RESISTANCE OF THE PREDACIOUS MITE, *AMBLYSEIUS SWIRSKII* (ACARI: PHYTOSEIIDAE) TO THE INSECTICIDE DIMETHOATE IN EGYPTIAN CITRUS ORCHARDS

BY M. EL-BANHAWY[1], B.M. EL-SAWAF[2], & S.I. AFIA[1]

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AMBLYSEIUS SWIRSKII
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PREDACIOUS MITES
RESISTANCE

SUMMARY: Resistance of the predacious mite, *Amblyseius swirskii* (Acari: Phytoseiidae) to dimethoate in Egyptian citrus orchards. *Amblyseius swirskii* Athias-Henriot was reported. Samples collected from the citrus orchards representing different production areas in Egypt. Predators were transferred to the laboratory and reared. Dosage mortality relationships were used to measure the susceptibility of *A. swirskii* to the citrus insecticide dimethoate in laboratory bioassays. In orchards with no or occasional use of organophosphates, the field rate (1.5%) caused high mortality. *A. swirskii* from populations exposed to frequent applications of dimethoate were resistant (up to 12 times fold) to the field rate. In a moderately-resistant population malathion was three times as toxic as dimethoate and diazinon 68 times. The synthetic pyrethroid, deltamethrin was 108 times as toxic. Under field conditions, application of diazinon in this orchard greatly reduced *A. swirskii* populations for at least 6 months.

Prior to the widespread use of organophosphorus (OP) pesticides, spider mites were insignificant pests. The higher toxicity of most OP insecticides to predaceous mites and their elimination after field application (McMurtry *et al.*, 1970) led to outbreaks of spider mites and some insects like thrips (Swift, 1988; Flaherty & Huffaker, 1970; Readshaw, 1975; Grout, 1994). As a result, scientists have searched for selective pesticides effective on target pests and harmless to natural enemies like predaceous mites. Studies indicated that strains of predaceous phytoseiid mites could develop resistance to insecticides (*Neoseiulus fallacis* (German), Motoyama *et al.*, 1970, Croft & Meyer, 1973; *Metaseiulus occidentalis* (Nesbitt) Roush & Hoy 1981; *Phytoseiulus persimilis* A.-H., Schulten & van de Klashorst, 1974; *Amblyseius cydnodactylon* Shehata & Zaher, El-Banhawy et al., 2000). Therefore, in an ecosystem like citrus, populations of predacious mites may develop resistant strains when exposed to regular applications of the commonly used insecticide dimethoate for the control of the target pest *Ceratitis capitata* Weid. (Tephritidae). Resistant strains of the predacious mites may then control secondary pests like spider mites and thrips. To date, there is no evidence that *C. capitata* has developed resistance to

1. Plant Protection Dept., National Research Centre, Dokki, Cairo, Egypt
2. Entomology Dept., Fac. of Science, Ain Shams Univ., Cairo, Egypt

No. orchard	Population	*Area*	LC_{50}	Slope	**Resistance ratio**	*Insecticide applied*
1	Fedemene	El-Fayoum	1.103	2.133	1.00	Mineral oils
2	Beni Souif	Beni Souif	1.117	1.883	1.00	Mineral oils
3	Al-Katta	Giza	2.648	0.410	2.50	Malathion & dimethoate
4	Al-Khanka	Greater-Cairo	1.670	1.699	1.90	Dimethoate
5	Mullak	Sharkia	2.710	1.244	2.60	Dimethoate
6	Al-Azizia	Sharkia	2.230	1.789	2.11	Dimethoate
7	Bochom	Menofia	1.947	1.169	1.90	Dimethoate
8	Tafahna	Gharbia	1.055	2.185	—	—
9	Aga	Dakahlia	11.501	0.684	10.90	Dimethoate
10	Bostan	Behaira	1.193	2.014	1.10	Mineral oils

TABLE 1: Susceptibility of different populations of *Amblyseius swirskii* in citrus orchards of the Nile delta and middle Egypt to the insecticide dimethoate

the widely used insecticides in citrus orchards (Carbaryl or Diptrex in Cape Province, South Africa, EL-BANHAWY, 1997; dimethoate in Sharkia governorate, Egypt, AFFIA, 2002).

The present work was designed to determine the level of natural resistance in different populations of the common citrus predaceous mite, *Amblyseius swirskii* Athias-Henriot after exposure for at least 12 consecutive years to the common insecticide dimethoate.

MATERIALS AND METHODS

To test the susceptibility of different populations of the predaceous mite, *A. swirskii* to dimethoate, predators were collected from selected orchards representing different citrus production areas in the Nile Delta and Middle Egypt (TABLE 1).

Individuals were sampled from each orchard by beating the branches with a stick and collecting predators on a plastic board. They were removed by a fine hairbrush and confined on the lower surface of detached young citrus leaves laid on cotton wool saturated with water in Petri dishes. Three hundred individuals/orchard were obtained and transferred to the laboratory. Predators were fed on *Ricinus communis* (L.) pollen grains for a week and young females were used for toxicological tests. Water dilutions of dimethoate were prepared from the commercial formulation (E.C. 40% (O, O dimethyl–S–[N–methyl carbamoyl methyl] phosphorodithioate) at rates equivalent to field rates (2.25, 1.5 and 0.75%). Citrus leaf discs (3 cm in diameter) were dipped for 20 seconds in the different concentrations and left to dry. Discs were placed upside down on cotton wool soaked with water and a small strip of cotton was arranged on the edge of the leaf disc to prevent escape of mites. Pollen was added to every disc as a source of food and young females were transferred to every disc. Each concentration was replicated four times (40 females/ replicate). Each test, including the various concentrations was repeated at least twice. Mortality was recorded 48 hours after exposure, corrected according to ABBOTT's formula (1925), and plotted on log-dosage probit paper.

The susceptibility of a dimethoate-resistant population of *A. swirskii* (Mullak orchard, TABLE1) was evaluated against other insecticides common on citrus (diazinon, E.C. 60% (O, O diethyl–O–(2–isopropyl–4–methyl-4-pyrimidinyl phosphorothioate), malathion, E.C. 57% succinic acid, mercapto–diethyl ester, S–ester with (O, O–dimethyl phosphorodithioate), and deltamethrin, E.C. 2.5% (cyclopropanecarboxylic acid, 3–(2,2–dibromoethenyl) –2,2–dimethyl, cyano (3–phenoxyphenyl) methyl ester). Predators were transferred to the laboratory and fed pollen for a week. Toxicity was assessed by confining young females on the lower surface of citrus leaf discs (3 cm in diameter), previously dipped in various concentrations of the water dilutions of the commercial formulations. Each test contained 4-6 concentrations, with four replicates (40 female/ replicate), repeated at least twice. Mortality counts recorded 48 hour after treatment were corrected and plotted on log-dosage probit paper. Experiments were conducted in the laboratory under a temperature and relative humidity fluctuating between 24-28°C. and 60-80% respectively.

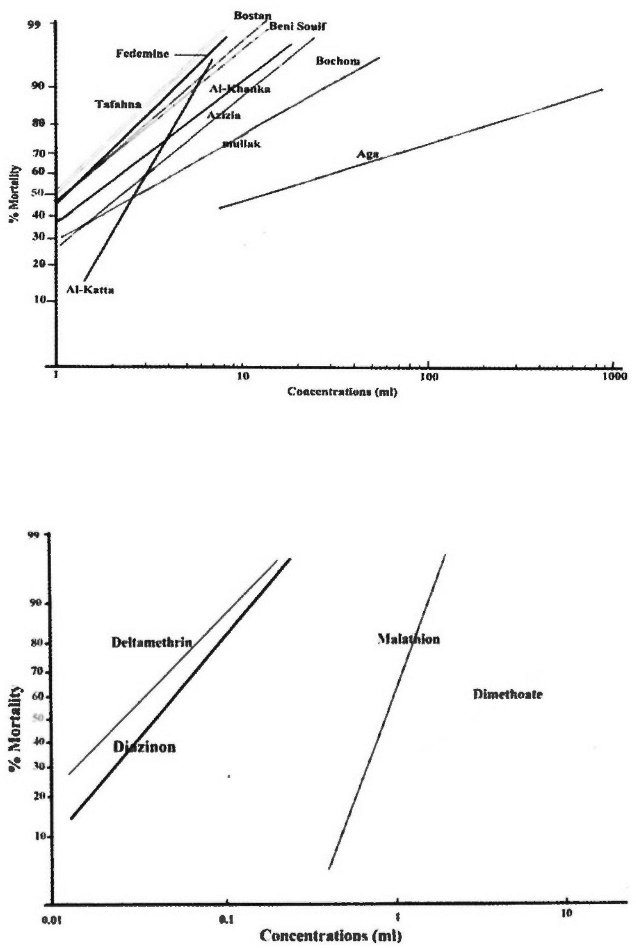

FIG. 1-2. 1. — Mortality of *A. swirskii* exposed to Dimethoate application. 2. — Compared mortality of *A. swirskii* due to insecticide application.

In the same dimethoate-resistant population (Mullak citrus orchard, TABLE 1) (10,000 trees) trees were identified in 25 plots (400 trees/plot). Four plots were randomly selected and at each plot four sites (20 trees each) were sampled for mites every 15 days for two successive years (1999-2000) using the beating technique. Branches were beaten for five minutes/site and predators were preserved in alcohol (70%), counted later and the average number/plot was recorded. In October 1999, two plots were selected and sprayed with diazinon at the rate of E.C. 1.5%, while the rest of the orchard received the regular application of dimethoate at 1.5%. Observations were made on the average number of predators /plot.

RESULTS

Individuals from different populations of *A. swirskii* showed variation in their response to dimethoate. In orchards where dimethoate or other organophosphorus compounds were irregularly or rarely used, individuals were susceptible and suffered high mortalities at the field rate (1.5%). For example, in Fedemene, Benisouif, Tafahana and Bostan, where populations were regularly sprayed with only mineral oils, LC_{50} were 1.103, 1.117, 1.055 and 1.193% respectively (TABLE 1).

In orchards exposed to regular and frequent applications of dimethoate, populations were less susceptible. In the Aga populations, exposed to frequent applications of dimethoate for over 10 years, susceptibility was about eleven times less than that of infrequently exposed populations, indicating a high level of resistance to dimethoate (FIG. 1).

In moderately resistant populations such as Mullak (TABLE 1) individuals showed susceptibility to other common insecticides used in citrus. For example, malathion was three times as toxic as dimethoate, diazinon 68 times, and the synthetic pyrethroid deltamethrin 108 times (FIG. 2).

Although *A. swirskii* at the Mullak orchard was exposed to regular applications of dimethoate, sampling indicated a high population level of the predator (25-50 predators per sample). After application of diazinon in two plots of the orchard in 2000 the population was greatly reduced for at least six months and total samples representing *A. swirskii* populations contained only 0-5 predators per sample (FIG. 3).

DISCUSSION

Predaceous mites develop resistance to various groups of insecticides. A population of *N. fallacis* collected from an apple orchard sprayed for nine consecutive years with carbaryl exhibited a 27-77 fold resistance to carbaryl (CROFT & MEYER, 1973). In the present study, populations of *A. swirskii* developed different levels of resistance to dimethoate. In orchard under consecutive applications of dimethoate, resistance developed in *A. swirskii* which biologically control red spider mites and small insects like thrips and scale insects (AFIA, 2000).

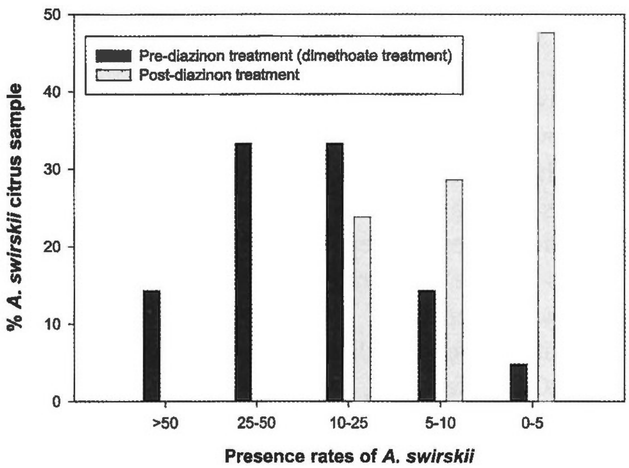

FIG. 3. — Presence rate and percentage of *A. swirskii* per citrus sample in pre- and post-diazinon treatment.

In a resistant population, the predaceous mite, *A. swirskii* was three times more sensitive to the organophosphate malathion, 68 times to diazinon and 108 times to the synthetic pyrethroid deltamethrin. In a field experiment on the same population, application of diazinon eliminated predators for at least 6 months. In their absence, intensive infestations of red spider mites have been reported (AFIA, 2000). In Michigan apple orchards (U. S. A.) populations of an azinophosmethyl resistant strain of *N. fallacis* were highly sensitive to the synthetic pyrethroid permethrin (STRICKLER & CROFT, 1981); and populations of the predaceous mite, *Typhlodronus pyri* (Schuten) from English apple orchards with history of organophosphates and carbaryl showed cross-resistance to azinophosmethyl, parathion and carbaryl, yet no resistance to permethrin was recorded (KAPETANAKIS & GRANHAM, 1983).

Insecticide	LC_{50}	LC_{90}	Slope	Sensitivity compared with dimethoate at LC_{50}
Malathion	0.836	1.621	4.456	3.2
Diazinon	0.040	0.150	2.291	68.0
Deltamethrin	0.025	0.119	1.874	108.4

TABLE 2: Susceptibility of *Amblyseius swirskii* of Mullak population (dimethoate resistant strain) to malathion, diazinon and deltamethrin

In commercial production systems such as citrus, target and non-target pests infest trees and growers are required to integrate control of both of pests without obvious negative effects on the other. The genetics of predaceous mites have been studied and it is possible to select insecticide resistant strains of predaceous mites (CROFT, 1982; EL-BANHAWY et al., 2000). These strains can be used in agro-ecosystem like citrus for the biological control of secondary pests while insecticides control the target pests without interrupting function and behaviour of the predaceous mites. No key pests like codling moth on apple (CROFT, 1982); or the Mediterranean fruit fly (EL-BANHAWY, 1997) has developed resistance to the widely used insecticide such azinophosphomethyl on apple and diptrex or carbaryl on citrus

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