appearance of black spots (Izhar et al., 1990b). Although the cottonseed bug, *Oxycaraenus hyalinipennis* (Lygaeidae), develops on plants of the family Malvaceae, it sometimes feeds on leaves and stem of avocado seedlings and may even cause their Wilt.

2.4. White-flies (Homoptera: Aleyrodoidea)

The Japanese bayberry whitefly, *Parabemi .sia myri.cae*, was discovered in Israel in 1978, causing heavy damage to avocado and citrus trees (Stemlicht, 1979). Since predaceous mites of the family Phytoseiidae, lacewings (Neuroptera), ladybeetles (Coccinellidae), predaceous bugs of the family Anthocoridae and parasitic wasps were unable to suppress the whitefly effectively, exotic natural enemies were imported. The parasite *Eretmocerus debachi* (Aphelinidae) was discovered in 1982 by M. Rose in southern California. It was released in various citrus orchards, curbed the populations of the pest successfully and thereby solved the problem (Rose and DeBach, 1992). *E. debachi* was introduced into Israel by D. Blumberg in June 1982, mass-reared in the laboratory at Bet Dagan, colonized in 61 localities, and within 2 years of the parasite's introduction the Japanese bayberry whitefly had been controlled. The following exotic natural enemies were colonized in numerous avocado and citrus groves and probably did not become established: the parasitic *wasps Eretmocerus sp., Encarsia sp., Encarsia ? bemisiae* (Aphelinidae) (from Japan); the lady beetles *Nephaspis oculatus and Delphastus pusillus* (from Hawaii, sent by Po Yung Lai); the beetle *Cybocephalus binotatus* (Cybocephalidae) (bred by D. Blumberg); and the fungus *Aschersonia aleyrodis* (investigated in cooperation with R. Kenneth) (Swirski et al., 1987). In 1992, outbreaks of the Japanese bayberry whitefly were recorded in some avocado orchards of Western Galilee. They were caused by drift of baits containing insecticides (malathion), which were applied aerially against the Mediterranean fruit fly, *Ceratitis capitata* (Trypetidae), in adjacent groves of citrus, deciduous fruit trees or subtropical fruit trees. In a few plots considerable damage was inflicted to fruit and foliage. However, the high efficiency of *E. debachi* was manifested also in this case and within a short period the populations of the pest declined.

2.5. Aphids (Homoptera: Aphidoidea)

In the spring of 1990 an outbreak of the melon aphid, *Aphis gossypii*, and of the spirea aphid, *Aphis spiraecola*, on avocado trees was observed. The most heavily infested cvs. were Nabal' and 'Horshim'. The attack was concentrated on young foliage, but sometimes involved damage to inflorescences (Swirski et al., 1991).

2.6. Mealybugs..(Homoptera: Coccoidea: Pseudococcidae)

In the late 1960s and early 1970s, avocado plots in close proximity to cotton fields were heavily damaged by the long-tailed mealybug, *Pseudococcus longispinus.* Drift of broad-spectrum insecticides from aerially sprayed fields killed natural enemies, interfered with the biological equilibrium and resulted in severe outbreaks of the mealybug. Moreover, females of the honeydew moth, *Cryptoblabes gnidiella, are* attracted to the honeydew of the mealybug and their caterpillars nibble at the fruit. These spray-induced outbreaks of the mealybug were successfully curbed by forbidding aerial applications of broad-spectrum insecticides within 200 m of avocado orchards, and by the release of the parasitic wasps *Anarhopus peregrinus and Anagyrusfisciventris.* The latter was sent to us by Mr. G.O. Furness (Loxton, S. Australia) in 1971 (Swirski et al., 1980).

2.7. Soft scales (Homoptera: Coccoidea:Coccidae)

The pyriform scale, *Protopulvinaria pyriformis,* was first detected in Tel Aviv in 1980 on a single avocado tree (Ben-Dov and Amitai, 1980), and is now recorded from the avocado orchards of Western Galilee, the central and southern Coastal Plain, Shefela and Ramat Menashe. It has not yet been found in the eastern Yi2re'el, Jordan and Hula valleys. This coccid sometimes causes serious damage to avocado trees in Florida (Ebeling, 1959) and to citrus and avocado trees in Spain (Del Rivero, 1966). Variations have been found in the susceptibility of avocado cvs. to the attack by the pyriform scale. 'Nabal' is the most susceptible cultivar, followed by 'Ein Vered', 'Reed', 'Hass' and 'Fuerte; whereas 'Ettinger' trees are sometimes attacked when located close to infested trees of the susceptible cvs. In laboratory trials, the pyriform scale completed development and reproduced on 'Nabal' and 'Ein Vered' seedlings, and to a lesser extent on those of 'Hass'. Survival of the scale was rather poor on 'Fuerte', 'Horshim' and 'Wurz! cvs. and higher on 'Ettinger' 'Pinkerton' and 'Reed' (de Meijer et al., 1989). The pyriform scale produces on avocado two generations annually - a winter generation with a peak in November-December and a summer generation with a high level in June-July (Hadar, 1993).

The following local natural enemies, amongst others, were unable to curb the populations of the pyriform scale below the economic threshold: Parasitic wasps - *Microterys flavus, Metaphycus flavus* (Encyrtidae), *Coccophagus lycimnia* (Aphelinidae); predators - *Chilocorus bipustulatus, Oenopia conglobata and Scymnus* (ladybeetles, Coccinellidae), *Anisochrysa carnea* (green lacewings, Chrysopidae), spiders and the Rmgus *Verticillium lecanii* (Hadar, 1993). Thus, efforts were exerted to import various natural enemies. *Metaphycus swirskii* (imported from Kenya), initially the most abundant parasite, was soon replaced by *Metaphycus stanleyi* (imported from USA, S. Africa and Spain), which is today the dominant natural enemy of the pyriform scale in Israel. *Metaphycus helvolus* (imported from USA) is rare in the avocado orchards and *M. galbus* (from S. Africa) probably failed to become established. Two ladybeetles were imported from Spain: *Cryptolaemus niontrouzieri* is sporadically found in the avocado orchards, whereas *Nephus peyerimhoffi* is rare. The two secondary parasites *Mariettajavensis and Pachyneuron concolor* have an adverse effect on the efficiency of *Metaphycus* spp. In some avocado plots 70% of the total parasite fauna may consist of these two secondary parasites. Population studies of the active parasitization of the scale by M *stanleyi* showed an increase in September, with high levels during the winter, a peak in May and a decline in summer. The high rates of encapsulation of *Metaphycus* eggs by the pyriform scale during the summer, may interfere with efficient biocontrol of the pest (Blumberg and Blumberg, 1991; Hadar, 1993). The site, duration and rate of oviposition, as well as host marking-and preference of host stages in the

various species of *Metaphycus*, were studied by Hadar (1993). Since local and exotic natural enemies are not sufficiently effective in suppressing the pyriform scale populations, mineral oil - the selective scalicide - is recommended. It kills the three nymphal stages of the pest, but does not affect the ovipositing females. Oil sprays are likely to produce satisfactory results if applied in December-January (or January-February) and July-August, when the pest populations consist mainly of young nymphal stages (Hadar, 1993). Only heavily infested trees are treated with broad-spectrum scalicides.

2.8. Lepidoptera

In Israel the giant looper, *Boarmia selenaria* (Geometridae), is the most important pest of avocado in the regions where cotton is grown. It produces five generations a year, of which the most destructive ones are the first (spring) and second (early summer) (Wysoki and Izhar, 1986). Its reproductive behavior was studied by Hadar (1983). Long list of the natural enemies of the giant looper in Israel was compiled in earlier publications (Swirski et al., 1988; Wysoki and Izhar, 1980). The spiders are very common in the avocado groves, and contribute to some extent to biocontrol of the pest (Mansour et al., 1985). The wasp *Apanteles cerialis* (Braconidae) oviposits in young caterpillars of the giant looper. Observations carried out in avocado groves revealed that the rate of parasitization is highest in October and November and may reach 70% of the caterpillars (Wysoki and Izhar, 1981). Females of the tachinid flies (Tachinidae), such as *Compsilura concinnata and Exorista nr. sorbillans, attack* advanced stages of the giant looper caterpillars; the rate of parasitization reaches its peak in late summer or autumn. Since local egg parasites of the giant looper had not been recorded in Israel, endeavours were made to import exotic ones. Two wasps, *Ooencyrtus ennomophagus* (Encyrtidae) and *Telenomus alsophilae* (Scelionidae), which parasitize eggs of loopers, were sent by A.T. Drooz from North Carolina (USA). However, they did not attack eggs of the giant looper (Wysoki and Izhar, 1980). During 1983 to 1984 several shipments of *Trichogramma platneri* (Trichogrammatidae) were sent to us by E.R. Oatman. This egg parasite is used in avocado groves of California for controlling the western avocado leafroller, *Amorbia cuneana* (Tortricidae), and the omnivorous looper, *Sabulodes aegrotata* (Geometridae) (Oatman et al., 1983). In the laboratory, eggs of the giant looper and of the honeydew moth were attacked by T *platneri* (Wysoki et al., 1988). During 1988-1990 approximately 16 million wasps were released in the avocado groves but have not yet been recovered. In Israel, natural enemies suppress giant looper populations in the avocado groves effectively, but in regions where cotton is widely grown pesticide-induced outbreaks of the looper may occur owing to the disrupted balance with its natural enemies by the drift of pesticides from aerially sprayed cotton fields in the vicinity. Infestations are controlled, when necessary, by preparations containing *Bacillus thuringiensis (B.t.) var. kurstaki.* Since these preparations are toxic only to young caterpillars, other varieties of Rt., as well as various strains of *B.t. var. kurstaki,* were evaluated for the control of more developed caterpillars as well. Timing of the control measures is based on traps baited with virgin females (attracting males) and scouting the groves for young caterpillars. Since mass production of giant looper virgin females for monitoring purposes is laborious and expensive, efforts were made to replace the virgin females by synthetic pheromone (in cooperation with the Technion - Israel Institute of Technology, Haifa, and Institut für Organische Chemie, Universität Erlangen, Nürnberg, Germany). (Z,Z)-6,9-cis-3S,4R epoxynonadecadiene and (Z,Z,Z)-3,6,9-nonadecatriene were identified as sex pheromone components (Becker et al., 1990). Bioassays performed by electroantennograph (EAG) and in a wind tunnel gave positive results, but in field tests males

were not sufficiently attracted to these two compounds. Following experiments involving decapitation of the giant looper and subsequent PBAN injections, a third compound was revealed (in cooperation with the Department of Stored Products, ARO and the Insect Neurobiology and Hormone Laboratory, USDA, Beltsville, NM, USA).

Females of the honeydew moth, *Cryptoblabes gnidiella* (Pyralidae), are attracted to the honeydew of mealybugs and coccids, and the moths caterpillars gnaw at the avocado fruit. Sometimes the fruit is damaged even when no honeydew-producers are present. The honeydew moth prefers fruits of cv. 'Hass' to those of other avocado cvs. Besides avocado, many fruit trees in Israel are known to serve as hosts of the honeydew moth, including: loquat, persimmon, *Annona* spp., citrus, etc. The honeydew moth has the potential to survive throughout the year in an avocado orchard, feeding on the fruits or on leaves infested with the pyriform scale, and on *Paspalum dilatatum* weeds infected by the fungus *Claviceps paspali.* Adult moths probably fly between avocado orchards and neighboring host-crops. The pest can produce five generations a year and overwinters in the larval stage in fresh or dry avocado fruits (which remain on the trees). The extent of damage varies from year to year and from site to site (Ben-Yehuda, 1990). The reproductive behavior of the honeydew moth was studied by Wysoki et al. (1992). No studies have been carried out in Israel of the natural enemies of the honeydew moth. In the laboratory, its eggs were attacked by the exotic wasp T *platneri* (see giant looper). *R t. var. kurstaki* preparations are very effective against honeydew moth caterpillars of all stages.

The young caterpillars of the carnation leaf roller, *Cacoecimorpha pronubana* (Tortricidae), tunnel through the avocado fruits and the more developed ones gnaw at them superficially. They can be found also on the young foliage of the trees or on suckers. The life history of the carnation leaf roller in Israel has not been investigated. In this country the caterpillars of the pest are parasitized by the wasp *Elachertus lateralis* . (Eulophidae) and consumed by spiders and by larvae of lacewings (Chrysopidae). Preparations of *R t. var. kurstaki* are used to control the pest.

Great numbers of large caterpillars of the Egyptian cotton worm, *Spodoptera littoralis* (Noctuidae), from defoliated cotton fields may migrate to adjacent avocado plots and gnaw holes in the leaves and fruit. In order to prevent such damage, safety belts on the ground may be treated with insecticides and/or poison baits.

3. Discussion and conclusions

Long-term studies have shown that in Israel, as elsewhere, many arthropod species may inflict damage to avocado trees. In the past a "blessed biological equilibrium" was maintained in the avocado orchards between potential pests and their natural enemies. However, on this agro-ecosystem the following four pressures, among others, were applied: cotton, new pests, new avocado cultivars and the human factor. "Bad neighborly relations" existed between avocado and aerially sprayed cotton, resulting from the drift of broad-spectrum pesticides which killed natural enemies and disrupted the biological equilibrium in the avocado orchards. The avocado trees were victims of newly introduced pests, e.g. the Japanese bayberry whitefly and the pyriform scale. Pest-susceptible avocado cultivars, such as 'Ardit', which is heavily attacked by the greenhouse thrips, have been imported and cultivated on a large commercial scale. The above mentioned factors pressed upon those involved in the avocado industry to choose chemical control, as though it would solve all their problems, but they preferred to remain with the biological and integrated control methods.

It is recommended to include the following elements in the IPM program of avocado pests in Israel: (i) importation of additional natural enemies against the pyriform scale and greenhouse thrips; (ii) conservation and augmentation of local natural enemies in the avocado orchards by the use of selective pesticides only, and by observance of the regulations dealing with the limitation of pesticide drift from adjacent cotton fields; (iii) further studies to identify the giant looper sex pheromone for use in developing a monitoring system; (iv) continuation of surveys of pests and their natural enemies in the avocado groves, in order to prevent the possible sudden and unexpected appearance of a new pest and/or outbreaks of a local one owing to changes in agrotechnical practices; and (v) thorough studies of the biology and dynamics of population of pests and their natural enemies.

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