Effects of Some Acaricides on Life Table Parameters of the Predatory Mite, *Phytoseiulus macropilis* Fed on the Two-Spotted Spider Mites

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Abstract: The objective of this study was to evaluate the effects of some selected acaricides recommended for the control of the two-spotted spider mites; chlorfenbyer (Challenger® 36% SC), hexythiazox (Maccomite® 5% WP) and pyridaben (Pyromate® 20% WP) on development and life table parameters of *Phytoseiulus macropilis* (Banks) as an important natural enemy of this pest mite under laboratory conditions. Life cycle duration averaged 8.44, 8.20 and 9.45 days for chlorfenbyer, hexythiazoxand and pyridaben, respectively compared to 5.49 days in the control. The tested acaricides caused a significant reduction in the female longevity and fertility of the predatory mite. The intrinsic rate of increase (r_m) and finite rate of increase (λ) values were significantly lower than those in the control. Mean generation time (T) was 13.32, 14.96 and 13.88 with chlorfenbyer, hexythiazox and pyridaben, respectively, and significantly lower than the control (11.91 days). Pyridaben reduced fertility by 68.64% relative to the untreated control.

Keywords: *Phytoseiulus macropilis*, Life-table, Acaricides, Survival.

INTRODUCTION

The two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae), is an important agricultural pest with a global distribution. Its phytophagous nature, high reproductive potential and short life cycle facilitate rapid resistance development to many acaricides often after few applications (Herron and Rophail, 1993). The predatory mite, *Phytoseiulus macropilis* (Banks) has shown some efficacy against almost all stages of the two-spotted spider mites, *Tetranychus urticae* Koch, in Egypt (Heikal and Ibrahim, 2013); it also has the ability to prey on other tetranychid species (Ali, 1998).

Predator-prey interactions in crops may be affected by pesticides used to control phytophagous mites. A single control method against pests is not adequate and the success rate without any chemical control is significantly low, but pesticides should be chosen from products with the least effect on environment and natural enemies (Alzoubi and Conbanglu, 2008). Knowledge of pesticides side effects is essential when management spider mite population. To minimize the effect of chemical control on biological control agents and providing an ecological balance between pests and their natural enemies, these control strategies can be integrated to provide a more rational form of managements (McMurty and Croft, 1997). Bonazos *et al.* (2007) mentioned that development of resistance in some phytoseiid predators has played an important role in their conservation in commercial production, contributing to the success of integrated phytophagous mite management programs.

Some research has been reported for direct effects of acaricides on the predatory mites; *Phytoseiulus macropilis* (Brun *et al.,* 1983; El-Sharabasy and El-Kady, 2015), *Phytoseiulus persimilis* (Athias-Henriot) (Kim and Yoo, 2002) and *Amblyseius womersleyi* Schicha (Kim and Seo, 2001). No studies have been published about the side effects of any of these acaricides on *Phytoseiulus macropilis*. So, experiments were conducted to evaluate the effects of chlorfenbyer (Challenger® 36% SC), hexythiazox (Maccomite® 5% WP) and pyridaben (Pyromate® 20% WP) used to control the two-spotted spider mites, *Tetranychus urticae* in Egypt. Such information can be used to predict the potential of these compounds in combination with one of the natural enemies of this mite pest.

MATERIALS AND METHODS

Predator mite rearing:

The predatory mite *P. macropilis* was collected from strawberry fields and reared in plastic boxes (26 x 15 x 10 cm), in which a cotton pad was put in the middle of each box, and provided with water as a barrier to prevent mites from escaping. The original population of *T. urticae* was collected from the castor oil plant (*Ricinus communis* L.), and reared continuously on sweet potato plants. The old dried leaves have been weekly replaced with new ones.

Acaricides:

Three acaricides were tested under laboratory conditions. Chlorfenbyer (Challenger® 36% SC (162 ppm), Hexythiazox (Maccomite® 5% WP (20 ppm) and Pyridaben (Pyromate® 20% WP (40 ppm). The concentrations were chosen based on the field recommended concentrations in Egypt.

Life table assay:

All experiments were conducted in the laboratory at 25±2°C and 65±5% RH and 16:8 L: D h. The experiment was performed on mite eggs using the leaf dip methods (Ibrahim and Yee, 2000). Mite females were left on castor bean leaves to lay eggs for 24 h then removed. The leaves with eggs were dipped in the tested acaricides for 10 s, and then placed upside down on a wet cotton pad and allowed to dry for about 2 h. Four discs with 5 eggs were dipped in each concentration. The control leaf discs were dipped in distilled water only. Hatched eggs were checked for five days. Twenty hatched larvae were reared singly up to adulthood. In each experiment, all stages of *T. urticae* were provided as a food source. Daily monitoring of survived females, growth index (GI) (mean of adult emergence % / average of life cycle), the number of eggs laid and the number of offspring individuals reaching the adulthood were provided to calculate the life table parameters.

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These parameters were: l_x (Age-specific survival): the proportion of living females in the age x, m_x (age-specific fertility): the number of female offspring/female in the age x, *where* x the age of females in days. The net reproductive rate (R_o), the mean generation time (T), the intrinsic rate of increase (r_m) and the finite rate of increase (λ) were calculated using the method recommended by Birch (1948):

$R_o = \sum(l_x \times m_x)$

$T = \sum(x \times l_x \times m_x)/R_o$

$r_m = \text{Ln}\ (R_o)/T$

$\lambda = \exp\ (r_m)$ (antiloge r_m)

The numerical data obtained were computerized and statistically analyzed through ANOVA (SAS Institute, 2002) and Duncan's Multiple Range test.

RESULTS AND DISCUSSION

Effect on biological parameters:

Results in Table (1) shows that the predator successfully completed its development after treatments. Each of the tested acaricides significantly affected egg incubation period, immature stage period and life cycle in comparison to the control. Data revealed that no significant effects between acaricides on incubation period, which lasted for 2.51, 2.54 and 2.63 days in chlorfenbyer, hexythiazox and pyridaben treatment, while lasted for 1.98 days in the control.

Deutonymphal duration was 1.43 days in the control, and ranged between 2.09 to 2.34 days in treatments, which were approximately similar to the results acquired by Lee and Gillespie (2011) for *Amblyseius swirskii* Athias-Henriot. There was a significant difference between the effects of chlorfenbyer, hexythiazox on one side and pyridaben on the other side on life cycle duration that averaged; 9.45, 8.20 and 8.44 days, respectively compared to 5.49 days in the control. Tawfik and El-Gohary (2013) found that the incubation period and life cycle of the predaceous mite, *Phytoseiulus persimilis* Athias-Henriot were significantly affected by chlorfenbyer, and the predator females were died just reached to adulthood with eggs treated by this acaricide.

Table (1): Effects of the tested acaricides on developmental durations of different stages of *P. macropilis* feeding on *T. urticae*

Life stage	Treatments			
	Control	Chlorfenbyer	Hexythiazox	Pyridaben
Egg	$1.98^{b} \pm 0.2$	$2.51^{a} \pm 0.22$	$2.54^{a} \pm 0.11$	$2.63^{a} \pm 0.11$
Larvae	$0.91^{b} \pm 0.2$	$1.49^{a} \pm 0.03$	$1.46^{a} \pm 0.03$	$1.61^{a}\pm\pm 0.11$
Protonymph	$1.22^{b} \pm 0.3$	$2.31^{a} \pm 0.11$	$2.11^{a} \pm 0.01$	$2.82^{a} \pm 0.22$
Deutonymph	$1.43^{b} \pm 0.1$	$2.13^{a} \pm 0.91$	$2.09^{a} \pm 0.18$	$2.34^{a} \pm 0.21$
Total immature	$3.51^{c} \pm 0.38$	$5.93^{b} \pm 0.38$	$5.66^{b} \pm 0.08$	$6.77^{a} \pm 0.10$
Life cycle	$5.49^{c} \pm 0.11$	$8.44^{b} \pm 0.15$	$8.20^{b} \pm 0.10$	$9.45^{a} \pm 0.18$

Means within a row followed by the same letter are not significantly different ($P > 0.05$)

Data in Table (2) revealed that the acaricides tested had no effects on pre-oviposition period. Post-oviposition period lasted 4.01 days in case of hexythiazox treatment, and it was closer to control (5.81 days) in pyridaben.

There were a significant difference between the effect of tested acaricides on female longevity, fecundity and egg hatching compared to the control. Results also showed that pyridaben, had the greatest direct impact on adult female longevity that was reduced to 35.11 days. Chlorfenbyer, hexythiazox and pyridaben had significant effect ($p > 0.05$) on adult longevity compared to the control. All of the acaricides reduced *P. macropilis* fecundity compared with the control. Tested acaricides reduced *P. macropilis* fertility, where pyridaben reduced fertility by 68.64% relative to the untreated control. In another study, pyridaben inhibited reproduction of *Galendromus occidentalis* (Acari: Phytoseiidae) (Alston and Thomson, 2004) whereas Ahn *et al.* (2004) reported that no indirect effects associated with sex ratio of *P. persimilis*.

Effects on life-table parameters:

The life table parameters of offspring of the treated females are shown in Table (3). Compared to control, treated females had significantly lower net reproductive rate, especially with hexythiazox (R_o = 18.78). Further, the intrinsic rate of increase (r_m) and finite rate of increase (λ) values were significantly lower than those in the control. Mean generation time (T) was 13.32, 14.96 and 13.88 with chlorfenbyer, hexythiazox and pyridaben, respectively, and significantly lower than the control (11.91 days). Similar value for control treatment of T (18.45 days) was obtained by Silva *et al.,* (2005) when *P. macropilis* reared on *T. urticae* at 26°C.

The intrinsic rate of increase (r_m) has been recommended to use for evaluating the total effects of pesticides, because it is based on both survivorship and fecundity. Several researchers have reported that life-table parameters of phytophagous and predatory mites were affected by sub-lethal concentrations of pesticides (Ibrahim and Yee, 2000; Hardman *et al.,* 2003). Sanatgar *et al.* (2011) argued that the effect of frequent application of hexythiazox on r_m was not significant after spraying of *P. persimilis* for several generations. This difference is possibly due to different experimental methods and predatory species.

Table (2): Effects of the tested acaricides on biological parameter of *P. macropilis*

Biological parameters	Treatments			
	Control	Chlorfenbyer	Hexythiazox	Pyridaben
Pri-oviposition	$3.41^a \pm 0.03$	$3.66^a \pm 0.11$	$3.01^a \pm 0.08$	$3.11^a \pm 0.03$
Oviposition	$8.23^a \pm 0.19$	$6.84^b \pm 0.03$	$6.19^b \pm 0.22$	$6.86^b \pm 0.03$
Post- oviposition	$5.11^a \pm 0.12$	$3.81^b \pm 0.01$	$4.01^a \pm 0.22$	$4.76^b \pm 0.13$
Female longevity	$43.12^a \pm 0.12$	$38.64^b \pm 0.13$	$38.05^b \pm 0.11$	$35.11^b \pm 0.03$
Fecundity (eggs)	$35.21^a \pm 0.11$	$25.81^b \pm 0.11$	$25.11^b \pm 0.08$	$25.17^b \pm 0.11$
Egg hatch %	$97.91^a \pm 0.11$	$70.01^b \pm 0.11$	$73.09^b \pm 0.08$	$68.64^b \pm 0.38$

Table (3): Effects of the tested acaricides on life table parameters of *P. macropilis* feeding on *T. urticae*

Parameters	Treatments			
	Control	Chlorfenbyer	Hexythiazox	Pyridaben
R_0 **(females/female)**	32.44	22.93^b	18.78^c	21.46^b
r_m **(eggs/female/day)**	0.2921	0.2351^b	0.2074^b	0.2209^b
λ **(antiloge r_m) (female/female/day)**	1.95	1.71^a	1.61^b	1.66^b
T **(day)**	11.91	13.32	14.96	13.88

Effects on survival percentage and growth index (GI):

Table (4) showed that egg survival, larvae and nymphal stage of *P. macropilis* were decreased and influenced by the tested acaricides. Pyridaben was the most effective on the mean survival percentage; reaching 78.01% of the control, followed by hexythiazox 85.71% and chlorfenbyer 84.01%. Tawfik and El-Gohary (2013) found that chlorfenbyer caused 41.6% survival with *Phytoseiulus persimilis* feed on *Tetranychus urticae*. Growth index (GI) was 8.26, 10.21 and 9.96 for *P. macropilis* females after treatment with chlorfenbyer, hexythiazox and pyridaben, respectively, while it was 18.21 in the control treatment.

Table (4): Effects of the tested acaricides on survival of immature stages of *P. macropilis*

Treatments	Stage survival %				Adult emergence %	Growth index
	Egg	Larvae	Protonymph	Deutonymph		
Control	99.01 ± 0.11	98.13 ± 0.56	100.00	100.00	100.00	18.21
Chlorfenbyer	$91.47^b \pm 0.11$	$88.15^c \pm 0.31$	$89.50^c \pm 0.56$	$81.22^b \pm 0.38$	$84.01^b \pm 0.38$	8.26
Hexythiazox	$92.13^b \pm 0.14$	$90.45^b \pm 0.01$	$92.11^b \pm 0.10$	$91.69^b \pm 0$ .58	$85.71^a \pm 0.37$	10.21
Pyridaben	$86.11^c \pm 0.37$	$83.36^b \pm 0.38$	$84.16^b \pm 0.14$	$78.71^b \pm 0.19$	$78.84^a \pm 0.13$	9.96

The low concentrations of the tested acaricides may be used in combination with biological control agents within an IPM system reducing the selection pressure, development of resistance and to adjust the predator/prey ratio (Cheon *et al.,* 2007). Our laboratory results clearly show that all the acaricides tested had detrimental side effects on *P. macropilis*. Also, the side effects were manifested differently on adult female longevity fecundity, fertility and development of progeny**.** IOBC/WPRS (Oomen, 1988) guidelines suggest that studying the side effects of pesticides on beneficial organisms is highly recommended.

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