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Orijinal araştırma (Original article)

The effect of commonly used insecticides, cypermethrin and diazinon active ingredients on different types of behavioural activities of *Coccinella septempunctata* Linnaeus, 1758 (Coleoptera: Coccinellidae) and *Aphidius uzbekistanicus* Luzhetzki, 1960 (Hymenoptera: Aphidiidae)[1]

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Summary

In this study, the effects of residual deposits of active ingredients of cypermethrin and diazinon on behavioural activities of *Coccinella septempunctata* Linnaeus, 1758 (Coleoptera: Coccinellidae) and *Aphidius uzbekistanicus* Luzhetzki, 1960 (Hymenoptera: Aphidiidae) females were investigated using a video/computer recording and measurement system. In this study, 500-1000 $\mu\ell/\ell$ dosages of cypermethrin and diazinon for *C. septempunctata* and 1000-2000 $\mu\ell/\ell$ dosages of cypermethrin and 250-500 $\mu\ell/\ell$ dosages of diazinon for *A. uzbekistanicus* were tested at laboratory conditions in 2001-2002. The results obtained from behavioural activities, indicated that walking time of the predators was much higher in diazinon treatment than that in cypermethrin treatment, Cypermethrin treatment had no effect on the speed of predators, while they often turned with high angles. In diazinon treatment, predator insects moved with high speed and changed their direction by moving in same direction with low turning angles. In cypermethrin applied areas, movement traces of *C. septempunctata* indicated that they often turned their own surrondings. The predator insects in high diazinon dosage applied areas had a dense movement trace. At both application dosages of cypermethrin and diazinon *A. uzbekistanicus* spent more time in walking and less time in resting. At high dosages, net speed of the parasitoid decreased. At high dosage of cypermethrin, parasitoid slightly changed direction with low angles, while they often

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turned with high angles in diazinon treatments. In diazinon applied areas, parasitoid had dense movement trace in a slightly wider area than that in cypermethrin applied areas and narrower area than that in control.

Key Words: Insecticide, *Coccinella septempunctata*, *Aphidius uzbekistanicus*, behaviour, activity

Anahtar sözcükler: İnsektisit, *Coccinella septempunctata*, *Aphidius uzbekistanicus*, davranış, aktivite

Introduction

The application of insecticides with wide spectrum in agricultural lands causes negative effects on biological control agents such as the predators and parasitoids. These insecticides either directly or indirectly affect the predators and parasitoids. Direct effects can be seen with either the contact of predators and parasitoids with insecticide-applied surface or consumption of insecticide-applied prey by the predators. Indirect effects are known as the direct contact of predators and parasitoids with the toxic materials. In both case, due to the toxic effect of the insecticides, the number of natural enemies is decreased and thus predation and parasitism rate can be reduced (Blümel et al., 1999). As a result of this, the natural pressure of these natural enemies on insect pests are prevented and outbreaks of the insect pests occur in many agricultural lands and secondary insect pests suddenly become serious primary pests that cause economic crop losses (Toros et al., 2001).

In integrated pest management programme in cultivated plants, natural enemies should be protected against the toxic effects of insecticides and should be conserved to enhance conditions for natural enemy survival and reproduction relative to pests so that pest population rates are lowered and pest densities reduced over time. For this reason, many studies have been done to determine the side effects of insecticides on natural enemies. Among these studies, several biological tests have been done to determine the effects of active ingredients of several insecticides used in several cultivated plants at various dosages on natural enemies (Başpınar & Uygun, 1990; Kılınçer et al., 1990; Karaca et al., 1994; Kazak & Şekeroğlu, 1996; Jansen, 2000; Van De Veire et al., 2002; Dalcı et al., 2009). On the other hand, residual toxicities of some insecticides to beneficial insects have been also studied (Roger et al., 1994; Cho et al., 1997). In addition to these studies, effects of some insecticides on behaviours of predators and parasitoids have been investigated by Borgemeister et al. (1993) and Longley & Jepson (1996).

Determining the negative effects of insecticides used in different cultivated plants in Turkey on natural enemies is quite important to develop integrated control programmes in agricultural production. Herein, present study was carried out to determine the effects of ingredients of commonly used

insecticides, cypermethrin and diazinon active ingredients on prey and host searching behaviours of aphid *Coccinella septempunctata* L. (Coleoptera: Coccinellidae) and wheat aphid *Aphidius uzbekistanicus* L. (Hymenoptera: Aphidiidae), respectively.

Material and Methods

Rearing of *Coccinella septempunctata*: This study was conducted at laboratory conditions in 2001-2002. *Coccinella septempunctata* was cultured on wheat aphid *Rhopalosiphum padi* (Linnaeus, 1758) (Homoptera: Aphididae). Wheat aphid, *R. padi* and the coccinellid predator, *C. septempunctata* were collected from wheat fields in Kahramanmaraş, Turkey. Cultures of both aphids and coccinellids were established in a growth room at 20 ± 1°C and 60 ± 5% r.h., with a LD 16:8 h photoperiod. Wheat aphids were reared on wheat (*Triticum vulgare* L.) grown in the growth room. Wheat plants infested by wheat aphid were placed into rearing cages covered with muslin nets in the growth room. After the population of wheat aphid had built up on the wheat plants in the cages, five male and five female adults of coccinellid predator were released separately into the cages for reproduction. After emergence of coccinellid larvae, some of the larvae were transferred to other cages containing wheat plants infested by wheat aphid. The wheat plants infested by wheat aphid were regularly added to cages as coccinellid predators consumed the aphids. Thus, one-week-old *C. septempunctata* females were regularly obtained and used for the experiments.

Rearing of *Aphidius uzbekistanicus*: In february, parasitized (mummified) aphids were collected from the wheat fields and were placed into small container (250 x 150 x 100 mm) which had two 2 cm diameter holes in the lid, covered by a piece of fine muslin net to provide ventilation. For food of *A. uzbekistanicus* adults emerged from the mummified aphids, cotton pieces wetted with sugar-water dilution (100 gr sugar/ℓ) were placed into the container. Newly emerged males and females feeding on sugar-water dilution were collected from the container by sucking tube and then were placed into the cages including wheat plants infested with *R. padi*. Mummified aphids by the parasitiods were transferred to the container which can easily be observed to obtain new parasitoid adults. Thus, mated 1–2 days old *A. uzbekistanicus* female indivudals fed with sugar-water dilution were regularly obtained and used for examinations. Culture of parasitoids was established in a growth room at 20 ± 1°C and 60 ± 5% r.h., with a LD 16:8 h photoperiod.

Insecticides and application dosages: In the study, cypermethrin (Arrivo 20EC) from synthetic pyrethroid group and diazinon (Bazinon 20EC) from organophosphate group were used. The commercial dosages of these insecticides recommended for wheat-plant grown in Turkey were used for the

biological tests. Commercial dosages of cypermethrin (40 ml/da) and diazinon (375 ml/100 ℓ) refers to 400 and 3750 μℓ/ℓ respectively, which was estimated according to Toros et al. (2001) reported that 100 L/da water is used in agricultural lands. For *C. septempunctata* females 500 and 1000 μℓ/ℓ dosages of both insecticides were used in behavioural tests, while 1000 and 2000 μℓ/ℓ dosage of cypermethrin and 250 and 500 μℓ/ℓ dosages of diazinon were used for *A. uzbekistanicus* females. The reason to be used a higher dosage of cypermethrin was that local farmers tend to use its increasing dosages in the field to ensure an adequate level of control of the target insect pests. The purpose of using of diazinon at a lower dosage than recommended was also to determine whether the behaviours of beneficial insects could be affected.

Video/Computer recording and measurement system: For all experiments, the video/computer recording and measurement system was used to record and analyse the activities of *C. septempunctata* and *A. uzbekistanicus* female. A complete system consists of a JVC video camera with lens and AC adaptor, a video recorder, a personal computer with the monitor and a computer video analysis software (Inchworm) developed at Wye College by Jon Varley in 1989 (Varley et al., 1994). The CCTV video camera with a 50 mm SLR camera lens was mounted above the experimental setup to observe the activities of the predator. The camera signal was fed into a video recorder to record all the activities on videotape. During the recording, the video signal was also displayed on the computer monitor to show predator activities in the experimental arena. Afterwards, the recorded videotapes were analysed using Inchworm Software.

Petri dish experiments for behavioural test: The solutions were prepared using the dosages of cypermethrin and diazinon mentioned above. The insecticides with various dosages were transferred into beher glass including 1 ℓ of water by the micropipette. To get homogeneous distribution of insecticide solution in water, a magnetic mixer was used for 20 min After filter papers with 9 cm diameter were dipped in prepared solutions for 20 sec, they were left on punched metal discs for drying for 1,5 h at room temperature. Filter papers treated with insecticide were placed into petri dishes with 2 cm diameter hole in the middle of the lid, which was covered by a piece of fine net to provide ventilation. The sides of the petri dish were coated with fluon to prevent the tested insects climbing onto the sides and lid of arena. One week and 1–2 days old females of *C. septempunctata* and *A. uzbekistanicus* respectively were released into each petri dish. In petri dish experiments, individuals that were experienced in feeding in insect culture were used. Afterwards, video/computer record/analysis system (Varley et al., 1994) was used to record behavioural activities of *C. septempunctata* and *A. uzbekistanicus* female on a video cassette for 12 min and their movement traces in the experimental arena. In control treatment, filter papers in petri dishes were treated with only water and

their behavioural activities were also recorded and analyzed by the same method. For each applied dosage and control application, five individuals were used as replicates. For recording their movement traces in the experimental arena only one individual from each treatment was used. All petri dish experiment for behavioural test were conducted under laboratory conditions of photoperiod with a continuous light produced by a cold light illumination, a temperature of 20°C ± 1°C, and 60 ± 5% relative humidity. In insecticide treated and non-treated arenas, insects were allowed to settle in experiment area at the first two minutes and therefore, their behavioural acitivites was analysed for 10 min on recorded videotapes.

Pre-recorded videotapes were analysed to determine the following behavioural activities of *C. septempunctata* and *A. uzbekistanicus* female:

Total duration (sec): Total observation duration,

Walking duration (sec.): Total wandering duration of insect during observation,

Walking distance (cm): Total distance travelled by the insect during observation,

Resting time (sec): The total time insect spend in a motionless pause during observation,

Gross speed (cm/ sec.): Gross speed of insect – total distance / total time,

Net speed (cm/ sec.): Net speed of insect - average speed of insect during movement,

Turning angle 1 (degree/ sec): Turning angle of insect from movement direction depending time – turning angle in each second,

Turning angle 2 (degree/ cm): Turning angle of insect from movement direction depending the distance - each turning angle arranged distance unit.

Data processing and analysis: The different types of behaviour activities (walking duration, walking distance, resting time, and gross and net speed, turning angle) of *C. septempunctata* and *A. uzbekistanicus* female individuals were analysed using one-way analysis of variance (ANOVA). Significant differences among treatments were determined by using the LSD test at 1% level (SAS Institute, 1988).

Results and discussion

Walking distance and resting time of *Coccinella septempunctata* females: Walking distance and resting time of *C. septempunctata* female individuals in cypermethrin and diazinon treated and non-treated arenas are presented in Table 1. Walking distance of *C. septempunctata* female at both dosage of cypermethrin was shorter than that at control treatment although they were not statistically different. However resting time at both dosage of cypermethrin was significantly longer than that at control treatment. In contrast to the results for cypermethrin, walking distance

and resting time of *C. septempunctata* female in diazinon treated arenas were signifantly longer than that in control treatment. However, there was no significant difference between the dosages of cypermethrin and diazinon in both walking distance and resting time of *C. septempunctata* female (Table 1).

Table 1. Walking distance and resting time of *Coccinella septempunctata* L., 1758 female individuals in cypermethrin and diazinon treated and non-treated arenas*

Treatments	Dosage (μL/l)	n	Walking distance (cm)±SE	Resting time (sec)±SE
Cypermethrin 1	500	5	217±13.4 B	246±6.7 A
Cypermethrin 2	1000	5	232±6.0 B	232±12.2 A
Diazinon 1	500	5	555±22.4 A	51±9.0 C
Diazinon 2	1000	5	524±0.7 A	68±15.5 C
Control	-	5	267±11.9 B	143±03.4 B
F value			$F_{4.20}$=8.9	$F_{4.20}$=83.1
P *value*			0.0003	<0.0001
LSD value			143.78	30.294

Different upper case letters indicate significant differences among means within a column for a particular activity (ANOVA followed by LSD, α = 0.01).
*Observation time is 600 seconds
n: number of replicates

Gross and net speeds of *Coccinella septempunctata* females: Gross and net speed of *C. septempunctata* females in cypermethrin and diazinon treated and non-treated arenas are presented in Table 2. There was no significant difference in gross and net speed of *C. septempunctata* females in cypermethrin treated and non-treated arenas. However, gross and net speed of *C. septempunctata* females in diazinon treated arenas were significanly higher than those in non-treated arenas. At each dosage of both active ingredients, there was not signifanctly difference in their gross and net speeds (Table 2).

Table 2. Gross and net speed of *Coccinella septempunctata* L., 1758 females in cypermethrin and diazinon treated and non-treated arenas*

Treatments	Dosage (μL/l)	n	Gross speed (cm/sec) ±SE	Net speed (cm/sec)±SE
Cypermethrin	500	5	0.36±0.02 B	0.64±0.03 BC
Cypermethrin	1000	5	0.39±0.01 B	0.57±0.03 C
Diazinon	500	5	0.78±0.19 A	1.20±0.03 A
Diazinon	1000	5	1.00±0.05 A	0.89±0.22 AB
Control	-	5	0.47±0.01 B	0.64±0.01 BC
F value			$F_{4.20}$=9.3	$F_{4.20}$=4.9
P *value*			0.0002	0.0065
LSD value			0.2702	0.309

Different upper case letters indicate significant differences among means within a column for a particular activity (ANOVA followed by LSD, α = 0.01)
*Observation time is 600 seconds
n: number of replicates

Turning angle 1 and 2 of *Coccinella septempunctata* females: Turning angles 1 (degree/sec) and 2 (degree/cm) of *C. septempunctata* females in cypermethrin and diazinon treated and non-treated arenas are given in Table 3. The turning angles of *C. septempunctata* females with respect to time and distance in both dosages of cypermethrin treated arenas were significantly higher than those in non-treated arenas. There was no significant difference in turning angles in both dosages of cypermethrin treated arenas. Turning angles of *C. septempunctata* females in diazinon applied arenas (500μℓ/ℓ) were similar to those in non-treated arenas. Turning angles 1 of *C. septempunctata* females in diazinon applied arenas (1000 μℓ/ℓ) were similar to those in non-treated arenas, but their turning angle 2 was significantly lower than that in non-treated arenas. There was no significant difference in turning angles in both dosages of diazinon treated arenas (Table 3).

Table 3. Turning angles 1 (degree/sec) and 2 (degree/cm) of *Coccinella septempunctata* L., 1758 females in cypermethrin and diazinon treated and non-treated arenas*

Active ingredient	Dosage (μL/l)	n	Turning angle 1 (Degree/sec)±SE	Turning angle 2 (Degree/cm)±SE
Cypermethrin	500	5	69±2.3 A	116±8.7 A
Cypermethrin	1000	5	70±1.7 A	115±2.9 A
Diazinon	500	5	54±2.5 AB	56±3.1 BC
Diazinon	1000	5	44±11.3 B	44±1.2 C
Control	-	5	48±2.3 B	74±3.6 B
F value			$F_{4.20}$=4.7	$F_{4.20}$=23.8
P *value*			0.0076	<0.0001
LSD value			16.069	20.064

Different upper case letters indicate significant differences among means within a column for a particular activity (ANOVA followed by LSD, α = 0.01)
*Observation time is 600 seconds
n: number of replicates

Movement traces of *Coccinella septempunctata* females: The movement traces of *C. septempunctata* females in cypermethrin and diazinon treated and non-treated arenas during observation of 600 sec are given in Figure 1. In non-treated arenas, *C. septempunctata* females moved regularly with a certain speed and time interval and changed their direction with a certain speed and interval. Their movement traces became expansive (Figure 1 E). In cypermethrin treated arenas, movement traces were not denser than those in non-treated arenas. It appears that they often turned around their own surroundings. The movement traces of *C. septempunctata* females in both dosages of cypermethrin treated arenas were similar to each other (Figure 1 A-B). In diazinon treated arenas, *C. septempunctata* females moved continuously and travelled more distance. As result of this, the apperance of movement traces of *C. septempunctata* female in diazinon treated arenas became denser and more complex than that in non-treated arenas. Movement traces of

C. septempunctata female in diazinon 500 μℓ/ℓ treated arenas were not so dense as compared with diazinon 1000 μℓ/ℓ treated arenas (Figure 1 C-D). The differences in movement traces of *C. septempunctata* female in cypermethrin and diazinon treated arenas due to their residual toxicity were also referred to the values of walking distances presented in Table 1.

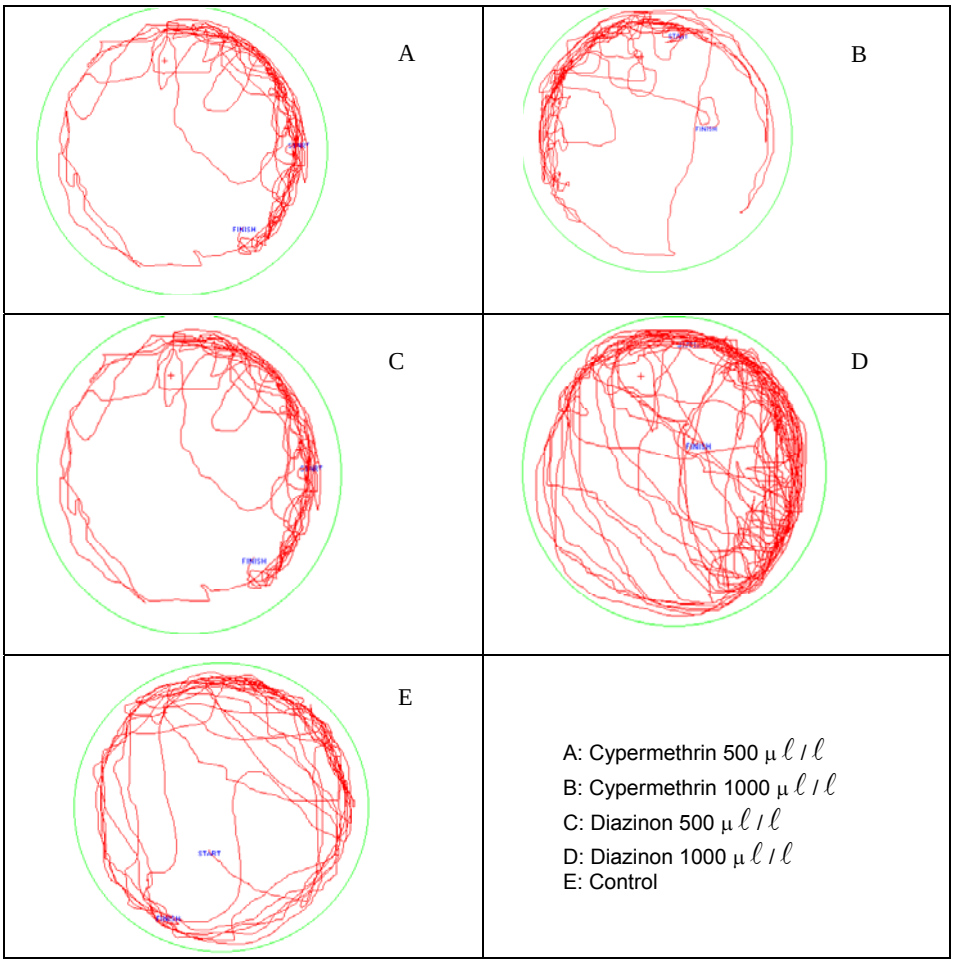

Figure 1. The movement traces of *Coccinella septempunctata* L., 1758 females in cypermethrin and diazinon treated and non-treated arenas during observation of 600 seconds.

Coccinella septempunctata females were more active and travelled a longer distance in diazinon treated arenas than that in cypermethrin treated arenas. In cypermethrin treatments, net and gross speeds of *C. septempunctata* females were not affected. In diazinon treatments, *C. septempunctata* females moved more quickly than those in control treatments. At the applied dosages of both diazinon and cypermethrin, there was no difference in their net and gross speed of the predator.

In cypermethrin treatments, turning angles of *C. septempunctata* females with respect to time and distance were higher than those in control treatments. In diazinon treatments, behavioural activities of *C. septempunctata* females were affected and they changed their directions by moving in the same direction with low turning angles. At different dosage of cypermethrin and diazinon, there was no difference in walking distance, resting time and turning angles with respect to time and distance. Only, at various diazinon dosages, there was statistical resemblance between turning angles of females. The studies regarding to foraging behaviours of coccinellids before and after feeding have been reported by Kalushkov (1999) and Nakamuta (1982) but there is not much study regarding to effect insecticides on their foraging behaviours. Although *C. septempunctata* female individuals displayed expansive and regular movement traces in control application, movement traces on screen in insecticide treated arenea showed that behavioural activities of the predator was not so normal. Ferran & Dixon (1993) reported that coccinellids moved regularly and expansively while searching for their preys, could use all visual clues and traces during accommodation to the environment, their prey searching behaviours were affected by biotic and abiotic factors. As reported, the predators could be affected not only from the residuals of insecticides but also from their odour. Present study also showed that insecticides used in agro ecosystems could affect behavioural activities of the predators.

Walking distance and resting time of *Aphidius uzbekistanicus* females: Walking distance and resting time of *A. uzbekistanicus* female individuals in cypermethrin and diazinon treated and non-treated arenas are given in Table 4. Walking distances of *A. uzbekistanicus* females at both dosages of cypermethrin and diazinon were longer than those of control treatment, but the resting time was shorter. Statistically, walking distance and resting time of the individuals at high dosages of cypermethrin and diazinon were shorter than those at the low dosages (Table 4).

Table 4. Walking distance and resting time of *Aphidius uzbekistanicus* Luzhetzki, 1960 female individuals in cypermethrin and diazinon treated and non-treated arenas*

Treatments	Dosage (μL/l)	n	Walking distance (cm)±SE	Resting time (sec)±SE
Cypermethrin 1	1000	5	278±3.4 B	88±2.6 C
Cypermethrin 2	2000	5	267±2.3 C	28±1.9 E
Diazinon 1	250	5	300±5.0 A	112±4.5 B
Diazinon 2	500	5	281±3.4 B	58.0±2.7 D
Control	-	5	168±2.6 D	296±3.1 A
F value			$F_{4.20}$=224.2	$F_{4.20}$=1172.2
P *value*			<0.0001	<0.0001
LSD value			10.289	9.0627

Different upper case letters indicate significant differences among means within a column for a particular activity (ANOVA followed by LSD, α = 0.01).
*Observation time is 600 seconds
n: number of replicates

Gross and net speeds of *Aphidius uzbekistanicus* females: Gross and net speed of *A. uzbekistanicus* female individuals at various dosages of cypermethrin and diazinon application are given in Table 5. At both dosages of cypermethrin and diazinon, brut speed of *A. uzbekistanicus* was higher than that of control application. The speeds of female parasitoids were similar to each other at various dosages of cypermethrin. However, gross speeds of individuals at high dosage of diazinon were lower than those of at low dosages statistically. For net speed, it was statistically the same with that of control application at low dosage of cypermethrin while it was higher than that of control application at low dosage of diazinon. The net speed was lower than that of control application at high dosage of both cypermethrin and diazinon. Active ingredients of high dosage of both cypermethrin and diazinon caused individuals' net speeds to be statistically lower than that at lower dosage (Table 5).

Table 5. Gross and net speed of *Aphidius uzbekistanicus* Luzhetzki, 1960 females in various dosages of cypermethrin and diazinon treated and non-treated arenas

Active ingredient	Dosage (μL/l)	n	Gross speed (cm/sec) ± SE	Net speed (cm/sec) ± SE
Cypermethrin	1000	5	0.40±0.012 C	0.56±0.01 B
Cypermethrin	2000	5	0.45±0.002 BC	0.48±0.003 D
Diazinon	250	5	0.50±0.008 A	0.60±0.01 A
Diazinon	500	5	0.46±0.01 B	0.52±0.009 C
Control	-	5	0.30±0.01 D	0.55±0.01 B
F value			$F_{4,20}$=43.9	$F_{4,20}$=24.4
P *value*			<0.0001	<0.0001
LSD value			0.0329	0.0282

Different upper case letters indicate significant differences among means within a column for a particular activity (ANOVA followed by LSD, α = 0.01).
*Observation time is 600 seconds
n: number of replicates

Turning angle 1 and 2 of *Aphidius uzbekistanicus* females: Turning angles 1 (degree/sec) and 2 (degree/cm) of *A. uzbekistanicus* females in cypermethrin and diazinon treated and non-treated arenas are given in Table 6. Turning angle 1 of *A. uzbekistanicus* females at low dosage of cypermethrin applied arenas (1000 μℓ/ℓ) was similar to those in non-treated arenas, but their turning angle 1 at higher dosage of cypermethrin (2000 μℓ/ℓ) was significantly lower than those in non-treated arenas. Turning angle 1 of *A. uzbekistanicus* females with respect to time at low dosage of diazinon was higher than that for control treatment. However, as the dosage was doubled it was the same with that for control treatment. Turning angle 2 of parasitoid individuals with respect to distance at dosages of both cypermethrin and diazinon was significantly higher than that for control treatment (Table 6).

Table 6. Turning angles 1 (degree/sec) and 2 (degree/cm) of *Aphidius uzbekistanicus* Luzhetzki, 1960 females in cypermethrin and diazinon treated and non-treated arenas

Active ingredient	Dosage (μL/l)	n	Turning angle 1 (Degree/sec) ± SE	Turning angle 2 (Degree/cm) ± SE
Cypermethrin	1000	5	54.3±1.5 AB	113.6±3.4 A
Cypermethrin	2000	5	46.4±1.3 C	108.1±1.72 A
Diazinon	250	5	56.6±1.3 A	93.6±0.9 B
Diazinon	500	5	52.4±1.1 B	98.7±2.2 B
Control	-	5	51.6±1.1 B	82.7±1,5 C
F value			$F_{4.20}$=9.1	$F_{4.20}$=33.2
P *value*			0.0002	<0.0001
LSD value			3.7357	6.214

Different upper case letters indicate significant differences among means within a column for a particular activity (ANOVA followed by LSD, α = 0.01).
*Observation time is 600 seconds
n: number of replicates

Movement traces of *Aphidius uzbekistanicus* females: The movement traces of *A. uzbekistanicus* females in cypermethrin and diazinon treated and non-treated arenas during observation of 600 seconds are given in Figure 2. In control treatment, the parasitoids moved by a certain speed and time interval and they continued to their search by changing direction at certain time and distance (Figure 2 E). Movement traces of *A. uzbekistanicus* females in cypermethrin-applied arenas were generally dense in a narrow area (Figure 2 A-B). In diazinon-applied areas, parasitoid females moved continually in slightly wider area than in cypethrin-applied areas. However, they had dense movement traces in much narrower area compared to that in control treatment (Figure 2 C-D). At high and low dosage of cypermethrin and diazinon, there were not any difference in movement traces of *A. uzbekistanicus* (Figure 2 A-D).

Aphidius uzbekistanicus females were affected by cypermethrin and diazinon treatments and so they continuously moved by showing abnormal food searching behaviour. Particularly, parasitoids were highly affected by high dosages of cypermethrin and diazinon. *Aphidius uzbekistanicus* females moved changing direction with low angles for a long time at high dosage of cypermethrin. Diazinon treatments resulted in parasitoids turning with high angles and affected the behaviour activities of parasitoids. Longley & Jepson (1996) reported that parasitoid *Aphidus rhopalosiphum* DeStefani–Perez and hyperparasitoid *Dendrocerus carpenteri* (Curtis, 1829)'s host searching duration decreased, walking duration increased and rested less. The results obtained from present study were similar to those reported by Longley & Jepson (1996) for parasitoid *A. rhopalosiphum.*

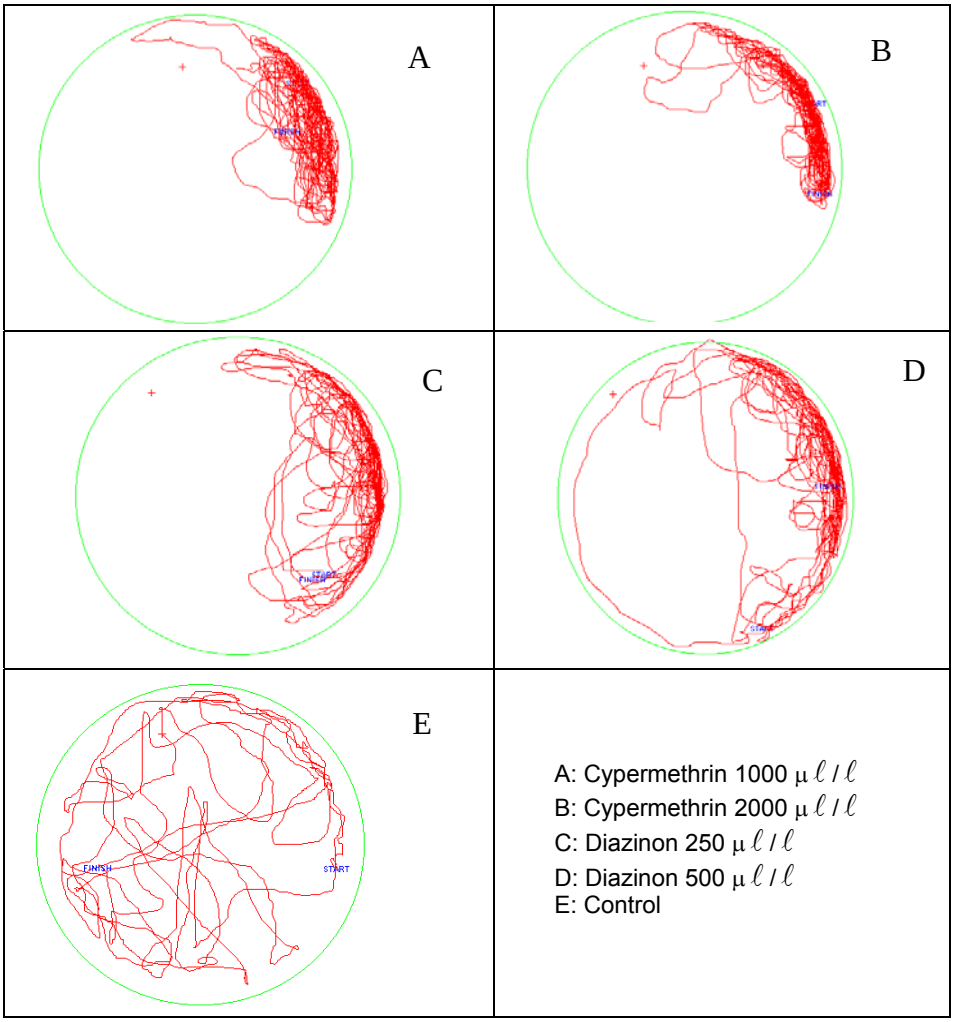

Figure 2. The movement traces of *Aphidius uzbekistanicus* Luzhetzki, 1960 females in in cypermethrin and diazinon treated and non-treated arenas during observation duration of 600 sec.

Aphidius uzbekistanicus indicated expansive movement traces in insecticide treated areas. Orientation configuration of parasitoid individuals got narrow in cypermethrin and diazinon applied areas. Longley & Jepson (1996) reported that existing duration of females in deltamethrin treatment with honeyed material was longer than that in deltamethrin application without honeyed material. In the same study, they reported that searching behaviours of *A. rhopalosiphi* in insecticide and honeyed material treated areas speeded up, they walked more quickly and/or they showed irregular movements. They reported that parasitoids were affected in different ways from insecticide treatments existing with and without food and they showed different behavioural activities from control treatments. Likewise, in this study, movement traces of *A.*

uzbekistanicus females were denser and more complex in insecticide treated arena in comprasion with those in non-treated arena.

Knowing effect of the insecticides on behavioural activities of the predators and parasitoids beside their toxic the effects plays important role in implementing a succesfull biological control programmes. Clearly, cypermethrin and diazinon had negative effect on foraging behaviour of female adults and of *A. uzbekistanicus* and *C. septempunctata*. While diazinon resulted in the increase of walking time and decrease of resting time due to the disturbance of tested insects on insecticide treated area, cypermethrin contrarily resulted in the decrease of walking time and increase of resting time. Therefore, foraging behaviour of female adults of *A. uzbekistanicus* and *C. septempunctata* was observed to be not normal on cypermethrin and diazinon treated areas, which can have a great impact on the number of aphids consumed daily by coccinellid species and on the number of aphids parasitized by parasitoid species. Thus, these changes on behavioural activities can reduce the efficiency of natural enemies to control insect pests. However, it is necessary to study foraging behaviour of the predators and parasitoids under field conditions evaluating the effect of some other factors such as, mainly prey population density, size and behaviour of prey.

Özet

Yaygın olarak kullanılan insektisitler, cypermethrin ve diazinon aktif maddelerinin *Coccinella septempunctata* Linnaeus, 1758 (Coleoptera: Coccinellidae) ve *Aphidius uzbekistanicus* Luzhetzki, 1960 (Hymenoptera: Aphidiidae)'un farklı tipteki davranış aktiviteleri üzerine etkileri

Bu çalışmada cypermethrin ve diazinon aktif maddelerinin kalıntı miktarlarının *Coccinella septempunctata* Linnaeus, 1758 (Coleoptera: Coccinellidae) and *Aphidius uzbekistanicus* Luzhetzki, 1960 (Hymenoptera: Aphidiidae) dişi bireylerinin davranışları üzerinde etkileri video/bilgisayar kayıt ve analiz sistemi kullanılarak araştırılmıştır. *Coccinella septempunctata* için her iki aktif maddenin 500-1000 $\mu\ell/\ell$ dozları, ve *Aphidius uzbekistanicus* için ise cypermethrinin 1000-2000 $\mu\ell/\ell$ ve diazinonun 250-500 $\mu\ell/\ell$ dozları kullanılmıştır. Elde edilen sonuçlar diazinon uygulamasında avcıların gezinme süresinin cypermethrin uygulamasına göre daha uzun olduğunu göstermiştir. Cypermethrin uygulaması çoğunlukla yüksek açılarla dönen avcıların hızı üzerinde etkili olmamıştır. Diazinon uygulamasında avcı böcekler yüksek hız ile hareket etmiş ve düşük dönüş açıları ile aynı yöndehareket ederek yön değiştirmişlerdir. Cypermethrin uygulanmış alanlarda, *C. septempunctata*'nın hareket izleri sık sık kendi çevrelerinde hareket ettiklerini göstermiştir. Yüksek dozda diazinon uygulanmış alanlardaki avcı böcekler yoğun bir hareket izine sahip olmuşlardır. Uygulanan cypermethrin ve diazinonun her iki dozlarında da *A. uzbekistanicus* gezinmeye daha fazla ve duraklamaya daha az zaman harcamıştır. Yüksek dozlarda parazitoitin net hızı azalmıştır. Diazinon uygulamalarında parazitoit çoğunlukla yüksek

açılarla dönerken, cypermethrinin yüksek dozlarında daha düşük açılarla daha az yön değiştirmiştir. Diazinon uygulanmış alanlarda, parazitoit cypermethrin uygulanmış alanlara göre daha geniş, kontrole göre ise daha dar bir hareket izi göstermiştir.

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