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THE PEST STATUS OF CITRUS SCALE INSECTS IN ISRAEL (1984-1994)

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ABSTRACT

During the decade of 1984-1994, significant changes have occurred in the economic importance of scale insect pests in Israeli citrus groves. The California Red Scale, *Aonidiella aurantii* (Maskell) (Diaspididae), was a destructive pest until the mid-1980s due to its remarkable build-up of resistance to OPs scalicides and a disrupted biological balance. Since the mid-1980s the pest is under satisfactory control by the use of the IGR pyriproxyfen (Tiger) and an improved biological balance. The Florida Wax Scale, *Ceroplastes floridensis* Comstock (Coccidae), is occasionally causing considerable damage. Improved biological balance helps to maintain this pest below economic threshold level. However, under certain climatic conditions, pest outbreaks occurred and required chemical control. C. *floridensis* developed resistance to carbamates, which had been effectively controlling it until the mid-1980s. IGRs, especially pyriproxyfen, provided satisfactory control of the pest. The citrus mealybug, *Planococcus citri* (Risso) (Pseudococcidae), is an important citrus pest in certain regions of Israel. In recent years we have observed a decrease in its susceptibility to scalicides, by which the efficiency of chemical control was reduced. Efforts have been made to enhance biological control of the pest. The cottony-cushion scale, *Icerya purchasi* (Maskell) (Margarodidae), was a serious pest in the northern part of the country. As a result of an improved biological balance, the use of selective chemicals, as well as of the introduction of the parasite *Ciyptochaetum iceryae* Williston (Cryptochaetidae), this scale is at present considered a minor pest.

KEY WORDS: Coccoidea, scale insects, citrus, *Aonidiella aurantii, Ceroplastes floridensis, Jcetya purchasi, Planococcus citri, Pseudococcus ciyptus.*

Scale insects are important pests in citrus plantations of Israel, causing both direct and indirect damage. During the decade of 1984—1994, significant changes have occurred in the economic importance, as well as in the control, of scale insect pests of Israeli citrus, as compared with their status during the previous decade, as reported by Ben-Dov (1988). In the present paper, the status of five important scale insect pests of citrus in Israel is discussed.

California Red Scale (CRS), *Aonidiella aurantii* (Maskell) (Diaspididae)

This notorious scale insect was a major pest in various regions of Israel, especially the inner valleys; this required annual scalicide application. Several factors were responsible for CRS infestations: (i) Extreme climatic conditions, such as high temperature and low humidity; these

enhance scale development while having an adverse effect on natural enemies. (ii) Disrupted biological balance due to chemicals drifting from adjacent crops, mainly cotton, and the use of non-selective insecticides.

Until the beginning of the 1980s, CRS was effectively controlled by OPs scalicides such as methidathion, chlorpyrifos and ethion + oil. Usually, one annual cover spray provided satisfactory control. Toward the mid-1980s we observed inefficient control of the scale in citrus plantations in the northern regions of Israel. Laboratory tests proved that the CRS had developed resistance to OPs. Since then, scale resistance has spread all over the country. CRS is now highly resistant to all OPs scalicides. We therefore had no effective means to control the scale, especially in groves with a disrupted biological balance. The scale became a destructive pest, jeopardizing the citrus industry in certain areas.

Several steps were taken in order to maintain the damage caused by the scale below economic level. At present, CRS is under satisfactory control due to the following steps taken:

(i) Introduction of pyriproxyfen (Tiger) for CRS control. This selective IGR is highly effective in controlling OPs-resistant CRS (Peleg, 1988). Usually, one application of Tiger is sufficient to maintain the scale population below economic level for a period of 2 years (Bar-Zakay, 1992). However, fruits exported to the Far East must be totally scale-free; even a very light infestation is not acceptable. Therefore, fruits earmarked for export to the Far East are subjected to an annual pyriproxyfen treatment.

(ii) Improved biological balance brought about by: (a) the use of selective chemicals, such as IGRs and summer oil, for pest control. The elimination of the use of non-selective insecticides in citrus groves has enhanced the activity of natural enemies; (b) the decrease of the cotton field area cultivated in Israel, which resulted in a significant reduction of the drift of toxic chemicals held responsible for disruption of the biological balance in adjacent citrus groves.

(iii) The use of descaling machines in packing houses, which are efficient means to remove armored scales from infested fruits, reducing the need for chemical treatments in groves infested only mildly with CRS.

Florida Wax Scale (FWS), *Ceroplastes floridensis* Comstock (Coccidae)

Following the introduction of OPs scalicides in the mid-1960s to control citrus pests, the FWS became a major citrus pest. Until the mid-1980s the pest was controlled effectively mainly by carbaryl (Sevin, Ravyon) and carbosulfan (Marshal). Carbaryl has a significant adverse effect on natural enemies for as long as 4 months. In order to avoid outbreaks of non-target pests, carbaryl was usually applied in combination with a specified OP. Frequent use of such non-selective insecticides interfered with the activity of beneficial insects and mites and prevented the creation of a favorable biological balance. The result was a continuous need for chemical treatment in order to maintain the scale population below economic threshold. In the mid-1980s FWS became resistant to carbaryl, and later to carbosulfan. Thus, a new approach to *C. floridensis* control had to be considered (Yardeni and Shapira, 1994). We could not use carbamates, and the use of OPs such as methidathion (Supracide) resulted in CRS infestation. FWS has efficient natural enemies which generally, if undisturbed, regulate the pest below economic threshold. However, following extreme climatic conditions, we have observed severe infestations by FWS once in several years.

When FWS population outbreaks occur, the following measures have been recommended.

If chemical intervention is necessary, only selective chemicals are applied: (a) IGRs such as Tiger and Applaud (buprofezin). Tiger was found very effective in controlling the pest, since nymphal stages (1st, 2nd and 3rd) as well as young females are very susceptible to it (Peleg, 1988). On the other hand, Applaud provides satisfactory control only of the 1st and 2nd instars. (b) Summer oil exhibits scalicide activity only against 1st and 2nd instars. However, summer oil is being used successfully to peel off sooty mold infestation, which is the major damage incurred by the prevailing FWS population. (c) Potassium nitrate sprayed as a nutrient, alone or with oil, was found to induce mortality among crawlers and very young nymphs. At mild infestations this treatment may reduce the scale infestation below the need for further chemical applications (Yardeni and Shapira, 1994).

Citrus Mealybug (CMB), *Planococcus citri* (Risso) (Pseudococcidae)

This pest is causing considerable damage in certain regions: it damages the fruit both directly and indirectly, due to its association with several species of moths. Until recently, the pest was controlled effectively by chlorpyrifos sprays. In the last 2–3 years, we observed a significant decrease in the susceptibility of the pest to OPs scalicides (Peleg and Bar-Zakay, unpublished data). At present, no effective chemical means is available for control of CMB, and we must rely on biological control. Trials have been conducted in order to enhance biological control of the pest by means of mass releases of laboratory-reared natural enemies. The efficacy of such releases is still under study (Z. Mendel, personal communication). To diminish the damage of the carob moth, *Ectomyelois ceratoniae* Zell. (Lepidoptera: Phycitidae), which is attracted to CMB-infested fruits, field trials have been conducted employing traps loaded with specific moth attractants.

***Pseudococcus cryptus* Hempel (Pseudococcidae)**

Since the introduction into Israel of the encyrtid *Clausenia purpurea* Ishii in the late 1930s, the mealybug has been kept below economic threshold. Although sporadic infestations were recorded during this period, chemical control was only rarely needed. In 1991–1992, due to unknown reasons, a large area became heavily infested by this mealybug, resulting in considerable damage. Outbreaks occurred regardless of the pest management history of a particular plantation. A relatively large area had to be sprayed with OPs, mainly chlorpyrifos. Satisfactory control was obtained, and, apparently, this mealybug has not yet developed resistance to OPs.

Cottony-Cushion Scale (CCS), *Icerya purchasi* (Maskell) (Margarodidae)

The CCS is usually a minor pest in Israel being successfully controlled by its effective predator, the coccinellid *Rodolia cardinalis* Mulsant. In the mid-80s, the CCS became a destructive pest in the northern part of Israel, causing severe damage. These unusual outbreaks may be attributed to the following: citrus groves in the north were subjected to annual OPs applications aimed at controlling CRS, which were also effective in controlling CCS. Because of CRS resistance to OPs, these chemicals were not applied, and consequently CCS populations increased. Because of chemicals drifting from surrounding crops, this predator was adversely affected and was unable to prevent scale infestation. The high CCS infestation may be attributed also to the late appearance of *R. cardinalis*, even in citrus groves with undisturbed biological balance. Thus the delayed activity of the beetle did not prevent considerable damage by CCS.

TABLE 1
The area and cost of chemical control of scale insect pests on citrus in Israel (1975–1993)

Year	Sprayed area		Total estimated cost per year in US $
	in hectares	% of total citrus area	
1975–80	32,000	80	9,600,000
1984	16,800	42	5,040,000
1986	21,600	54	6,480,000
1987	10,000	30	3,000,000
1988	10,000	30	3,000,000
1989	9,000	27	2,700,000
1990	9,000	27	2,700,000
1991	13,000	50	3,900,000
1992	10,000	40	3,000,000
1993	9,000	40	2,700,000

At present, in the northern parts of Israel *I. purchasi* is kept below economic threshold due to: (i) The regular use of pyriproxyfen to control CRS, which is also effective in controlling CCS. (ii) Improved biological control, by (a) diminution of cotton field areas, as well as introduction of selective methods to control cotton pests; (b) introduction and establishment of the parasite *Cryptochaetum iceryae* (Diptera: Cryptochaetidae) (Mendel and Blumberg, 1991).

Due to application of selective chemicals, as well as by an improved biological balance in citrus plantations, the use of scalicides has been significantly reduced in comparison with the early 1980s (Table 1).

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