J. Agric. Sci. Mansoura Univ., 27(4): 2575 - 2586, 2002

EFFECT OF SUBLETHAL DELTAMETHRIN DEPOSITS ON SOME BIOLOGICAL ASPECTS OF SPIDER MITE *Tetranchus urticae* AND THE PREDATORY MITE *Amblyseius fallacis*

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ABSTRACT

Whole bean leaves were dipped in a range of deltamethrin concentrations to identify a concentration which causes no mortality, but which affected the feeding of the predatory mite, *Amblyseius fallacis* on the eggs of the two spotted spider mite, *Tetranychus urticae*. This concentration (0.0002%) was then used to assay the sublethal effects of deltamethrin on the oviposition of the two mites, prey consumption by the predator, and on the activity of *T. urticae* and *A. fallacis*.

The deltamethrin deposit reduced oviposition in both predator and the prey, this egg consumption by *A. fallacis* was effectively reduced by presence of chemical on the leaf surfaces.

Predators placed on leaves with no prey very quickly moved to infested leaves and remained there as long as adequate prey was available. During a seven days period, prey mites did not move from the leaf on which they were placed. The predator moved to treated leaves carrying prey, but preferred untreated leaves these were available. *T. urticae* activity showed that there was a significantly higher percentage of movement on treated discs and there was also a significantly longer average movement duration.

On chemically treated surfaces, *A. fallacis* showed decreased feeding and oviposition capacity compared with the control. *A. fallacis* showed no significant increase in duration of movement on treated surfaces but the frequency of movement was increased about 50% and the proportion of time spent in moving was roughly doubled compared with control.

INTRODUCTION

At the present time, the synthetic pyrethroids are among the more important groups of chemical control agents used in pest management. They present less of hazard to the environment than other groups due to their low mammalian toxicity and low dose rates. However, Strickler and Croft (1982) stated that their poor arthropodal selectivity might limit their use in control programmes which include the use of beneficial arthropods. The use of pyrethroid insecticides in recent years had stimulated spider mite outbreaks on cotton and other crops (Plant and Mansour, 1980; Sukhoruchenko *et al.*, 1982; Maggi and Leigh (1983).

In reviewing the toxicity of the synthetic pyrethroids to arthropod natural enemies, Croft and Whalon (1982) suggested that outbreaks of spider mites associated with pyrethroid applications to apple, could be partly attributed to the fact that phytophagous species were generally less affected by these chemicals than their phytoseiid predators. Fenvalerate was shown to inhibit mite feeding and when a choice between treated and untreated surfaces was offered, the latter were more attractive as oviposition sites (Hall, 1979). This activity has been confirmed in other investigations (Penman *et al.*, 1981; Penman and Chapman, 1983). Acaricidal activity of pyrethroids consists of at least, direct toxicity and repellency or avoidance of residues. There are increasing claims that new pyrethroids have acaricidal activity in contrast to early chemicals such as fenvalerate and permethrin (Iftner and Hall, 1983). The pyrethroids deltamethrin and fenvalerate significantly reduced the total duration of probing of apterous *Myzus persicae* and *Aphis nasturtii* by from 33% to 77% (Lowery and Boiteau, 1988). Sublethal effects can supplement mortality in several ways, for example by causing the insects to avoid treated surfaces; by reducing the reproductive potential (Jackson and Wilkins, 1985); and by interfering with feeding and oviposition (Hajjar and Ford, 1989).

The sublethal concentrations of deltamethrin was probably toxic and definity repellent to the spider mite *Tetranychus urticae* and deltamethrin deposit reduced oviposition on treated leaves compared with control leaves, (Salama *et al.*, 1991, Keratum, 1993 and Keratum *et al.*, 1994).

The pyrethroids fenvalerate and deltamethrin were the most effective in decreasing spider mite fecundity (Hosney *et al.*, 1998).

Derbalah (1999) showed that fecundity was highly reduced by bromopropylate followed by fenpyroximate and dicofol, while benomyl had a moderate effect on rate of egg deposition. Propargite, bupirimate, cypermethrin and Biofly had little effect on this biological character and no significantly differences between them and control were observed.

These effects could be important because unlike organophosphorus and carbamate compounds, synthetic pyrethroids are able to leave residues which act as antifeedants. Low levels of chemicals remaining from earlier treatments could be non-lethal but could affect the number of predatory mites required for successful biological control. Increasingly, mite control on crops relies mainly on predation by predators and the influence of residues on this relationship is potentially very important. This possibility was one of the principal reasons for this study.

Also, the effects of sublethal deposits of pyrethroid against the two spotted spider mite *T. urticae* and the predatory mite, *A. fallacis* are investigated.

MATERIALS AND METHODS

1. Mite cultures:

The prey species was the two-spotted spider mite, *Tetranychus urticae*. Which was reared on French bean (*Phaseolus vulgaris*) plants, grown singly in John Innes No. 1 compost.

Adult female mites were allowed to oviposit overnight on French bean leaves and were then removed. The leaves with eggs were placed on clean plants which were transferred to small isolated gauze cages. After 16 days ovipostional adult females of uniform age were produced by these cultures for experimental use. Fresh plants were place din the cages when necessary. The prey cultures were kept at 25 $\pm$ 2°C under a 16 hours photoperiod.

The predatory mite, *Amblyseius fallacis* was reared separately, under the same conditions on French bean plants infested with red spider mite.

2. Chemical used:

Technical deltamethrin (100 a.i) dissolved in a 10% butanone. The chemical name: (5-cyano-3-phenoxy-benzyl (IR, 3R)-Cis-3-(2,2-dibromovinyl)-2,2-dimethyl cyclo propane carboxylate).

3. Experimental techniques:

a) Dipping of leaves:

Croft and Nelson's (1972) method was used. Leaves were dipped in the required concentration of technical deltamethrin, left to dry, and laced on water-soaked cotton wool pads in petri dishes. Twenty eggs of *T. urticae* were placed on each leaf and adult females of *A. fallacis* were added: The number of eggs eaten and laid were recorded after 24 hours.

b) Dipping of whole plants:

The method of Smith *et al.* (1963) was adopted. Young plants bearing only four primary leaves were dipped in the required concentration of deltamethrin (technical a.i). After the foliage had dried, the plants were infested with spider mites. After the mites had become established and had laid eggs for one day, adults of *A. fallacis* were transferred to the plants and the stages present were counted after one week.

Three sets of four-leaves plants were compared; i.e. untreated, completely dipped or top pair of leaves only dipped. A single female mite was placed on each of three of the four untreated leaves. Two mites were placed on each treated leaf. On partially treated plants, a pair of females was placed one each treated leaf and on one of the untreated leaves. The total number of eggs produced were counted at the end of seven days.

c. Preparation of disks:

A cork borer was used to cut each 1 cm leaf disk from a broad bean leaf, with the midrib forming the diameter of the disk. The disk was supported on water by a small cotton wool pad in a 9 cm Petrti dish. Treated disks were dipped into a solution of the pesticide under test for five seconds, drained vertically, air dried and placed in Petri disches as described above.

d. Video technique:

All video recording were made on BASF E 240 chromdioxid video lapes, using a Panasonic NV 788 video cassette recorder connected to a Sony colour television camera, WVP-200 E.

The timer built into the camera was used to place a time trace on the traps as they were recorded. The time was displayed down to one-hundredth of a second. A SABA 14 inch ultracolour video monitor CRXM14 was connected into the system enabling a live picture of the disc being filmed to be viewed at any time during the recording process. Recordings were always made with tapes which allowed up to 8 hours recording on one tape.

e. Measurement of activity:

The activity of *T. urticae* on treated and untreated leaf disks were prepared as described above, the dose used was 0.002% deltamethrin and 3 adult female *T. urticae* were placed on each disk. The percentage of time spent moving, the mean duration of movement, and the frequency of movement were used to assess activity. The activity of *A. fallacis*, twenty *T. urticae* eggs were transferred with a fine sable hair brush, ten being place don either side of the midrib.

A female predator was placed on the periphery of the leaf disc, and the number of eggs subsequently eaten and laid were recorded.

The egg stage of *T. urticae* is the preferred prey stage for *A. fallacis* and has a greater duration than any other immature stage of the life cycle (Laing, 1969).

Plant discs carrying mite eggs were dipped into a solution of the pesticide under test for five seconds, drained vertically, air dried and place din petri-dishes as described above.

RESULTS AND DISCUSSION

1. Choose of sublethal deltamethrin deposit:

Results showed that, no mortality occurred at these concentrations but a significant fall in prey consumption took place as the concentration was increased from 0.00002% to 0.0002% (Table 1). The latter was therefore used for all whole plant treatments and activity.

Table (1): The daily mean number of eggs eaten per female of *A. fallacis* (with 95% confidence limits).

Dose	No. of eggs eaten/female/day
Untreated	9.4 ± 0.7
0.00002%	8.3 ± 1.2
0.0002%	5.7 ± 2.9
0.0005%	4.7 ± 2.6
0.001%	4.7 ± 1.3

2. Effect of sublethal deposit on *T. urticae*:

Table (2) shows a reduction in egg laying on treated leaves. None of the mites moved from the leaf on which they were originally placed and the reduction in egg number was presumably due to reduced feeding.

Table (2): Effect of 0.0002* deltamethrin on *T. urticae* oviposition.

Plants		No. of adults	No. of eggs	Eggs laid/female/day
Untreated plants	1	3	165	7.9
	2	3	166	7.8
	3	3	173	8.2
Treated plants	1	8	260	4.6
	2	8	263	4.7
Partially treated plants	1. Treated leaves	4	133	4.7
	Untreated leaves	2	101	7.2
	2. Treated leaves	4	133	4.7
	Untreated leaves	2	106	7.6

3. Effect of deposits on predator egg consumption and oviposition:

Table (2) provides theoretical mean rates of egg production (8.0 untreated and 4.6 treated) for estimating egg consumption by predators on treated and untreated plants (ignoring partially treated plants).

Table (3) shows that the presence of the chemical reduces the consumption of prey by a factor which approaches 50%. Correspondingly the egg production of the predator is approximately reduced on treated leaves.

Table (3) also indicates that decreasing the prey/predator ratio reduces availability of the prey and hence consumption.

Table (3): Effect of 0.0002% deltamethrin on *A. fallacis* egg consumption and oviposition.

Plants	Untreated			Treated	
No. of replicates	3	2	1	2	12
No. of *T. urticae*	9	6	3	12	386
Estimated eggs laid	504	336	168	386	203
Observed No. of eggs	303	114	9	205	183
Estimated No. of eaten	201	222	159	181	6
No. of *A. fallacis*	3	4	3	6	5.1
No. of eaten/female/day	11.2	9.3	8.8	5.0	36
No. of eggs laid	42	54	41	39	1.0
No. of eggs female/day	2.3	2.2	2.3	1.1	2.0
Prey/predator ratio	3.0	1.5	1.0	2.0	

4. Effect of deposits on distribution of mites:

4.1. *T. urticae*:

In virtually all of the experiments using untreated, treated or partially treated plants the two spotted spider mite females remained on the leaf on which they were originally placed, for the whole of the seven day period. There was only one exception, where a mite moved from a treated to an untreated leaf (Table 4, expt. 6).

4.2. *A. fallacis*:

The predators were always placed on one of the lower leaves (L2), in all experiments. This leaf carried no prey mites or eggs, except in the one case of *T. urticae* migration quoted above. On untreated plants, nine of the ten predators finally moved to upper leaves. The lower leaf was not visited by predators in expt. 2 suggested visits by predators other than the one located there at the end of seven days.

Experiments 3 shows that prey location behaviour of the predator was not disrupted by the presence of the chemical. If the predators had the choice between treated leaves carrying prey and untreated leaves lacking prey (expt. 4) they all seemed to have spent their time on the former.

Table (4): Effect of presence of prey and presence of pesticide on predator distribution after seven days.

No. of experiment	No./plant		U1	U2	L1	L2
1	2 predators	A	2	2	0	0
		B	26	328	0	0
		C	8	5	101	0
2	3 predators	A	2	3	1	0
		B	27	33	21	0
		C	5	5	18	0
3	3 predators	A	3 (T)	1 (T)	2 (T)	0 (T)
		B	20	6	13	0
		C	37	100	68	0
4	3 Predators	A	2 (T)	2(T)	2 (T)	0
	Placement leaf	B	311	12	13	0
	untreated	C	69	64	70	0
5	3 predators	A	1 (T)	1 (T)	5	0 (T)
	non-placement	B	7	6	54	0
	lower leaf	C	95	97	5	0
	untreated					
6	3 predators one	A	4	0 (T)	1 (T)	1
	upper and one	B	52	2	6	9
	lower treated	C	5	90	96	3

(T) = Treated
A = Distribution of predators (sum of two replicates)
B = Distribution of predator eggs (sum of two replicates)
C = Prey eggs remaining (sum of two replicates)
U = Upper leaf
L = Lower leaf

All predators initially place don L2.

In experiments 5 and 6 the choice was between untreated or treated leaves with prey and untreated leaves without prey. There was a significant bias of predators towards untreated leaves with prey. The predator avoided the deposit if possible, but this behaviour was overridden by attraction to prey, if treated leaves were the only source of food.

Both predator and prey were affected by the sublethal deposit. In both cases egg laying was reduced, presumably as a result of inhibition of feeding.

The reduction in prey oviposition might delay the time at which damaging numbers were reached, even though predation was also reduced. However, the reduction in predator oviposition would necessitate changes in the predator: prey ratio required to bring a damaging population under control in a given period of time.

A further complication would arise if the deposit was uneventIy distributed on the plant. the data provided evidence that the prey on treated leaves were protected from predation if less repellent alternatives were available to the predator.

The influence of sublethal chemical deposits on these population parameters should be included in computer simulations of biological control operations.

The obtained results were in agreement with that recorded by (Keratum 1993; Ayyappath *et al.*, 1997; Hosny *et al.*, 1998 and Derbalah, 1999).

5. Activity:

5.1. *T. urticae*:

Control and treated disks were prepared as described above. The dose used was 0.002% deltamethrin and 3 adult female *T. urticae* were placed on each disk. Table (5) gives the data for mites which were maintained on either treated or control disks for 8 hours. the percentage of time spent moving, the mean duration of movement, and the frequency of movement were used to assess activity.

In the case of movement duration, there was no significant difference between the means of the replicates, but the individual data were highly showed and required transformation, the log data were normalized.

There was a significantly higher percentage movement on treated disks, and there was also a significantly longer average movement duration. Although the number of moves on treated discs appeared greater than on control disks, the number of observations of each was not sufficient to show a significant difference.

On beans the total duration of all movements by *T. urticae* was 18.9% of the total time on untreated disks, whereas on 0.002% treated disks it was 43.4%. The ratio of treated: untreated movement was therefore 2.3. The ratio of untreated: treated oviposition was 6.7: 2.5 = 2.7. Oviposition appeared therefore to be roughly inversely proportional to amount of movement. No direct measurement of feeding was made on *T. urticae* but it might be assumed to be proportionally related to oviposition.

The mean move duration of *T. urticae* on untreated disks was 136.4 secs and on treated disks was 255.98 secs, whereas the number of moves per hour was 4.98 on untreated discs, and 6.1 on treated disks. The increase in duration as a result cf treatment was much more marked in *T. urticae*. In this study the results showed that the oviposition was reduced with deltamethrin, but the activity of movement was raised on treated compared with control surfaces.

Table (5): Percentage of time spent moving, mean duration of movement, and frequency of movement on control and treated disks of *T. urticae* (TU).

No. of mites	Duration of recording	Total move time	Mean No of moves per hr.	% Total time moving	Mean move duration	Log. move
TUC. 1	25455	3917	4.38	15.4	126.35	1.847
TUC. 2	27948	5736	5.54	20.5	133.40	1.873
TUC. 3	28258	5763	4.97	20.4	147.77	1.870
Pooled (C)	81661	15416	4.98	18.88	136.42	1.863
TUT. 1	27740	13508	6.10	48.7	287.40	2.090
TUT. 2	27619	9890	4.04	35.8	319.03	2.181
TUT. 3	28478	1970	8.09	49.1	218.28	2.040
TUT. 4	27733	11012	6.10	39.7	234.30	2.116
Pooled (C)	111570	48380	6.10	43.36	255.98	2.096

(C = Control & T = Treated)

* Statistical analysis was done according to the method of Sabelis (1981)

This activity has been confirmed in other investigations (Penman *et al.*, 1981; Penman and Chapman, 1983 and Iftner and Hall, 1983). Acaricidal activity of pyrethroids consists of, at least, direct toxicity and repellency or avoidance of residues. There are increasing claims that new pyrethroids have acaricidal activity in contrast to early chemicals such as fenvalerate and permethrin. The pyrethroids deltamethrin and fenvalerate significantly reduced the total duration of probing of opterous *Myzus persicae* and *Aphis nasturtii* by from 33% up to 77%. These decreases were however obtained with doses which caused some mortality and cannot be ascribed to a purely repellent effect (Lowery and Bioteau, 1988). Giboney (1981) and Barritt (1984) indicated that the active mite showed greater percentage movement, greater frequency of pauses and moves, and longer activity blocks.

5.2. *A. fallacis*:

Discs carrying 20 eggs into two rows were treated with 0.0002% deltamethrin by being dipped for five seconds, drained and air dried. One experiment was carried out on a disc which was half treated and half untreated. Recordings were made for 8 hours, and the percentage of time spent moving the mean duration of movement, and the frequency of movement are given in Table (6).

The following points are concluded from Table (6):

1. The predators increase their activity in response to the pesticide.
2. *A. fallacis* did not appear to increase duration of movement, but frequency of movement was up about 50%.
3. The proportion of time spent moving was roughly doubled.
4. On the half treated disc, activity was equally elevated on both sides.

The portion of time spent moving by *A. fallacis* was slightly less than by *T. urticae* (Keratum, 1989). On untreated discs the predator's total movements were 13.5% of the total time, but on 0.0002% treated discs the movement proportion was 25.3%, this gives a ratio of 1.9:1, which was a rather bigger difference than the reduction in feeding (1.6:1). The corresponding value for oviposition was (1.7:1) and the general relationship between these three factors appeared to be confirmed.

The existence of relationships between feeding and oviposition, and feeding and certain activity parameters, and the connections between the levels of these elements and the nature of surface on which mites were placed, suggested that disturbances in all three patterns of behaviour could be triggered by the effects of sensory detection of the pesticide on the surface. Mite activity can certainly be influenced by the substrate (Blommers *et al.,* 1977; Everson, 1979, 1980), and the hypothesis that deltamethrin on treated discs induced changes in the activity patterns of *A. fallacis* that were responsible for decreased feeding and egg laying appeared valid.

Table (6): **The percentage of time spent moving by *A. fallacis*, the mean duration of movement, and the frequency of movement on control and treated discs.**

	Duration of recording	Total move time	No. of moves per hour	% total time moving	Mean move duration	Log move
Control. 1	28578	3018	4.28	10.56	88.76	1.81
Control. 2	28435	4686	5.06	16.48	117.15	1.68
Control. P	57013	7704	4.67	13.51	104.11	1.745
Treated. 1	46445	5088	7.63	19.24	90.86	1.61
Treated. 2	28461	8815	7.97	30.97	139.92	1.87
Treated . P	54906	13903	7.80	25.32	116.83	1.74
Control. M	28610	9168	9.19	32.04	125.60	1.79
Treated. M	27721	6054	9.87	21.84	79.66	1.597

Control. P = Control Pooled
Treated. P = Treatment Pooled
Control. M = Control side of half treated disc
Treated. M = Treatment side of half treated disc.

Keratum and Hosny (1994) found line relationship between feeding and egg laying by *Phytoseiulus persimilis* under the effect of some pyrethroids.

Clearly, any factor which affects frequency of movement of the predator could affect the frequency of contact between predator and prey.

The mean move duration of *A. fallacis* in this study was 104.1 sec. on untreated discs and 116.8 sec. on treated disc, whereas the number of moves per hour was 4.7 on untreated discs and 7.8 on treated discs therefore deltamethrin stimulated activity.

The obtained results were in agreement with that recorded by (Giboney, 1981; Barritt, 1984 and Aziz, 1985).

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تأثير الجرعات غير المميته من متبقيات دلتاميثرين على بعض العوامل البيولوجية لاكاروس العنكبوت الاحمر (تترانيكس اورتيكا) والعنكبوت المفترس (أمبلسيس فالاسيس)

اسماعيل ابراهيم الفخرانى
قسم المبيدات ــ كلية الزراعة بكفرالشيخ ــ جامعة طنطا

غمرت أوراق نبات الفول الكاملة فى سلسة من التركيزات لمبيد الدلتاميثرين وذلك لتعيين التركيز المناسب الذى لا يسبب أى موت ولكن فى نفس الوقت يؤثر على معدل الافتراس للعنكبوت المفترس (أمبلسيس فالاسيس) وعلى بيض أكاروس العنكبوت الاحمر (تترانيكس أورتيكا).

واستعمل هذا التركيز (٠,٠٠٠٢%) من الدلتاميثرين لاختبار التأثيرات للجرعات غير المميته من المبيد على معدل وضع البيض لكل من العنكبوت المفترس وأكاروس العنكبوت الاحمر وكذلك معدل الافتراس للعنكبوت المفترس وكذلك دراسة النشاط لكل من أكاروس العنكبوت الاحمر والعنكبوت المفترس.

ولقد أوضحت الدراسة أن معدل وضع البيض لكل من العنكبوت المفترس وأكاروس العنكبوت الاحمر المعرض لمتبقيات مبيد دلتاميثرين كانت منخفضة. وربما يرجع ذلك الى خصائص متبقيات البيرثرويد كمضادات للتغذية.

وأوضح العنكبوت المفترس (أمبلسيس فالاسيس) انخفاض فى التغذية على السطوح المعاملة كيميائيا وكان التأثير الى النصف اذا قورن بالسطوح غير المعاملة. وعندما وضع المفترس على ورقة النبات الكامل بدون عنكبوت (فريسة) فانه سرعان ما تحرك الى ورقة اخرى حيث يوجد العنكبوت الفريسة وعادة ما يبقى هناك طالما وجدت الفريسة خلال فترة السبعة أيام لا يتحرك العنكبوت الفريسة الى ورقة نبات أخرى طالما بقيت حالة الورقة جيدة. يتحرك المفترس بسرعة من ورقة نبات معامل الى اخرى تحمل الفريسة حيث تنخفض التغذية ولكن اذا توافرت اوراق غير معاملة فان المفترس يفضلها ويهاجر اليها.

أما بالنسبة لنشاط اكاروس العنكبوت الاحمر فكان التأثير منعكس حيث ازدادت معايير الحركة معنويا (النسبة المئوية للحركة ، الوقت المستهلك فى الحركة ، تكرار الحركة) فى العنكبوت الاحمر المعرض لاوراق معاملة بالنسبة للافراد المعرضة لاوراق غير معاملة.

وقد أظهر الاكاروس المفترس على السطوح المعاملة انخفاضا فى التغذية على بيض الاكاروس تترانيكس اورتيكا وانخفاضا ايضا فى وضع البيض بالمقارنة بغير المعامل. ولم تظهر أى زيادة جوهرية فى فترة الحركة فوق تلك السطوح المعاملة ولكن زادت تكرارات الحركة بما يعادل ٥٠% تقريبا ، وتضاعف ايضا الزمن المنقضى فى الحركة عن مثيله على السطوح غير المعاملة.